Implementability of inquiry-based science education in the Foundation Phase classroom

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Implementability of inquiry-based science education in the Foundation Phase classroom

by

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(Learning Support, Guidance and Counselling)

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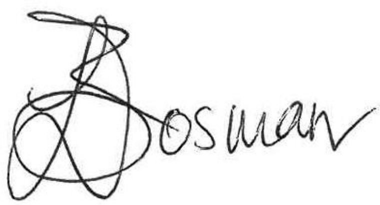
March 2017

Declaration of originality

I declare that the thesis titled **Implementability of inquiry-based science education in the Foundation Phase classroom** that I hereby submit for the degree PhD at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.



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[1]Opinions expressed and conclusions arrived at are those of the author and not necessarily to be attributed to these institutions.

Abstract

This study investigated the implementability of the French *La main à la pâte* (LAMAP) inquiry-based science education (IBSE) programme in South African Foundation Phase classrooms. The primary research question directing the research was formulated as follows: *How can insight into the experiences of participants in IBSE broaden existing knowledge on the implementability of IBSE in the South African Foundation Phase classroom context?* The study focused on eliciting the voices of both children-as-scientists engaged in scientific inquiry and student teachers who facilitated science education following the LAMAP approach.

In constructing a conceptual framework I integrated contemporary perspectives on childhood, theory theory and constructivist theory concepts and LAMAP IBSE. I utilised an interpretative, qualitative multiple-case study design and explored the participants' engagement and experiences of IBSE in the context of a real-world classroom. I combined convenience and purposive sampling to select three schools in an urban setting as cases, with 70 Grade 1 to Grade 3 learners and three student teachers as participants. Data were collected and documented by means of direct interactive observation, whole class reflection sessions, focus group discussions, document analysis, field notes and a research journal.

From inductive thematic data analysis four themes emerged relating to student teachers' experiences of implementing IBSE in Foundation Phase classrooms, learners' active engagement in the various phases of IBSE, their experience of social learning, and learners perceiving IBSE as an empowering approach. The findings of the study indicate that implementing IBSE contributed to shaping student teachers' professional identity as science teachers. They furthermore revealed learners' potential as natural scientists, and their cognitive capacity to act, think and learn like real scientists in the context of their classrooms. Engagement in IBSE shaped learners' sense of agency and identity as

scientists. As young scientists-in-waiting learners are, however, dependent on researchers, decision-makers and the broader education community to mobilise and sustain their potential for being and becoming scientists. The findings of the study resulted in a framework proposing guidelines for IBSE implementation in the South African Foundation Phase classroom context.

Key Terms

- Child-as-scientist
- Contemporary perspectives on childhood
- Facilitation of learning
- Foundation Phase
- Implementability
- Inquiry-based science education (IBSE)
- *La main à la pâte* (LAMAP)
- Theory theory

Declaration by language editor

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TO WHOM IT MAY CONCERN

I, the undersigned, hereby declare that the doctoral thesis titled **Implementability of Inquiry-based Science Education in the Foundation Phase Classroom** by **Linda Bosman** has been edited for grammar errors. It remains the responsibility of the candidate to effect the recommended changes.

Prof. Tinus Kühn

Ethical clearance certificate

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- Data storage requirements.

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SETTING THE STAGE

"Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results" — John Dewey (1859-1952)

"I feel like it's better because you can actually do something and it's more creative than just writing on a piece of paper. I'll rather do than say" — Grade 3 learner (2015)

La main à la pâte **… (Hands-in-the-dough)… Hands-on, minds-on**

1.1 INTRODUCTION AND BACKGROUND TO THE STUDY

This study involves a systematic empirical inquiry into the implementability of a specific practice (inquiry-based science education) in the education setting of Foundation Phase learners[1] (six- to nine-years-olds) (Hatch & Coleman-King, 2014). This study on inquiry-based science education (IBSE) at Foundation Phase level was inspired by a movement towards introducing inquiry-based science education during the early years of schooling. Ongoing concerns about and debates on the current situation in science education and learner achievement in South Africa further motivated me to conduct the study.

Inquiry-based learning entails a range of teaching and learning approaches where learners' inquiry drives the learning experience. The inquiry process requires a purposeful, active mind-body involvement in a challenging and supportive learning environment where learners can construct and share knowledge. Inquiry-based learning is regarded as an empowering approach to learning that implies several educational benefits, including the development of higher-order intellectual abilities (Harlen, 2013a; Levy, Lameras, McKinney & Ford, 2011; Rocard, 2007).

Science education has become increasingly important as the 21st century unfolds (Duschl, Schweingruber & Shouse, 2007). To live, learn and work successfully in an increasingly complex world requires of citizens to be innovative and to be critical thinkers, problem solvers and decision makers, information seekers, knowledge creators, effective communicators, capable technology users and informed, responsible and contributing citizens (Next Generation Science Standards, 2013; Plomp, 2013; UNESCO, 2010).

To prepare children appropriately for the expectations of transformed societies requires fundamental shifts in thinking about education and the role of schools in society (Plomp, 2013). Harlen (2013a) maintains that children need to develop the skills, will, flexibility in thinking, and the energy needed to make effective decisions. Dumont and Istance (2010) expand on this list, referring to skills such as learning to

[1]When referring to children in the school setting, I use the term "learners" throughout this thesis. When referring to children in general, I use the term "children".

generate, process and sort complex information; thinking systematically and critically; taking decisions by weighing different forms of evidence; asking meaningful questions about different subjects; being adaptable and flexible to new information; being creative; being able to identify and solve real-life problems; being able to work in teams; and being able to communicate effectively in a work and societal context. To thrive in today's world, scientific and technological literacy therefore seems to be an important prerequisite (Next Generation Science Standards, 2013; Osborne, 2010).

Governments of both developed and developing countries place a high premium on a scientifically literate populace, and recognise the value of investment in high quality science education as a means of developing 21st century skills and competencies among citizens (Australian National Curriculum Board, 2009; Ireland, Watters, Brownlee & Lupton, 2012; Minner, Levy & Century, 2010; Rocard, 2007). In this regard Cofré and co-researchers (2015, p. 45) contend that "The consensus in the world is that scientific literacy should be the main objective of science education" (Cofré, Gonzáles-Weil, Vergara, Santibáñez, Ahumada, Furman, Podesta, Camacho, Gallego & Pérez, 2015). Globally, inquiry-based education is viewed as a means of improving not only education in general (PRIMAS, 2011), but science education outcomes in particular (Alake-Tuenter, Biermans, Tobi, Wals, Oosterheert & Mulder, 2012). IBSE aims at producing scientifically literate learners (Seraphin, Philippoff, Kaup & Vallin, 2012), and is promoted as one of the most valuable means of developing the aims of modern society (Australian National Curriculum Board, 2009). Inquiry-based approaches to learning may support children to become thoughtful, motivated, collaborative and innovative learners, capable of engaging in inquiry and thriving in a changing world (Ontario, 2013).

In line with new curriculum priorities worldwide, the South African Department of Basic Education claims to "develop, maintain and support a South African school education system for the 21st century", and envisions "a South Africa in which all our people have access to lifelong learning, as well as education and training, which will, in turn, contribute towards improving the quality of life and building a peaceful, prosperous and democratic South Africa" (DBE, http://www.education.gov.za/TheDBE/VisionMission/tabid/80/Default.aspx).

Currently, however, the education sector in South Africa is viewed as being in crisis (Spaull, 2013). Locally the Annual National Assessments (ANA[2]) show that the vast majority of South African learners are underperforming (Spaull, 2013). The underperformance, especially in the lower grades, is confirmed by the National Education Evaluation and Development Unit (NEEDU[3]) 2012 report (DBE, 2013b). Learner performance is taken as a significant indicator of the functionality of an education system (Hwenha, 2013).

On a broader level, since the first participation in meaningful international evaluations, South African learners' achievement has been a cause for concern (Spaull, 2013; Evans, 2013; Reddy, 2013; World Economic Forum, 2013). Specifically relevant to the context of this study are the TIMSS results, indicating that, when compared to peers, South African learners continue to lag behind in mathematics and science, also in relation to their peers in the rest of Africa (IAE, n.d.; Hwenha, 2013).[4] Further confirming the poor quality of mathematics and science in education, the World Economic Forum Global Competitiveness Report (2013-2014) ranks South Africa 148th out of 148 countries (WEF, 2013).

Mathematics and science are generally known as so-called gateway subjects that lay the foundation for higher education and for pursuing careers in STEM[5]-related fields. This fact highlights the responsibility of educational systems to produce critical masses of learners who pass mathematics and science at matriculation level (Hwenha, 2013). Despite this worldwide need, recent research (Spaull, 2013) indicates that the South African school system fails to produce sufficient numbers of learners passing mathematics and science at an adequate level. As a result a shortage currently exists in this country of professionals with the necessary

[2]Annual National Assessments (ANA) provide a standardised indication of learning in the primary grades, allowing for identification and early intervention of learning deficits.
[3]NEEDU is an independent unit responsible for providing the Minister of Basic Education with an authoritative, analytical and accurate account on the state of schools in South Africa and, in particular, the status of teaching and learning. The 2012 report focused specifically on Foundation Phase learners in Grades 1 and 3.
[4]TIMSS is the acronym for "Trends in International Mathematics and Science Study", a series of assessments of learners' achievement in mathematics and science under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). Similar projects are the Southern Africa Consortium for Monitoring Educational Quality (SACMEQ) and the Progress in International Reading and Literacy Studies (PIRLS).
[5]Science, Technology, Engineering, Mathematics (STEM).

mathematics and science skills to meet the workforce requirements of industry, commerce, health and education (Spaull, 2013).

While some progress has seemingly been made in promoting mathematics and science education in South Africa, ongoing interventions have not yet clearly been translated into significant positive learner outcomes (Hwenha, 2013). An emerging consensus exists that most problems encountered at high school level are caused by inadequate basic education and the failure to build a solid platform in the early years (Gauteng Department of Education, 2010). In this regard Spaull (2013) states that underperformance is widespread in the primary phases in South African schools and that learners acquire insurmountable learning deficits during their early education. Referring to Heckman's (2000, 2006) research, Spaull (2013) acknowledges the need to focus on the early schooling years due to the now acknowledged notion that remediation should target children while they are most susceptible to educational investment, i.e. during the early childhood and Foundation Phase years. Spaull views many South African interventions aimed at higher grades as too late, making effective remediation difficult. One of the eight most important findings emanating from the CDE research report entails that:

> *"The learning deficits that children acquire in their primary school career grow over time to the extent that they become insurmountable and preclude pupils from following the curriculum at higher grades, especially in subjects that are vertically demarcated like mathematics and science. Intervening early to prevent, diagnose and correct these learning deficits is the only appropriate response"* (Spaull, 2013, p. 57).

Consequently an urgent need exists to expand the scope of improvement strategies and to focus on effectively teaching science during the formative years in the Foundation Phase. In response to modern studies, many countries for example, England, Germany, Korea, Ghana, Turkey and other developed and developing countries are introducing science as part of the school curriculum from the first years of primary school (Tao, Oliver & Venville, 2013). These schools also invest in professional development courses and educational resources to support teachers in teaching science (Tao et al., 2013). In addition, countries such as Australia have developed comprehensive action plans to address the quality of science education at all levels of schooling (Howitt, Blake, Calais, Carnellor, Frid, Lewis, Mocerino, Parker, Sparrow, Ward & Zadnik, 2012). Many of these schools aim to develop the scientific literacy level of young children, and to raise interest and competence in science from early childhood (Siry, Ziegler & Max, 2012; Zogza & Ergazaki, 2013).

Against the background of inquiry-based education generally being regarded as an effective approach to teaching and learning, also in preparing young citizens with the skills and competencies required in a 21st society, the purpose of this study was to investigate to what extent and with what effect inquiry-based science education can be implemented in the South African Foundation Phase. Although young children have the capacity to develop and use the skills of scientific inquiry (NSTA, 2014), they should be supported by adults to develop and use these skills in an educational setting. Therefore, this study does not merely focus on how children engage in the inquiry-based learning process, but also on the adults responsible for supporting their inquiry-based science learning (i.e. facilitators of science inquiry and lecturers providing IBSE training).

1.2 RATIONALE FOR UNDERTAKING THE STUDY

My interest in this study was inspired by a personal interest as well as the apparent need for research in this area. In the preceding section I highlighted some current concerns about South African children's performance in science at school level, and the potential effect on the labour market in the country in terms of skills that adults generally possess. In this regard, I concur with Harlen and Léna (2013, p. 7), who state that:

> *"It became widely recognised that school science had to serve the education of the whole population, not just those who would become scientists or technologists. All citizens in a world increasingly dependent on science and technology applications, need to understand key science concepts and the nature of scientific activity, and be able to use evidence in making decisions. These needs were encapsulated in the notion of scientific literacy – 'an appreciation of the nature, aims, and general limitations of science, coupled with some understanding of the more important scientific ideas'. Moreover, it was recognised that such literacy will be better achieved if it begins early, in primary school".*

Harlen and Léna (2013) posit that scientific literacy can be better achieved if facilitated early, in primary school. Traditionally, however, science education during the early childhood and Foundation Phase has been largely neglected, mostly due to the out-dated notion that young children are not developmentally ready to conceptualise complex science (Fleer cited in Saçkes, 2014). As is the case in South Africa, in most countries science is rarely and sporadically taught during the early grades of schooling, and even when science is taught during these years, the experiences offered are often of low quality and do not typically engage learners in practices that encourage rigorous and reflective science learning (Bosman, 2006; Eshach, 2011; Mantzicopoulus, Samarapungavan & Patrick, 2009).

However, studies increasingly reveal that young children are surprisingly capable scientists (Metz, 2011). They are often referred to as “natural scientists”, naturally curious, with the inborn capacity to think and reason scientifically (Trundle, 2015). Young children’s thinking processes are sometimes even compared to the thinking processes of adult scientists as they engage in scientific inquiry. In this regard children’s innate curiosity gives rise to inquiry and exploration – which are the foundations for early learning, but also the foundation for science (Gopnik, Meltzoff & Kuhl, 1999; Kovalik & Olsen, 2010; Metz, 2011). To this end, research increasingly indicates the positive long-term outcomes of investment in quality early science curricula (Tao et al., 2013; Samarapungavan, Patrick & Mantzicopoulos, 2011; Hong & Diamond, 2012). Furthermore, the growing crescendo from governments, businesses, education systems and schools propagates that quality science education (as well as reform efforts) should start as early as possible, with greater emphasis on science during the early years of schooling than is currently the case (Eshach, 2011; Gelman & Brenneman, 2012; Slavin, 2012; Harlen & Léna, 2013; Metz, 2011; Tao et al., 2013).

This emerging trend in research views the early childhood years as a window of opportunity for developing the ability to think and reason scientifically. Referring to learners in the United States of America, Metz (2011) posits that the reform of early primary school science is fundamental to addressing underachievement in later grades, and that failure to support the scientific capabilities of primary school children can seriously handicap their future prosperity. As such, quality science education during this specific period may potentially promote lifelong science learning.

I have been involved in an inquiry-based science education (IBSE) project since 2013, implementing the French IBSE programme *La main à la pâte* (LAMAP) in the Intermediate Phase[6] of selected primary schools in Gauteng. The project was launched by the Academy of Science of South Africa (ASSAf) in 2012, in partnership with the French Academy of Sciences, with the support of the national and Gauteng provincial Departments of Education. The intention was to address the quality of science education in the South African context, starting on small scale with Grade 4 teachers from ten national Gauteng Province Department of Education (GDE) schools in Pretoria (District D4[7]). Although the LAMAP programme is suitable for children from pre-school upwards, the decision was made to implement this project in Grade 4 in South Africa, as the subject Natural Science and Technology was officially offered as a separate subject of the national Grade 4 curriculum for the first time.

As part of the LAMAP project[8] I have been partly responsible for training teachers in the implementation of the programme in their classrooms. The programme aims to develop learners' language as well as their scientific and critical thinking skills in an integrated way within the context of science. The programme furthermore aims to encourage children's curiosity, with a strong emphasis on reasoning and explanation, both verbally and in writing. Equipping children with such skills at an early age has several benefits. These children could have greater access to scientific careers, and may also become better equipped to participate fully and critically as citizens in a democratic country. I discuss the LAMAP[9] IBSE approach and supporting framework in more detail in Chapter 2.

In preparation for this study, I attended the *La main à la pâte* 6th international seminar[10] on science and technology education in Paris, France in 2015. The seminar is organised by the *La main à la pâte* foundation (Academy of Sciences - Institute of France) in collaboration with the Ministry of Foreign Affairs, the

[6]Grade 4 to 6 learners (age ten to twelve), in the Foundation Phase (ages six to nine).
[7]D4: Schools within the Tshwane South district (i.e. southern regions of Pretoria).
[8]See http://www.assaf.co.za/newsletter/?p=459; Hands-on training for teachers; http://www.assaf.co.za/newsletter/?p=620; and STEM Education, LAMAP Pilot Project: http://www.assaf.co.za/newsletter/?p=755.
[9]More information on LAMAP is available at: http://www.fondation-lamap.org/en/node/9511.
[10]For additional information on the seminar, see http://www.fondation-lamap.org/en//node/9559.

Directorate of European and International Affairs and Cooperation of the Ministry of Education, for Higher Education and Research, and the International Center for Educational Studies (CIEP). This international seminar aims to create a platform for participants from various countries to share guidelines on the implementation of IBSE, training of trainers and teachers, available resources, experiences in the application of IBSE (e.g. guides, materials for teachers and trainers), and ideas for translating the *La main à la pâte* approach to the context of other countries. Attending this seminar expanded my expertise and interest in the approach, and enhanced my motivation to become a "seed city"[11] for the approach in South Africa.

As former lecturer in the Post Graduate Certificate in Education (PGCE) programme at the University of Pretoria, I offered a course on IBSE to student teachers who specialise in early childhood development (ECD) and Foundation Phase (FP) teaching (from 2013 – 2015). The module I presented is based on the principles of LAMAP, but is specifically adapted to suit the South African curriculum requirements as well as the unique context of South African classrooms. Besides my interest in how young South African children would respond to inquiry-based learning experiences, I have over the years become interested in how student teachers experience the facilitation of inquiry-based activities in schools. In IBSE teachers and learners share the responsibility for learning (Ontario, 2013). As children depend on adults to orchestrate a learning environment that may enable inquiry-based learning, the experiences of both children and student teachers in an authentic school context as well as the interaction between these role players may provide valuable insight into the application of IBSE. As such, this study may inform existing literature related to elements that could support both learners and prospective teachers to implement IBSE in an effective manner.

In the current South African Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011b), literacy/language and mathematics remain curriculum priorities for Foundation Phase teaching, with little emphasis on science. Apart from suggesting themes, CAPS provides limited curriculum guidelines to assist teachers in innovative

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[11] An educative territory that supports IBSE in primary schools. In each seed city, "pollen" (research-based material, methodological and pedagogical resources, adapted to the local curriculum) is offered to support trainers and teachers.

science teaching practices. Despite a body of knowledge supporting inquiry-based learning as effective pedagogy, especially in terms of science education reform, IBSE is not prominently foregrounded in CAPS, and is therefore assumedly not often implemented in practice – especially not in the Foundation Phase.

As a result, research on the implementation of an inquiry-based education practice in the South African Foundation Phase, and studies exploring the experiences of different participants in inquiry-based teaching and learning situations remain under-explored. This study aims to contribute to the body of knowledge that deals with multi-level perspectives on the possibilities and challenges associated with implementing IBSE in the early years of schooling, as perceived by both teachers in training, and Foundation Phase learners. I support the view of Harlen and Léna (2013) that inquiry-based pedagogy, if well implemented, has the potential to equip learners with skills and competencies that are required in a 21st century society. However, as Harlen (2013a, p. 14) furthermore notes, “Inquiry-based learning is complex and is not an easy option. We strive to implement it because we believe that it promotes the understanding and development of skills needed by students to meet the demands of twenty-first century life”. These statements highlight the importance of ongoing research in the practical implementation of inquiry-based learning.

1.3 PURPOSE OF THE STUDY

The purpose of this study was to explore, describe and explain the implementability of IBSE in the South African Foundation Phase context. I utilised a multiple case study research design to collect data from participants on different levels, namely children-as-scientists as well as student teachers who facilitated IBSE with Foundation Phase learners. Following data collection, analysis and interpretation, I designed a framework for implementing IBSE in the Foundation Phase classroom context.

In undertaking the study, I firstly explored how young Foundation Phase learners engaged as scientists during a lesson following an inquiry-based approach in the context of a school classroom. More specifically, I explored how learners think, act and express themselves as scientists during IBSE. My aim was to gain insight into the experiences and reflections of learners acting and interacting within the context of IBSE, and into the meaning they attach to these experiences as expressed in verbal, visual and written modes.

Inspired by a rights-based perspective on childhood, I actively involved the child-participants as consultants in the research and attempted to understand reality as constructed by them in the context of their own lives. I focused on not interpreting their meanings of experiences from an adult point of view (i.e. looking down), but by looking up, to treat them as “actors and knowers” (Smith, 2011, p. 12). Involving children in this study deepened my insight into how they can express themselves as emerging scientists and how they could be supported to nurture their development as scientifically literate citizens.

As the complexity of IBSE often leads to questions concerning its effective implementation (Harlen, 2013a), I secondly explored how the facilitators[12] of inquiry-based learning (i.e. PGCE student teachers) experienced the process of facilitation, which challenges they encountered and what kind of support they required when applying inquiry-based theory in practice. I therefore collaborated with PGCE student teachers who facilitated inquiry-based science activities during their teaching practice period with Foundation Phase learners in Grades 1 to 3 in primary schools in Pretoria, South Africa. Thirdly, following data collection, analysis and interpretation, I developed a framework that may potentially benefit education stakeholders on different levels when conceptualising the implementation of IBSE in the Foundation Phase classroom.

1.4 POSSIBLE CONTRIBUTIONS OF THE STUDY

As stated, the implementation framework I developed (discussed in Chapter 7) should benefit various education stakeholders. More specifically, higher education

[12]The terms *student teachers* and *facilitators* of learning are used interchangeably. In this study student teachers fulfilled the role of PGCE students who facilitated IBSE in the Foundation Phase classroom.

institutions involved in Foundation Phase teacher education, the Department of Basic Education, and continuous professional teacher development (CPTD) programmes may build on this framework when putting theory into practice. The framework can also be beneficial to curriculum developers concerning the way in which curriculum goals can be realised through inquiry-based pedagogies. In addition, policy makers on inquiry-based science reform at Foundation Phase level may be informed by the findings of this study.

Theoretically the findings of this study may add specifically to existing literature on early childhood science education, in particular on the implementation possibilities of IBSE with Foundation Phase learners. This may, as a result, refine the practical application of theory. Early childhood qualitative studies hold the specific potential of providing insight into the lived realities of young children, as well as the experiences of adults who work with, and on behalf of them. As such the findings of this study may offer insight into the experiences of both learners and student teachers when IBSE is implemented in the Foundation Phase context, both broadening existing knowledge and informing future practice.

In my endeavour to investigate learners' own voices, and listening to how they view and experience themselves as scientists, and how they relate these experiences of engaging in scientific investigations, I regarded the child participants as primary informants and experts in their own lives, and engaged with them as consultants. As such this study may contribute to shaping adult views of children as competent social actors who have a say in matters affecting them (e.g. their science education). By obtaining information from children via consultation and disseminating their voices, I hope to inform practices and policies on the science education offered to young children in South Africa. Methodologically the study may create greater awareness among early childhood researchers that children, as competent contributors and participants in research projects, can add to knowledge creation when their voices are heard through mechanisms that may convey their views to audiences willing to listen and act in response.

1.5 RESEARCH QUESTIONS

This study was guided by the following primary research question:

How can insight into the experiences of participants in IBSE broaden existing knowledge on the implementability of IBSE in the South African Foundation Phase classroom context?

In order to answer the primary research question, the following secondary questions guided the study:

- How do Foundation Phase learners engage in IBSE?
- What are the reflections of Foundation Phase learners on their experiences of IBSE?
- How do Foundation Phase learners view and express themselves as scientists?
- How do student teachers reflect[13] on their experiences of facilitating IBSE with Foundation Phase learners?

1.6 WORKING ASSUMPTIONS

Based on existing literature in the field of early childhood science education and theories relating to IBSE, I undertook this study keeping the following assumptions in mind:

- Students studying ECD/FP are generally not scientifically inclined. I therefore assumed that student teacher participants could possess limited science background, and not be equipped with the necessary knowledge and skills to facilitate IBSE.
- The limited duration of IBSE training during teacher education programmes may not adequately prepare student teachers to be expert IBSE facilitators. However, I assumed that learning inquiry through inquiry, and translating theory into authentic teaching practice (during teaching practice in Foundation

[13]Reflection (reflective practice) is used as strategy for PGCE student teachers to engage in a continuous cycle of critical self-observation and self-evaluation in order to gain insight into their own actions and reactions in an attempt to improve their practice.

Phase classrooms), coupled with a critical reflective practice approach, may enhance student teachers' development of a professional identity as IBSE teachers.

- As effective implementation of IBSE depends on the knowledge and skills of the facilitator, I assumed that student teachers' understanding of the IBSE approach, and their perceptions of children and of how children learn, would have an impact on the way in which they implement IBSE.
- As teachers and learners share the responsibility for learning in IBSE, I assumed that the actions and interactions of children and facilitators during engagement in IBSE would have an impact on teaching and learning.
- As young children are natural scientists with inherent potential to think and work scientifically, I assumed that the child participants would have self-constructed scientific theories (ideas), the ability to engage naturally in IBSE and to form and revise their theories based on their participation in IBSE.
- I assumed that IBSE may enhance children's knowledge, skills and virtues across different subjects and areas.
- Finally, as science is a low curriculum priority subject, I assumed that the child participants might have had limited exposure to quality science experiences on a regular basis, and consequently of "being" scientists in the context of their classrooms. Furthermore, as it is not explicitly enforced by the curriculum, I assumed that science as inquiry is not practised in South African Foundation Phase classrooms, and that children may not necessarily be equipped with the skills and practices required of inquiry-based pedagogies.

1.7 CLARIFICATION OF KEY CONCEPTS

The following key concepts used in the study are relevant:

1.7.1 Implementability

To elucidate my choice of the term *implementability*, I consider the meanings of both *implement* (verb) and *ability* (noun). The Concise Oxford Thesaurus (2007, p. 419) defines the verb *implement* as "execute, apply, put into effect/action, put into practice, carry out/through, perform, enact; fulfil, discharge, accomplish, bring about, achieve, realize, …". The Merriam-Webster Dictionary (www.merriam-webster.com/dictionary/implement) similarly defines *implement* as to "begin to do or use (something, such as a plan); to make (something) active or effective". The derived noun *implementation* consequently refers to the act of carrying out something, or, more specifically, "the realization of an application, or execution of a plan, idea, model, design, specification, standard, algorithm, or policy" (http://implementability.askdefinebeta.com).

The noun *ability* is defined in the Concise Oxford Thesaurus (2007, p. 2) as "capacity (core synonym), capability, potential, potentiality, power, faculty, aptness, facility, wherewithal, or means". According to the Merriam-Webster Dictionary, ability means "the power or skill to do something" or "the quality or state of being able" (http://www.merriam-webster.com/dictionary/ability).

In this study, *implementation* refers to the act of putting into action and realising a specific pedagogical approach (IBSE) in a specific context (the Foundation Phase classroom). *Ability* refers to the power, capacity and potential of IBSE to be implemented. *Implementability* therefore implies the *ability* (power, capacity, and potential) to *implement* (carry out and realise) IBSE in the Foundation Phase context (hence, "implement-ability"). *Implementability* entails a set of guideline characteristics for effective implementation.

The implementability of IBSE in this classroom context was determined by focusing on the teaching-learning situation and by gaining insight into the experiences of participants (learners and facilitators of learning) during engagement in IBSE. Such insight may broaden knowledge of the practicality of implementing IBSE, and in turn lead to the formulation of recommendations (i.e. to develop a framework) on how to implement IBSE effectively in the South African Foundation Phase context.

1.7.2 Inquiry-based science education (IBSE)

Inquiry in the context of science education includes a number of interlinked categories, namely *what scientists do* (i.e. using scientific methods to investigate and explain the physical world), *how children learn* (i.e. actively pursuing questions or problems using processes similar to formal scientists), the *pedagogical approach* that teachers employ (i.e. design and facilitate learning activities that will engage children in scientific inquiry), as well as *curriculum materials* (Furtak, Shavelson, Shemwell & Figueroa, 2012; Minner, et al., 2010). Translating this into classroom practice, inquiry typically involves (1) how children do science using inquiry skills, (2) understanding the nature of scientific inquiry, and (3) allowing children to learn science by doing science (Ødegaard, Haug, Mork & Sørvik, 2014). Understanding scientific inquiry and the nature of science is thus fundamental to acquire scientific knowledge (Ødegaard et al., 2014).

I support the following comprehensive definition of IBSE provided by the InterAcademy Partnership (IAP) Science Education Programme (2012) (http://www.sazu.si/files/file-147.pdf; Harlen, 2013a, p.12):

> *"IBSE means students progressively developing key scientific ideas through learning how to investigate and build their knowledge and understanding of the world around. They use skills employed by scientists such as raising questions, collecting data, reasoning and reviewing evidence in the light of what is already known, drawing conclusions and discussing results. This learning process is all supported by an inquiry-based pedagogy, where pedagogy is taken to mean not only the act of teaching but also its underpinning justifications."*

For the purpose of this study, I thus view IBSE as a child-centred approach to science that assumes a shared responsibility towards knowledge creation between the facilitator of leaning (teacher) and the learners in the class. According to this approach, learners' prior scientific ideas (existing theories) are taken as the starting point for a teacher's facilitation of learning, through which learners are guided to construct knowledge during the entire inquiry process by means of active body-mind involvement in order to develop basic understandings in science. I discuss IBSE in greater detail in Chapter 2.

1.7.3 The Foundation Phase in the South African context

In the South African context, the umbrella term *Early Childhood Development* (ECD) is used to describe the development of children between birth and age nine (i.e. the end of Grade 3) and encompasses the Foundation Phase. The Foundation Phase includes children between ages five and ten (DoE, 2001). This phase thus entails the reception year (Grade R) and lower primary classes (Grades 1 to 3) in the South African school system. For this study, I focused on the implementation of IBSE for Foundation Phase learners in Grades 1 to 3 (i.e. learners at the onset of formal schooling).

The Foundation Phase is viewed as a period during which the basis for future learning in science should laid and essential skills for equipping learners with 21st century competencies be introduced and promoted (DBE, 2011a; DBE, 2013b). Although typically referred to as *learner* in the South African education context, I use the terms *child* and learner as interchangeable terms in this thesis, in order to foreground my view of children and childhood where fit.

1.8 UNDERLYING THEORETICAL PERSPECTIVES AND CONCEPTUAL FRAMEWORK

As I am specifically interested in how the theory of IBSE may be implemented in South African Foundation Phase classrooms, and in which considerations are important on different levels to make IBSE possible, I integrated a range of existing theories in determining a conceptual framework (Sumsion, Harrison, Press, McLeod, Goodfellow & Bradley, 2011). For IBSE I relied on the LAMAP IBSE approach, its framework, underlying principles, pedagogical considerations and specific pedagogical strategies to help me locate, interpret and explain my investigation.

In addition, I incorporated contemporary childhood views as someone who engages as scientist in IBSE, by drawing from current childhood theories (among others, James & Prout, 1997; James, Jenks & Prout, 1998; Mayall, 2002; Qvortrup, Bardy, Sgritta & Wintersberger, 1994). In understanding children as natural developing scientists, I considered the process of science development from a cognitive constructivist perspective, more specifically relying on theory theory (TT) (Gopnik, et al., 1999) to describe children's scientific thinking, inquiry and knowledge building processes. Finally, since the teacher plays an instrumental role in implementing

IBSE, I incorporated constructivist perspectives (for example, Piaget and Vygotsky) on the teacher's role as one of enabling learners' constructive engagement in IBSE.

The theories I relied on are discussed in more detail in Chapter 2. In this section, as an overview and introduction, I provide a summary of how I compiled the conceptual framework that is presented in Figure 1.1.

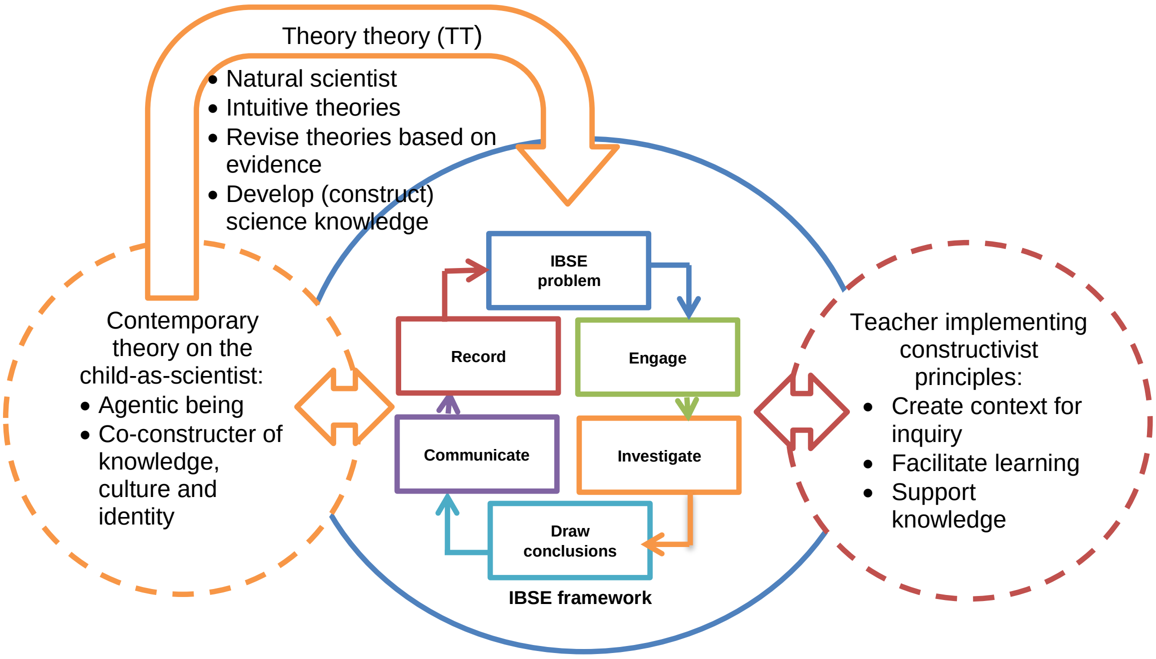


Figure 1.1: Integration of theories into a conceptual framework

Implementing a child-centred approach such as IBSE places the child at the core of the education context. In this regard adult conceptualisations of children and childhood have implications for how they are treated and educated (Morrow, 2011), and therefore, in the context of this study, how children are conceptualised will imply how they are engaged as learners in IBSE. In an attempt to understand how children think, act and express themselves as scientists during IBSE in the context of this study, I drew on emerging perspectives and current childhood theories. These theories shaped the view I held on children-as-scientists, and the central position they take in the IBSE situation.

Current childhood paradigms acknowledge children as a recognised social group with an independent place in society, with rights as individual human beings, and as full members of society (Dahlberg, Moss & Pence, 2013; Morrow, 2011).

Consequently, children are viewed as competent beings, citizens of today, and worthy for who they are (Dockett, Einarsdóttir & Perry, 2011; Kellet, 2014). To this end, child participants in this study were seen as capable of theory building and meaning making, able to contribute to knowledge construction from the very start of life, and consequently rich and competent beings (Rinaldi, 2006; Moss, 2013). This notion is further supported by Gopnik (2010; 2016) who argues that, far from being unfinished adults, children are designed to explore, create, change and learn. Consequently, in this study, I assumed that children enter the IBSE situation not as empty vessels, but as rich in theories about the world, constructed through real-life experiences since infancy. Since children are conceptualised as social actors (James & Prout, 1997), I believe in children's agency (i.e. capability to act) in contributing to learning and knowledge construction (Adair, 2014; Dahlberg et al., 2013; Schweisfurth, 2015). In agreement with Malaguzzi's (1993, p. 10) conceptualisation of children as "rich in potential, strong, powerful, competent and, most important of all, connected to adults and other children", I regard Foundation Phase children as scientists in their own right, who add richness to the IBSE situation. As such, within the context of this study, I conceptualised children as co-constructors of knowledge, culture and their own identity (Dahlberg, et al., 2013; Morrow, 2011).

Moreover, being viewed as valued members of and competent contributors to society, I acknowledge children as citizens, with associated citizen rights and responsibilities (Kellet, 2011). Consequently, I assumed children's competence to engage actively in IBSE as members of a community of scientists in which they take a central role in the learning process by, for example, relying on cultural tools (for instance, nature of science, knowledge, skills, dispositions, available materials and language of science) (Smidt, 2013). By regarding children as having a voice of their own (Clark & Moss, 2001; Kellett, 2014; Lansdown, 2005; Lundy 2007), the child participants in this study were encouraged to express their voice in verbal, visual and written modes. As such IBSE created opportunities for the learners to contribute their viewpoints, and to share power as co-creators of knowledge, culture and identity. Consequently, they were viewed as experts in their own experiences.

In addition to conceptualising the child in accordance with contemporary theorists, I considered the process of science development from a cognitive constructivist perspective. More specifically, I integrated in my conceptual framework the theory theory, as formulated by Gopnik and Meltzoff (1997) and Gopnik, Meltzoff and Kuhl (1999). Accordingly, scientific learning and children's learning are viewed from a combined perspective of children and scientists. Gopnik and Meltzoff (1997, p. 3) explain that "the central idea of this theory is that the processes of cognitive development in children are similar to, indeed perhaps even identical to, the processes of cognitive development in scientists".

Theory theory is applied to this study based on the notion of children participating in IBSE being seen as natural scientists, equipped by nature with powerful and flexible cognitive strategies that enable them to think scientifically, and to form and revise theories about the world, based on their active and personal experiences (thus, developing as scientists). As little scientists, children are furthermore seen to be driven by their natural curiosity to seek explanations through playful exploration, and to find pleasure in understanding. Just like scientists, children depend on their individual theory formation abilities, but also on a social network of shared information, as they construct knowledge about the world (Gopnik et al., 1999).

Finally, I integrated constructivist and social constructivist ideas in my conceptual framework on the role of the teacher in supporting learners' constructive engagement in IBSE. I regard knowledge not as being passively received, but rather as a result of learners actively constructing knowledge from experience (Aubrey & Riley, 2016). Applied to IBSE, the constructivist notion of learners' prior knowledge demands that teachers acknowledge learners as *knowers* who enter the IBSE situation with knowledge, based on their prior experiences (Koch, 2013; Martin, 2012). With science learning being a process of constructing and reconstructing theories (Martin, 2012), considering learners' prior knowledge furthermore emphasises the need for teachers to understand the role of the activity in building knowledge, but also to use learners' existing ideas when constructing new ideas (Koch, 2013). In this regard, the teacher merely acts as guide and facilitator of learner-centred science inquiry, while supporting learners' knowledge construction (Dahlberg et al., 2013; Zhai, Jocz & Tan, 2014).

However, constructing an understanding of science does not happen in a social or cultural vacuum, but is contextually embedded and socio-culturally mediated (Koch, 2013; Martin, 2012; Siry & Kremer, 2011). The constructivist role of the teacher in IBSE therefore includes establishing a classroom in which the teacher and learners use language that is socially and culturally accepted within the community of scientists, in order to co-construct knowledge (Koch, 2013).

In relating contemporary theories on child views, theory theory and the constructivist role of the teacher as facilitator of learning in the LAMAP approach, I regard the child entering the IBSE context as a competent learner able to take centre stage in the teaching-learning situation. Moreover, as agentic being and competent scientist, the learner is able to engage in IBSE as a member of a community of scientists, and to contribute to the construction of meaning. By relying on the assumptions of theory theory, I view children entering the IBSE framework as natural scientists, cognitively capable of engaging in scientific investigations. Moreover, engaging in IBSE relies on children’s intuitive theories, but also on their inclination to develop continually and revise theories in the process of knowledge accumulation. The teacher who implements IBSE will consequently employ constructivist principles by creating a context for inquiry, and by facilitating learners’ thought processes throughout the IBSE phases in order to support their science knowledge construction.

1.9 PARADIGMATIC CHOICES

Due to the nature of the study, the research context and participants, as well as the data I collected, I relied on interpretivism as onto-epistemological paradigm, and followed a qualitative approach. In this section I introduce these choices. Detailed discussions follow in Chapter 3.

1.9.1 Onto-epistemological paradigm

The purpose of this study was to gain insight into how the theory of IBSE can be applied to Foundation Phase practice in the South African context. In this regard I explored how young children acted as scientists when an inquiry-based approach was followed in the Foundation Phase classroom. I also explored the experiences of the facilitators of learning (student teachers) in making the complexity of inquiry practice possible. As I attempted to gain insight into the experiences and reflections of people (both learners and facilitators of learning) who acted and interacted within the context of inquiry-based science, and the meaning they attached to their experiences (as expressed through verbal, visual and written means) I adopted an interpretivist paradigm.

In taking an interpretivist stance, I viewed the participants as social actors (Cristensen & Prout, 2002), and consequently as knowers and active agents with a voice, in other words, young citizens with rights that should be respected (Groundwater-Smith, Dockett & Bottrell, 2015; Fraser, Flewitt & Hammersley, 2014; O'Reilly, Ronzoni & Dogra, 2013; Smith, 2011). Furthermore, I worked with children and young adults in the real education context, and not under experimental conditions (Hatch & Coleman-King, 2014). Within this philosophy I attempted to interpret reality as constructed by the participants based on their experiences, and the meanings they attached to these experiences during inquiry-based practice in an early childhood education context.

1.9.2 Methodological paradigm: Qualitative approach

I followed a qualitative approach due to my view that the nature of reality is socially constructed and that research findings are created rather than discovered (Nieuwenhuis, 2007). My study met the characteristics and criteria of early childhood qualitative research as it involved a systematic empirical inquiry (involving both children and adults) into the implementability of IBSE in the education setting of Foundation Phase children (six- to nine-year-olds), in an attempt to understand the meanings participants attached to their experiences.

Since qualitative research can provide a framework for investigating the experiences of young children and adults who work with them in their educational settings, as well as the tools that may help uncover the meanings attached to their experiences, I viewed a qualitative approach as suitable (Hatch & Coleman-King, 2014; Saracho, 2014). Qualitative research enabled me to capture information about the perspectives and experiences of young learners as well as of the student teachers that facilitated IBSE with them in an early childhood school context.

1.10 BROAD OVERVIEW OF RESEARCH DESIGN AND METHODOLOGICAL STRATEGIES

The research design I selected set the direction for my study, and guided my decisions regarding data collection, processing and analysis. This enabled me to realise the purpose of the study, answer the research questions and produce ethically sound and trustworthy findings (Creswell, 2014; Hammersley, 2014; Patton, 2015).

1.10.1 Research design

Stake (1995) regards case study research not as a methodology, but as a choice of what is to be studied. Case study designs are often used as a strategy of inquiry in qualitative research to explore the activities and processes of real-world issues systematically in the context of their natural settings, so to generate new knowledge (Rule & John, 2011; Yin, 2012). My study is defined within the parameters of multiple case study research, as I selected three examples of implementing IBSE in the Foundation Phase classroom as cases. My study was driven by my curiosity to answer “how”-questions within an early childhood educational context (Hill & Millar, 2014). To this end case study research allowed me to obtain a holistic picture of how children as scientists, and student teachers as facilitators of learning, reflect on their experiences during participation in IBSE in the (natural) context of a Foundation Phase classroom (i.e. early childhood education context) (Yin, 2012; Hill & Millar, 2014).

As researcher in early childhood education, driven by a desire to create the conditions for and encourage children to exercise their voices, I was particularly interested in hearing the voices of the participants. As Nieuwenhuis (2007, p. 75) points out, case study research implies a multi-perspective analysis in which a researcher can hear the voice, perspectives and views of a variety of participants, including the voice of the "powerless and voiceless" (i.e. children). A case study design enabled me to listen to the voices of learners as scientists, but also to the voices of adults (student teachers) who worked with them in the context of an educational setting.

In my attempt to allow for breadth and depth of focus (Rule & John, 2011) and to strengthen the trustworthiness of the findings (Miles, Huberman & Saldaňa, 2014), I used multiple cases (different Foundation Phase classrooms) with multiple units of analysis (student teachers as facilitators as well as learners in each Foundation Phase grade) (Yin, 2012). I purposively selected three Foundation Phase classrooms as a possible replication and that best represented a heterogeneous sample of Foundation Phase inhabitants in exploring the experiences of two groups of participants (learners and student teachers), in order to offer an in-depth and trustworthy account of the cases (Rule & John, 2011). In this regard Miles et al. (2014, p. 33) state that the "precision, validity, stability and trustworthiness" of the findings will increase with replication.

1.10.2 Selection of case and participants

I studied a small sample of people, nested in their contexts (Miles et al., 2014). To this end I purposefully selected three Foundation Phase classes from different primary schools in Pretoria. I specifically aimed to cover the formal Foundation Phase, and therefore selected one Grade 1 (six- to seven-year-olds), one Grade 2 (seven- to eight-year-olds) and one Grade 3 (eight- to nine-year-olds) class. In addition, the student teachers placed in these classrooms for teaching practice participated.

Each case thus consisted of a student teacher (facilitating IBSE following LAMAP principles) and a class of Foundation Phase learners engaged in IBSE. Within each case I studied the implementation of IBSE as facilitated by the student teacher and engaged in by the learners in the classroom. I include more detail on the participants in Chapter 3.

1.10.3 Role of the participants

Research in early childhood education often aims to gain meaningful insights into the lived realities of children and the adults who work with or on behalf of them in an early childhood education setting (Hatch & Coleman-King, 2014; Saracho, 2014; File & Midthun, 2014). The adults (who worked with children in an education setting) involved in this study, were student teachers enrolled for the Postgraduate Certificate in Education.

In the context of this study student teachers acted as facilitators of learning, facilitating IBSE according to a specific approach (LAMAP) with Foundation Phase learners in the context of a real classroom situation. Apart from being participants, the student teachers took on the role of "associates" (File & Midthun, 2014, p. 592), working cooperatively with their lecturer as co-researchers who tried out a new approach in early childhood practice and then reflected on it.

The Foundation Phase child participants (six- to nine-year-olds) involved in this study participated as learners engaged in IBSE, but also as primary informants and experts in their experience of IBSE. As I regarded their voices on the implementability of IBSE in the Foundation Phase classrooms as important for my understanding of their experiences, I involved them as consultants, and employed elements of participation and reflection wherever possible (Lansdown, 2005).

1.10.4 Data collection and documentation

In order to gain insight into how the theory of IBSE can be applied to Foundation Phase classroom practice, I collected data on the experiences and reflections of both the learners and facilitators of learning, i.e. the student teachers – acting and interacting within the context of inquiry-based science, and the meaning they attached to their experiences as expressed through verbal, visual and written means. So as to understand the implementation of IBSE as perceived by the participants, I utilised multiple ways of data collection associated with interpretivism (Hatch & Coleman-King, 2014; Hill & Millar, 2014; Nieuwenhuis, 2007). I collected data by means of direct (interactive) observation, whole group reflection sessions, focus group discussions and document analysis (Patton, 2015; Hatch & Coleman-King, 2014; O'Reilly et al., 2013).

I utilised direct observation supported by digital video and camera recordings to capture evidence of the learners' participation in IBSE in the context of a real-world classroom. I acted as interactive observer to study specifically the actions and interactions of learners during their engagement in IBSE. I also collected documents completed by the learners from all the classrooms based on their participation in the IBSE activity (e.g. science journals, posters, drawings).

Following the classroom observations, I conducted whole class reflection sessions with the children from the three classrooms, guiding them to reflect on their experiences on certain aspects of the IBSE process. During these sessions, they could elaborate on specific events and clarify issues where needed (e.g. their behaviour, thoughts and feelings occurring as a result of my interpretation of their participation).

To allow the children the opportunity to elaborate on their experiences of their participation, I conducted focus group discussions with three selected small groups of children, one from each classroom. Apart from gaining deeper insight into their experiences, I utilised these sessions as member checking opportunities – giving learners the chance to confirm or elaborate on my interpretation of their experiences.

Regarding the three student teacher participants, I conducted document analyses and facilitated a reflection and focus group discussion. Document analysis enabled me to gain insight into the experiences of the participants, analysing their words and reports (Creswell, 2014). The students' teaching practice portfolios contained several documents, including lesson planning, lesson reflections, and other evidence of learners' participation in a variety of classroom activities which I included as data. In addition, the students completed innovative visual reflection documents that I collected as data. For the focus group discussion, I relied on the interaction among and contributions of the students to provide rich data, focusing on the content of their discussions.

Throughout the research process I kept field notes and a reflexive research journal. My journal contained factual information as well as decisions, interpretations and personal reflections (O'Reilly et al., 2013), experiences, thoughts and feelings about my work with the participants (both children and student teachers). I documented my new insights, intuitions, and broad ideas that emerged during my observations (Creswell, 2012; Maree & Van der Westhuizen, 2009).

1.10.5 Data analysis and interpretation

Data analysis involves the process of making sense of, interpreting, and theorising about data, in order to produce findings that can answer the research questions (Creswell, 2014; Schurink, Fouché & De Vos, 2011). For this study, I generated descriptions of learners' and student teachers' experiences on IBSE in three cases of Foundation Phase classrooms (Creswell, 2014). I based my interpretations on inductive thematic analysis, a strategy that is compatible with the interpretivist stance I adopted (O'Reilly et al., 2013). Thematic analysis is regarded as a flexible approach, and as such allowed me to transform the data into findings with the intention of answering the research questions (O'Reilly et al., 2013; Patton, 2015).

I followed a typological and interactive, yet step-by-step process commonly used in analysing and interpreting qualitative data (Creswell, 2014; Hatch & Coleman-King, 2014). As a qualitative researcher, I was personally and primarily responsible for analysing and interpreting the data I collected (Creswell, 2014; Schurink, et al., 2011). Since meaning is dependent on context, I analysed and interpreted meanings and contributions within the IBSE context (Stake, 1995).

Data analysis commenced during the classroom observation sessions and reflective interviews. During transcription of the interview data I followed a reflective approach to help me make sense of what each participant was trying to tell me. Similarly, my initial attempts to make sense of the documents and visual data, included notes intended to develop a sense of how the participants had experienced IBSE. This process enabled me to gain insight into, make sense of, and interpret the participants' lived experiences of IBSE (Merriam, 2009; Stake, 1995).

The initial phase of analysis was followed by a search for essential aspects of the participants' experiences of IBSE as revealed across the data, from which I categorised similar responses into nodes of meaning (Creswell, 2014; Hatch & Coleman-King, 2014). During this process, I identified and explored themes and concepts, before doing a final analysis and interpretation of the research area (Creswell, 2014; Robb, 2014). Interpretations were then linked to existing theory, with the aim of understanding the implementability of IBSE in South African Foundation Phase classrooms.

1.11 QUALITY CRITERIA

Case study researchers working in early childhood settings need to ensure rigour in their representation of children's views (Hill & Millar, 2014). Throughout the research process I strived to ensure rigour by attending to the criteria of credibility, transferability, dependability, confirmability and authenticity (Suter, 2012).

Credibility aims to demonstrate the truth value of a study by providing evidence of multiple representations of reality, and that the reconstructions of the data are in line with the ideas of the participants who provided the original data (Hatch & Coleman-King, 2014). I used triangulation in order to increase the trustworthiness of the study. To cross-check my interpretations, I relied on more than one source of information, and used multiple methods to collect data. In addition I employed investigator triangulation, and involved colleagues, critical friends and my supervisors to comment on my interpretation of the data. I furthermore used member checking and asked the student teacher participants to review my initial interpretations of their contributions as well as the reactions of the learners, and to comment on these (Hatch & Coleman-King, 2014; Hill & Millar, 2014; Rule & John, 2011; Stake, 1995).

For both transferability and dependability, I include detailed descriptions of the research context in this thesis, reporting on all decision processes, and articulating the theoretical underpinnings of the study. I leave it open to researchers conducting studies within similar perimeters, to decide whether, or not, the findings of this study are transferable to other settings, how these findings may fit into another broad body of theory, and whether, or not, the same findings would emerge if the study were to be repeated (Rule & John 2011; Schurink et al., 2011; Suter, 2012). To attain confirmable findings, I strove to present the data and my interpretations as truthfully as possible, and as closely as possible to the real world of the participants. Being a reflexive researcher, I remained mindful of how my role, personal background, culture and experience could potentially influence the direction of this study. To this end, I explicitly reveal my biases in my research report (Crewell, 2014; Fraser et al., 2014).

In striving for authenticity I entered the worlds of the participants and spent prolonged time in the research setting to develop an in-depth understanding of the cases and of the experiences of the participants. I presumed that their ideas, perspectives and feelings were rational and relevant according to their understanding, and I therefore accepted them as authentic. Furthermore, I attempted to portray the multiple realities of both groups of participants in a true-to-life way. Other strategies I used relate to triangulation, member checking, including verbatim accounts of participants' responses in my thesis (Chapters 4 and 5), and providing rich and thick descriptions (Creswell, 2014; Harcourt & Conroy, 2011; Wallerstedt, Pramling & Samuelsson, 2011).

1.12 ETHICAL CONSIDERATIONS

In involving children and the student teachers who worked with them in an educational context (i.e. research with human beings), I was guided by the core ethical principles of autonomy, non-maleficence, beneficence and justice (Alderson, 2014; O'Reilly et al., 2013). Respecting the participants' autonomy was a central guiding principle. In this regard, I adhered to the principles of informed consent, assent and dissent, and participants' right to withdrawal (O'Reilly et al., 2013). All participants, regardless of their age, were informed about the nature, aim and potential benefits of the study as well as their role in it – prior to its commencement (Cameron, 2014). Participants had the option to withdraw at any stage and I looked out for any verbal or non-verbal signs indicating possible dissent (Dockett, Einarsdóttir & Perry, 2012).

It was important to establish respectful, reciprocal and trusting relationships with the participants before commencing with data collection (Harcourt & Conroy, 2011; Smith, 2011). In the case of the learners I took time to explain, in a child-friendly way, what their involvement in the project would entail. In order to maintain trusting relationships, I engaged in regular discussions with them about their involvement and kept them informed about any amendments that occurred. Similarly, in terms of the student teacher participants, I employed accuracy, honesty, objectivity and sensitivity at all times by updating them on aspects related to the research project (Elias & Theron, 2012).

Furthermore, I treated participants equitably and justly in order to serve their best interest (O'Reilly et al., 2013). As this research involved my own students as well as young children, I took special precautions not to coerce them explicitly or implicitly into participation and respected their right to take part willingly and withdraw if they wished to do so (O'Reilly et al., 2013; Te One, 2011).

In applying the principle of non-maleficence, I avoided harm (physiological and physical), and safeguarded the participants' privacy (O'Reilly et al., 2013). I applied confidentiality and anonymity by removing all identifying features for dissemination and representation of the data (O'Reilly et al., 2013). For protection from harm I closely observed participants' behaviour and any potential signs of distress, and had contingency plans in place (immediate debriefing sessions and withdrawing them from participation) should any child or student teacher have experienced distress due to participation in the IBSE activity or the research project. No such incidents occurred.

1.13 ROLE OF THE RESEARCHER

Case study research assumes specific researcher roles that relate to the specific context (Hill & Millar, 2014), and which may influence the research findings. In this section I disclose some personal understandings that may have impacted the interpretations I made.

Taking a first-person active voice in the study inevitably represented an "I"-perspective, and constant awareness of my role as qualitative instrument in the study (Patton, 2015). In this regard, following from the case study research design I selected, I, as the researcher, was primarily responsible for the collection, analysis, as well as interpretation of the data. An important role was to make decisions about which data to include in the analysis and in the final written report. From the copious amounts of data collected I had to select the most significant examples that would present a trustworthy reflection of the cases.

Qualitative inquiry is interpretive in nature (Creswell, 2014), and accordingly, my onto-epistemological beliefs are grounded within the interpretivist paradigm. As such, my role involved the interpretation of reality as constructed by the participants, based on their experiences, and the meanings they attached to these experiences during inquiry-based practice in an early childhood education context. As lecturer in the PGCE (ECD/FP) teacher education programme, and trainer of the IBSE course, I am familiar with the environment that defined the context of this study. My background as lecturer in the field of early childhood education, and specifically as lecturer and trainer in LAMAP IBSE, thus supported my understanding of the context of my study, and helped me grasp the meaning communicated through various actions and perceptions in the responses of the participants. As interpretivist researcher I could in this way draw on my background knowledge, experience and my own capacity to make sense of the context, and guide my interpretation of the participants' construction of meaning in terms of their participation in IBSE.

While being an advantage, this also increased the risk of subjectivity. I relied on member checking, critical peer reviews as well as my supervisors to minimise this risk. Moreover, due to my dual role of researcher and lecturer/trainer in IBSE, I may have held personal bias about the success of the implementation of the IBSE approach in the Foundation Phase context. Even though I attempted to gain a true and in-depth understanding of the participants' meanings, and present a trustworthy reflection of their voices, I also acknowledge that my own experiences and humanness may have influenced my interpretation of participants' experiences.

Being both lecturer and researcher I remained aware of the possibility that the quality of the working relationship between the consenting participants and myself may potentially have altered the effectiveness of the data collection process (Creswell, 2014; Hill & Millar, 2014). Being the student teacher participants' lecturer, I was aware of the possibility that my decision to involve them as participants could create a hierarchical perception that could potentially influence the involvement of the participants in this research negatively, and consequently affect the data. Involving the students implied that I would engage with them in a sustained and intensive way (Creswell, 2014). I therefore had to manoeuvre the lecturer-student relationship carefully into a researcher-participant relationship in which I relied on the student teachers' collaboration and co-construction of knowledge as research partners. To this end I spent enough time on explaining their exact role in this study before commencing with the research.

By involving young children as participants, I had to engage in critical self-reflection on my personal assumptions about children that could determine what I would expect of them. Furthermore, adding children's voices assumed the responsibility to make these voices known to an audience beyond the research community in order to maximise the potential impact on policy and practice (Robb, 2014). Increased pressure on researchers who work in early childhood education to demonstrate the impact of their research therefore required of me to rethink the relationship between my research and my audience constantly. I consequently had to consider how I would involve the participants in both the creation of new knowledge and the dissemination of new insight.

As reflexive researcher, I continually reflected on my own role as research instrument in the study, in particular on how my personal background and possible biases may have influenced my interpretations (Creswell, 2014). Notwithstanding the fact that I take ownership for my voice in this study, I retain a belief in the importance of reliable and trustworthy knowledge, acquired through a systematic and sceptical empirical investigation (Fraser et al., 2014). For this reason, I employed Patton's (2015) mindfulness of reflexive triangulation as guideline to communicate the voices of the participants authentically through my voice to my audience.

1.14 ORGANISATION OF THE THESIS

Chapter 1 serves as orientation and background to the thesis. I clarify the phenomenon I decided to focus on, introduce the purpose and research questions, contextualise the key concepts underlying the study, and state the assumptions of my research. I introduce the conceptual framework where I integrate child-centred concepts with LAMAP IBSE. I briefly state my paradigmatic assumptions, introduce the methodological strategies I followed, and refer to the quality criteria and ethical principles I considered in order to ensure the quality of the findings I present in subsequent chapters. I also present the roles I assumed as researcher in undertaking this study.

As background to the empirical part of the study, I review relevant literature from the field of early childhood science education in **Chapter 2**. I start the chapter by summarising the main findings of existing literature on early childhood science education and science as a subject in primary school curricula. I focus on IBSE as option to teaching science at Foundation Phase level, specifically highlighting the LAMAP approach. I conclude the chapter by discussing the theoretical grounding of my research and explaining how I integrated existing theories and constructs in a conceptual framework.

In **Chapter 3** I explain the empirical part of the study. I describe and justify my choice of an interpretative qualitative multiple-case study research design in the early childhood research context; I stipulate the selected methods for data collection, documentation, analysis and the way I interpreted the results, and conclude by summarising the methodological considerations for the research, including the quality criteria and ethical principles I strived to adhere to.

In **Chapters 4** and **5** I present and report on the results of the study. Chapter 4 focuses on the experiences of the student teacher participants and Chapter 5 on those of the child participants. I include the voices of the participants in the form of verbatim transcriptions, supporting these with visual data and excerpts from my field notes and research journal.

In **Chapter 6** I discuss correlations and differences between the results I obtained and existing literature as presented in Chapter 2. I relate the results I obtained to the theories and conceptual framework underlying this study in order to reach conclusions concerning the research problem. In addition to highlighting the areas where my findings correspond to or contradict existing literature, I identify silences in the data, and foreground new insights gained from this study.

In **Chapter 7** I provide the framework I developed, indicating implementation guidelines derived from the participants on three different levels. Firstly, the voices of children as scientists, their experiences and abilities to engage in IBSE, and the support they require in order to engage in IBSE are included. Secondly, the voices of student teachers as facilitators of IBSE provide specific guidelines to assist facilitators when implementing IBSE in a classroom context, also in terms of the support required when implementing IBSE. Finally, the framework presents guidelines that could be implemented in higher education institution training and teacher education programmes in support of IBSE. Chapter 7 furthermore presents my final conclusions, reflections on areas of strengths and challenges I experienced during the research process, and recommendations for Foundation Phase science education and classroom practice, policy, teacher training and further research.

1.15 SUMMARY

In this chapter I introduced the reader to IBSE as reform-oriented approach to science education. In spite of being strongly advocated as effective approach to science education reform, IBSE still seems highly under-utilised in school practice (Flores, 2015), regardless of its potential to awaken the potential of young scientists-in-waiting to become scientifically literate citizens in the society of today (Gelman & Brenneman, 2012). Against this background I provided the rationale for focusing on IBSE as approach to science education for young South African children. I introduced the purpose and research questions, my conceptual framework, selected paradigms, and the methodological strategies I implemented.

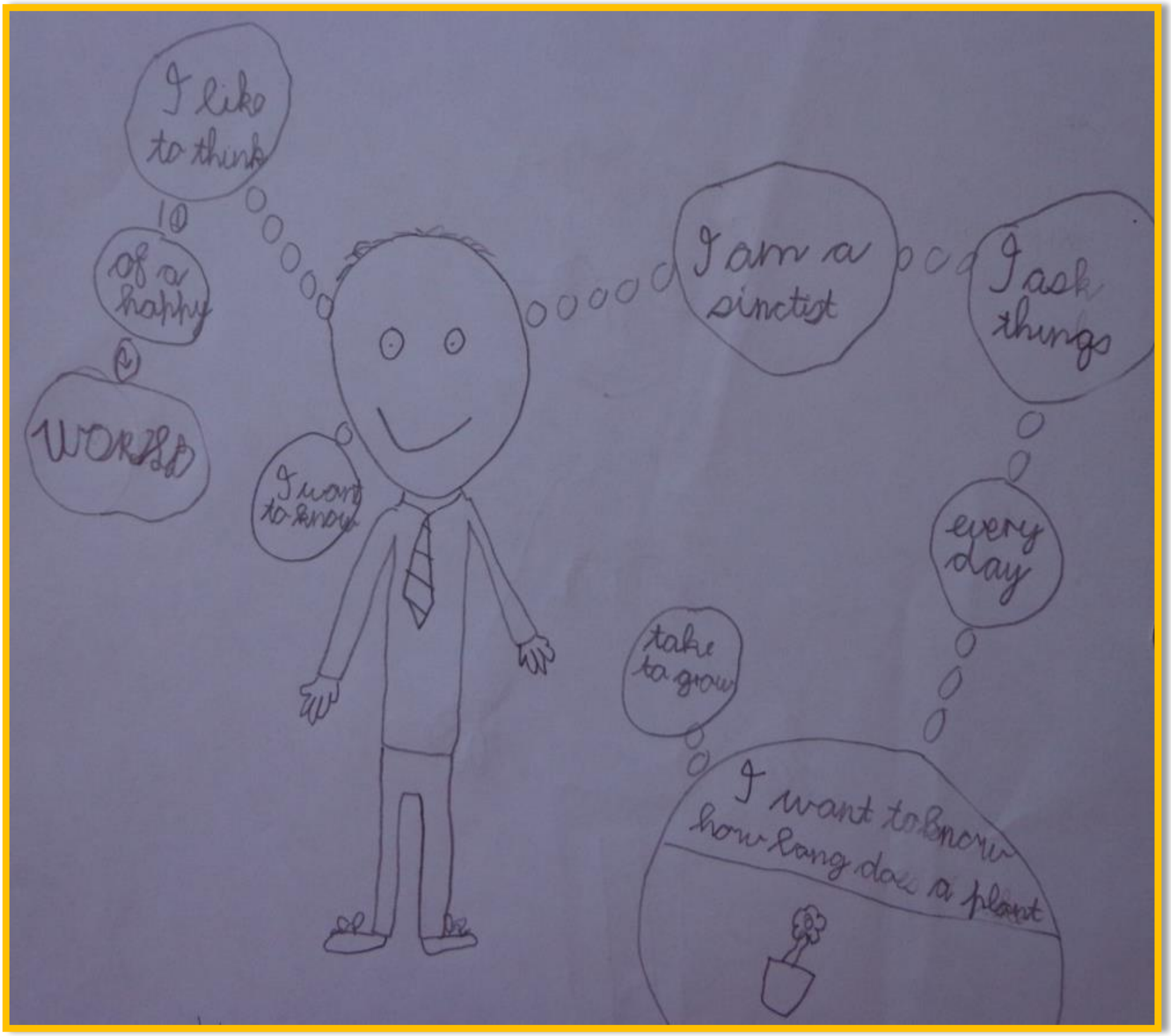
In the next chapter I present contemporary debates on inquiry-based science education, focusing on young children as capable scientists. I introduce the LAMAP IBSE approach and its supporting framework, and discuss teachers' roles in mobilising children's inherent scientific potential by means of IBSE. I also explain my conceptual framework and the guiding theories in support of LAMAP IBSE in more detail.

Chapter 2

LITERATURE REVIEW

AND CONCEPTUAL FRAMEWORK

OF THE STUDY



(Drawing by a Grade 3 child, School C, Pretoria, 2015)

2.1 INTRODUCTION

The previous chapter introduced the focus, background and rationale, and the methodological choices of this study. In this chapter I discuss current scholarship in the field of inquiry-based science education in order to formulate the study's conceptual framework. I first provide a general survey of current thinking on early childhood science education, focusing on reasons why quality science education is important at early childhood level, young children's potential to engage in science, and general tendencies on the inclusion of science as a subject in primary school curricula. Next, I contemplate IBSE as a pedagogical strategy, more specifically focusing on the LAMAP approach when teaching science. I also highlight the theories embedded in existing literature that guided my understanding of IBSE. Throughout I describe guidelines and characteristics that may predict effective implementation of IBSE. I conclude the chapter by explaining the conceptual framework of the study.

2.2 EARLY CHILDHOOD SCIENCE EDUCATION

The current body of knowledge on young children's scientific interests and abilities confirms the belief that children are natural scientists (Duschl et al., 2007; Eshach, 2011; Gelman & Brenneman, 2012; Kovalik & Olsen, 2010; Metz, 2011; NSTA, 2014; Trundle, 2015). This view sets the tone for the first part of this chapter, endorsing the responsibility of early childhood educators and researchers to "sustain and capitalize on the innate curiosity children entrust to us" (Trundle, 2015, p. 6). As I investigated the implementability of a child-centred approach to science education, I start this section with a focus on Foundation Phase learners' potential for being and becoming scientists; I discuss contemporary perspectives on children-as-scientists and briefly describe children's typical trajectory in science (contemplating the constructs of development and learning). Based on children's biologically determined predispositions and traits, I argue that quality science experiences (e.g. IBSE) may capitalise on children's natural potential, and foster their growth from being a child to becoming a scientist. Next I discuss literature on early childhood science education. I link the literature I discuss in this section at the end of the chapter when I present the conceptual framework and explain the concepts I used to frame the study.

2.2.1 Young learners' potential for being and becoming scientists

Kirch and Amoroso (2016, p.1) characterise children as "adventurous explorers, curious investigators, astute observers, inference-making 'machines', imaginative arguers, relentless knowledge seekers, creative interpreters, and meticulous note keepers". According to both Metz (2011) and Trundle (2015), such features are typically attributed to children to present them as natural scientists. Gelman and Brenneman similarly portray children as "young scientists-in-waiting" (2012, p. 155), suggesting their potential to become real scientists with proper encouragement.

Contemporary views of children as beings (who they are now) rather than becomings[14] (who they would be in the future) challenge adults to reconstruct any notions of children as immature and underdeveloped beings in becoming, lacking basic capacities for understanding. The quest is for adults to focus on images portraying children as competent, agentic beings, and active participants in their own knowledge creation (Montgomery, n.d.; Morrow, 2011; Smith, 2011). In the context of science, while children may be differently abled than adults, and less experienced due to age, maturity and opportunity, it is well accepted that their thinking is complex, sophisticated and creative (Hedges, 2014). Children – from birth onwards – are believed to form theories about the world around them continually, and then use these self-constructed theories to make sense of the new events and phenomena they encounter (Harlen, 2012). Consequently, by the time children enter the Foundation Phase, it is safe to assume that they are already competent learners (Fisher, 2013), equipped with a wealth of knowledge about the world (Harlen, 2012). In this regard, Fisher (2013) regards learners' *competence* as, on the one hand, the result of their natural predisposition to learn, and, on the other hand, the environment supporting their learning.

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[14]For the purpose of this study, "being" and "becoming" is conceptualised within the context of childhood studies currently challenging constructions of children and childhood, and is not based on the ideas of philosophers such as Deleuze and Agamben.

Closely related, Trundle (2015) views children's natural disposition towards exploration as an important force during child development. Similarly, Jirout and Zimmerman (2015) argue that children's science development revolves around their natural curiosity – a now widely held and unchallenged belief. As such, these authors argue that children's curiosity will create an uncertainty in their minds, which they will then desire to resolve by, for example, employing scientific skills such as questioning and active exploration (Jirout & Zimmerman, 2015). In this way science learning is encouraged.

To expand on the constructs of learning and development in terms of science, Hedegaard and Fleer (2013) draw an important correlation between the two constructs, and conceptualise *learning* as a change in children's relation to other people and activities in specific contexts, based on their acquisition of science concepts. As Fleer and Pramling (2014) explain, when young children acquire new science concepts and gain scientific understanding, they will be able to think and act differently in their worlds, based on newly acquired insight. Consequently, although the environment may not change, children's actions and thoughts in a specific environment can change, enabling them to interpret their worlds in new ways. Such learning can in turn create new possibilities and stimulate follow-up learning.

Development is conceptualised by Hedegaard and Fleer (2013) as a process whereby children's motivational orientation and engagement in different contexts change qualitatively – a process learning will contribute to. Fleer and Pramling (2014) explain that over time, and through conscious teaching and learning new science concepts, a qualitative change will become observable in children's development. Hence, as children learn, develop, mature and gain experience, they will progress from a play motive towards a learning orientation, and the desire to engage in more serious study of how their worlds work. I support Hedegaard and Fleer's (2013) explanations, as I view both learning and child development as processes of change (or transformation) resulting from first-hand experiences. In consequence, I regard children's learning and development in science as a trajectory that starts at birth, is driven by the natural curiosity of children and the drive to resolve uncertainty through inquiry, subsequently resulting in change (transformation).

Hedges (2014) argues for accepting the notion of so-called “working theories” as a way to describe children’s thinking, inquiry and knowledge building practices (i.e. learning). Based on the work of several theorists, Hedges (2014) conceptualises working theories as “evidence of inquiry acts, ways children process intuitive, everyday spontaneous knowledge and use this creatively to interpret new information, and think, reason, and problem-solve in wider contexts” (2014, p.40). As such, working theories are formed based on children’s prior knowledge, and are utilised to make sense of new experiences and test connections between ideas during ongoing inquiry. Being “working theories”, these theories are tentative, speculative, and open to revision as children encounter new information and experiences. As a result, children’s theories continuously grow and change (are modified and improved) by means of their own imaginative, inventive and resourceful ideas. Thus, learning accrues through a continuous process of editing, improving and creatively modifying theories, in order for existing theories to become more useful, effective, comprehensive and appropriate for making meaning of the phenomena children encounter (Hedges, 2014; Gopnik et al., 1999).

It seems clear that the process of theory revision may guide children’s development trajectory in science. Evidently, both the teacher and relevant science programme seem instrumental in creating experiences and environments suitable for promoting science learning and development. It is well accepted (Takohoma-Espinosa, 2011) that a good learning environment is one of the most important determinants of high quality teaching-learning exchanges. It follows that the way in which science is taught should be guided by the way in which children learn, and that learning environments should be structured accordingly to support effective learning (Dumont & Istance, 2010). Learning, or the capacity to change, is typically associated with the generation of neurons and changes in connectivity between neurons. The connections made in the brain may be shaped by what children see and do in a particular context. As such, classroom practices should capitalise on children’s biologically-determined traits, and build on what is known about how they learn (Fisher, 2013; Goswami, 2008).

In Kirch and Amoroso's (2016) view, the qualities that children possess and evidently bring to school, may be best developed by means of a science education programme that regards children as capable of understanding the world, but also as able to transform the world as well as themselves during the process of learning. My study, investigating the implementability of IBSE (i.e. a child-centred active learning approach to science education) for Foundation Phase learners, is based on my assumption that young South African children are natural scientists able to engage in scientific investigation. I view children as curious beings and active agents that construct working theories in the context of the natural and social world (Hedges, 2014). As children learn, develop and gain experience, their working theories are revised to become more useful for solving problems and making sense of the world (Gopnik, et al., 1999). To this end, I argue that IBSE (refer to Section 2.4 for a detailed discussion of IBSE) may offer learners the necessary opportunities to form, modify and refine their working theories (i.e. expand their capabilities), and through the interconnected process of being, knowing, and transforming, be and become scientists (Kirch & Amoroso, 2016).

I furthermore argue that IBSE does not only have knowledge acquisition for the sake of knowing as aim, but can also contribute to shaping identities (Stetsenko, 2012). I believe that quality inquiry experiences may contribute to children's science learning and development (thus, knowledge), but also continually shape stronger identities of being, and strengthen their potential for becoming scientists. In this regard, I conceptualise *being* as children's views of themselves as scientists (I am), and *becoming* as children's potential for becoming scientists (I can be) by doing science (becoming through doing), and consequently raising awareness that anyone can be and become a scientist (Kirch & Amoroso, 2016). Thus, "young scientists-in-waiting" (Gelman & Brenneman 2012, p. 155) represent children's inherent potential to grow from child to scientist – by getting an opportunity that needs to be unlocked.

2.2.2 Science education at early childhood level

The early childhood phase thus represents a phase during which children possess natural abilities to think and reason scientifically. My study, focusing on a specific science education approach in the Foundation Phase (i.e. early childhood), consequently resulted in my exploration of literature related to young learners' potential as natural scientists, and the importance of introducing IBSE during early years of education.

2.2.2.1 Young (natural) scientists-in-waiting

The view of young children as "natural scientists" is supported by existing literature describing children as being naturally curious, as actively inquiring natural scientists, or as biologically prepared to learn about the world around them (Duschl et al., 2007; Gopnik, 2016; Gopnik, 2010; Kovalik & Olsen, 2010; Martin, 2012; Metz, 2011; Trundle, 2015). Science is also often described as inherent to or a significant part of being human (Kovalik & Olsen, 2010). Expanding on this notion, Gopnik, et al., (1999) describe the keen curiosity with which both young children and real scientists approach their surrounding world, claiming that children, like scientists, are the "best learners in the universe" (Gopnik et al., 1999, p. viii). Moreover, Gopnik and Meltzoff (1997) propagate the following view: "It is not that children are little scientists but that scientists are big children. Scientific progress is possible because scientists employ cognitive processes that are first seen in very young children" (Gopnik & Meltzoff 1997, p. 32). In my view this statement confirms the notion that typical cognitive development in (all) young children encompasses scientific development, hence that children are naturally "little scientists". In line with this argument, Gelman and Brenneman (2012, p. 160) acknowledge young children's natural habits of mind as they explore the world, and refer to them as "scientists-in-waiting".

Supporting such a view, Patrick and Mantzicopulos (2015) as well as Trundle (2015) regard young children as intrinsically motivated to learn science, and driven by their natural curiosity and interest in life and physical science, earth and space science, and technology to explore their surrounding world across the domains of science. From Trundle's (2015) observations, children are highly motivated to explore and understand the natural world, and enjoy observing, exploring, discovering and thinking about their worlds. To this end, children naturally and continuously ask "Why?", "What?", "Where?" and "When?" questions to find answers about their world. Trundle (2015) explains children's boldness in experimenting, implying that they do not fear failure or experience distress when they realise that their initial ideas did not go as planned, but that they merely continue experimenting by revisiting their thinking and renewing their approach.

As existing literature on children as young scientists primarily reflects descriptions of children's traits and actions from adult researchers' views, research on children's views and perceptions of themselves as scientists is limited and requires ongoing investigation. Therefore, my study, with its focus on children's voices and based on their actual engagement in IBSE, may add to the emerging knowledge base on South African children's conceptualisations of themselves as being natural scientists.

2.2.2.2 The importance of science education at early childhood level

Twenty-first century children face an array of scientific discoveries and technologies, with some unanticipated associated consequences (Bell & St. Clair, 2015). Consequently, to thrive in today's world, scientific and technological literacy seems to be an important prerequisite for the development of 21st century skills (Bell & St. Clair, 2015; NGSS, 2013; Osborne, 2010). The specific competencies that children require are summarised by Boaventura and Faria (2015) as the abilities to think critically and solve problems; communicate effectively by synthesising and transmitting ideas in verbal and written formats; collaborate and work effectively with others; and be creative and innovative. In this regard the importance of science education in developing scientific literacy as well as the importance of modern day competency development is now widely accepted (refer, for example, to the Australian National Curriculum Board, 2009; Boaventura & Faria, 2015; Flores, 2015; Ireland et al., 2012; Minner et al., 2010; NGSS, 2013; Seraphin et al., 2012).

Science education at school level has the potential to expand learners' concept acquisition, improve their use of process skills, develop positive dispositions towards science, build knowledge of the nature of science, and create meaningful connections between science, technology, society and the environment (Harlen, 2013a). Moreover, through science education, learners can acquire skills related to inquiry for critical thinking, problem solving and decision making (Boaventura & Faria, 2015). Due to the dire socio-economic conditions and current education system and related challenges, particularly in terms of learner achievement in science (nationally and internationally) (Evans, 2013; Reddy, 2013; Spaull, 2013; World Economic Forum, 2013), the need for scientific literacy in South Africa seems more urgent than ever before. In this regard IBSE aims to produce scientifically literate learners (Seraphin et al., 2012), and is promoted as one of the most valuable means of developing the priority areas of modern society (Australian National Curriculum Board, 2009).

Ongoing research emphasises the importance of a greater focus on *doing* rather than *knowing* in order to prepare children to thrive in a rapidly-changing world (Sandoval, Sodian, Koerber & Wong, 2014). Rapid advancements in science and technology eliminate a focus on knowledge acquisition and memorisation, and emphasise two components of scientific literacy, namely what science is and what scientists do. As such, inquiry – with its focus on learning science by doing science – is increasingly adopted as fundamental approach to science education (Abd-El-Khalick, BouJaoude, Duschl, Lederman, Mamlok-Naaman & Hofstein, 2004; Haug & Ødegaard 2014; Minner et al., 2010; NRC, 2000; Rocard, 2007; Smolleck & Nordgren, 2014).

Another important rationale for early childhood science education is nested in the potential of establishing solid foundations. The potential value and importance of nurturing young learners' emerging scientific abilities are supported by a growing body of knowledge that points to the positive effects of early science on a child's later academic achievement (Kermani & Aldemir, 2015; Saçkes, Trundle, Bell, & O'Connell, 2011; Spaull, 2013). In this regard Saçkes (2014) summarises the findings of a number of scholars, suggesting that science concepts and thinking skills develop sequentially, that early exposure to developmentally appropriate science experiences will lay the foundation for more advanced concepts and inquiry skill formation in later years, and that quality early experiences can foster positive attitudes towards science, which in turn may lead to better outcomes and positively influence suitable career choices. Similarly, Brooks (2011) posits that by engaging children in scientific investigation while young, a viable foundation may be provided for physically developing the brain, and enhancing mindful reasoning and positive attitudes toward science.

Gelman and Brenneman's (2012) description of children as scientists-*in-waiting* however implies that children are dependent on adults who intentionally prepare the learning environment and actively engage them in rich science experiences (Kermani & Aldemir, 2015; Trundle, 2015). Furthermore, as science is built successively (concepts progressively build on concepts, skills progressively build on skills), young learners require opportunities for sustained engagement with science over a period of time, in order to effectively develop their science knowledge and skills (NSTA, 2014). It follows that developmentally appropriate science education holds the potential to support young learners' sensory explorations of the natural world, to equip them with foundational knowledge and skills for lifelong science learning, and instil a love and appreciation of nature (Trundle, 2015). Consequently, the inclusion of science education in all early childhood curricula and classrooms may prove to be beneficial (Trundle, 2015), also in the South African context.

In terms of investment and intervention, the early childhood years (up to Grade 3) are known to be a fundamental period of life in which high-quality early learning experiences may have far-reaching consequences and lifelong implications (Adair, 2014; Bredekamp, 2011; National Scientific Council on the Developing Child, 2007; Sripada, 2012; Willis, 2010). As young scientists, children in the early childhood and Foundation Phase are particularly susceptible to learning about the world around them (Kermani & Aldemir, 2015; NRC, 2012; NSTA, 2014), possibly due to the plasticity of the brain during the early years of development (Mustard, 2010; National Scientific Council on the Developing Child, 2007). In line with this biological argument, investment in quality science education or reform efforts, specifically in the South African context, may best target the early years of schooling. In this regard Heckman's (2006) research on the effect of investment in early learning – specifically aimed at children from disadvantaged backgrounds – indicates that programmes offered to young children may lead to better outcomes in education, health, sociability, economic productivity and reduced crime. Referring to Heckman's (2000, 2006) research, Spaull (2013) (specifically mentioning mathematics and science) acknowledges the need to focus on the early schooling years to address widespread underperformance and learning difficulties at primary school level, due to the acknowledged belief that intervention should target children while they are most susceptible to educational investment. As a result, quality science education during the early childhood and Foundation Phase (formative years) seems critical.

Despite some international examples of science reform initiatives and science education at an early age (such as USA Next Generation Science Standards[15]; the European Creative Little Scientists[16], Australian Primary Connections[17]), such initiatives are not apparent at national level in South Africa. This study may therefore contribute to the body of knowledge on the implementation of IBSE in the South African context at the Foundation Phase level. More specifically, insight stemming from my study may broaden existing knowledge of the practicality of implementing IBSE with young learners, and lead to recommendations on how such an approach may be implemented in the South African Foundation Phase context.

2.3 SCIENCE IN PRIMARY SCHOOL CURRICULA

In this section I discuss general tendencies in terms of science education in early grade curricula. After attending to international trends, I contemplate the place of science education in the South African Foundation Phase curriculum (CAPS).

2.3.1 Tendencies with regard to science as a subject in early grade curricula

Increasing demands for children to improve their tendency to inquiry and develop 21st century skills, require increased real-life applications in school curricula, and appealing learning environments that meaningfully relate to children's social realities. In order to develop scientific reasoning abilities and shape motivational attitudes, it is important for school children to become part of a community of inquirers, and to experience themselves as capable of learning science (Boaventura & Faria, 2015). It follows that learners require frequent high-quality, appropriate, contextualised and

[15]Multi-state effort to create standards for internationally benchmarked science education. Developed in collaboration with the National Research Council (NRC), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and Achieve. NGSS are based on the NRC's *A Framework for K-12 Science Education.*
[16]An intervention project focusing on the intersection between creativity and science and mathematics education for young children. The project includes nine European countries (Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania and the UK).
[17]An innovative national curriculum and professional learning initiative of the Australian Academy of Science.

coherent science experiences to build their knowledge, competence in the process of inquiry, and motivation to engage in science progressively (NRC, 2015; NSTA, 2014; Patrick & Mantzicopoulus, 2015). In my view early childhood science should be prominent in school curricula, and be designed to capitalise on and mobilise the potential of young scientists-in-waiting to be scientifically literate citizens in a rapidly changing world. To achieve this requires curricula that portray science as visible, meaningful and important, and focus on building frames of reference for science as a subject.

However, science education in the formative grades (e.g. the Foundation Phase) where young learners' attitudes and orientations are formed, seems to be problematic (Slavin, Lake, Hanley & Thurston, 2014; Tenaw, 2014). Despite evidence on the importance of inquiry science as component of the early primary school curriculum (NSTA, 2014), science has for many years been virtually absent from early grade curricula (Patrick & Mantzicopoulus, 2015; Trundle, 2015), not only in South Africa, but worldwide. Several reasons can be linked to this trend. Marginalisation of science education may be ascribed to a focus on mathematics and language subjects as priority areas for teaching and national assessment; the belief that young learners are not developmentally ready to conceptualise complex science; or the view that it is less important for learners to learn science during the early years than during later primary years (Krogh & Morehouse, 2014; Patrick & Mantzicopoulus, 2015; Slavin et al., 2014; Smolleck & Nordgren, 2014).

Science may furthermore become lost in curriculum integration (Krogh & Morehouse, 2014). Curriculum integration is often regarded as a powerful means to provide connected, meaningful learning opportunities for young school children, focusing on real-life inquiry-based activities that integrate different literacies (e.g. science, digital, information) (Boaventura & Faria, 2015; Ødegaard, Haug, Mork & Sørvik, 2014). Although I support curriculum integration as preferred approach to implementing IBSE, I also agree with Krogh and Morehouse (2014), who state that the significance and integrity of individual subjects may be lost as a result of such integration. The low integrity of science as a discipline in many curricula is furthermore pointed out by Patrick and Mantzicopoulus (2015), who are of the view that science not appearing as a separate subject in the curriculum may result in learners not constructing coherent notions about science as a discipline with its associated key concepts, content, processes and dispositions.

Following a thematic approach to curriculum integration may result in low-level science learning (Krogh & Morehouse, 2014). Accordingly, science lessons may be planned around themes or topics that a teacher finds attractive, and this may lead to superficial coverage of science subject matter. Additionally, teacher practices may focus on requiring learners to recall science facts, seldom involving them in the language and process of science, and not encouraging a deep understanding, elaboration or model articulation, in turn resulting in learners having limited opportunities to engage in meaningful science (Krogh & Morehouse, 2014; Patrick & Mantzicopoulus, 2015).

Even in countries where science visibly forms part of the curriculum, evidence exists that quality science opportunities are often infrequent, fragmented and decontextualised, focusing on learning isolated skills, e.g. categorising or classifying objects. As Patrick and Mantzicopoulus (2015) report, such infrequent encounters, that are not integrated into a cohesive curriculum framework, are unlikely to develop learners' understanding of the nature of science, or contribute towards developing foundational knowledge, science behaviours as well as positive motivational attitudes. As a result, learners may develop a superficial understanding of science as a discipline, and have little understanding of what science is, what science does, and its relevance to everyday life (Krogh & Morehouse, 2014; Patrick & Mantzicopoulus, 2015). Learners may consequently equate science to out-of-school experiences, more specifically as portrayed in the media, for example involving "unusual" people, "magic", the mixing of potions or the creation of devious inventions (Naudé, 2016; Patrick & Mantzicopoulus, 2015).

2.3.2 Science in the current South African Foundation Phase curriculum

Commenting on the quality of science education generally offered to young learners, Trundle (2015, p. 2) claims that, "The bad news is that, in general, we are not teaching science well or effectively for young children" (Trundle, Bell & O'Donnell, 2011). This appears true for South Africa as well, and is aligned with ongoing research indicating that little evidence of quality science education can be found in South African Foundation Phase classrooms (Beni, Stears & James 2017; Bosman 2006; Naudé 2016).

In the revised and restructured Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011b) for the Foundation Phase, the entire curriculum consists of the following four subjects: Home Language, First Additional Language, Mathematics and Life Skills. The subject Life Skills consists of Beginning Knowledge; Creative Arts; Physical Education, and Personal and Social Well-being (DBE, 2011b). Although science thus appears to be absent from the Foundation Phase curriculum, Natural Science and Technology forms a small part of the Life Skills subject, contained in Beginning Knowledge. The content and concepts of Beginning Knowledge have been drawn from Social Sciences (History and Geography) as well as Natural Sciences and Technology. Figure 2.1 outlines the current curriculum for Foundation Phase South African CAPS.

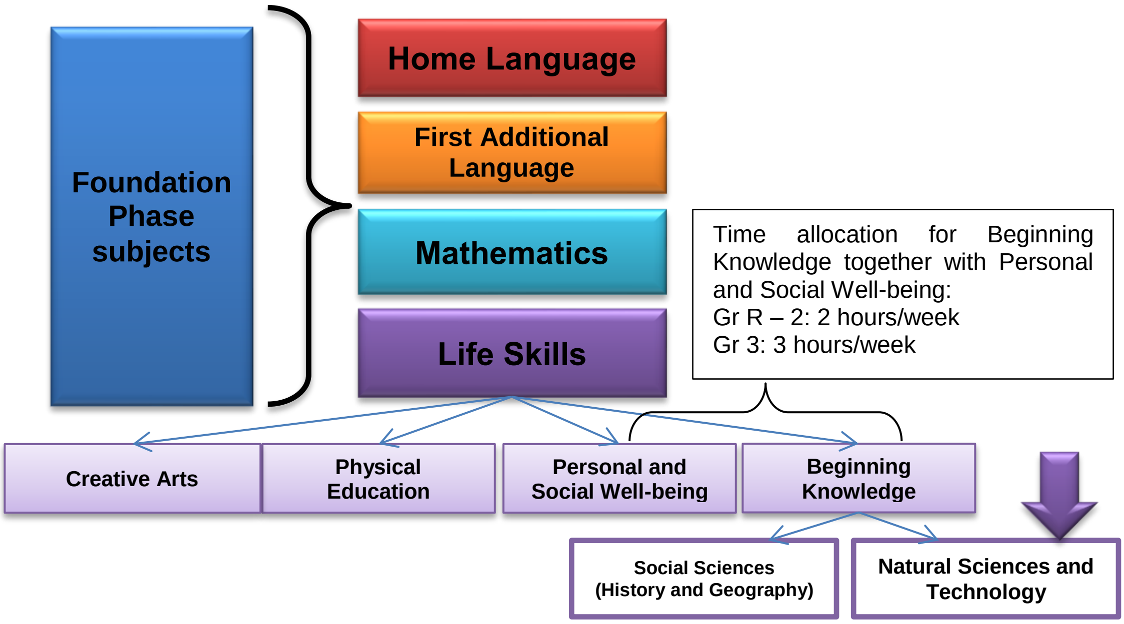


Figure 2.1: CAPS subjects for the Foundation Phase

The subject Life Skills aims at guiding and preparing Foundation Phase learners for "life and its possibilities", and for "meaningful and successful living in a rapidly changing and transforming society" (DBE, 2011b, p. 8). The subject specifically aims at building learners' competency in a number of areas, including social relationships, technological processes and elementary science (i.e. the specific outcome relating to Beginning Knowledge: Natural Science and Technology).

With regard to science, key concepts and skills for the Foundation Phase are detailed in CAPS as life and living; energy and change; matter and materials, and planet earth and beyond. These are generally known as content areas, domains or strands of science. Science process skills are presented as the process of inquiry that involves observing, comparing, classifying, measuring, experimenting, and communicating (DBE, 2011b). Apart from suggesting a number of themes per grade per term, no further details are stipulated in CAPS. Neither crosscutting concepts, science outcomes or successive sequencing of content, nor approaches to teaching science are provided. It is merely mentioned that sequencing and progression have been built into the design of the themes (topics) as stipulated in CAPS for each grade. A thematic approach is typically followed to ensure curriculum integration. In terms of the teaching time allocated for science, CAPS suggests two hours per week for Grades R to 2, and three hours per week for Grade 3 for Beginning Knowledge (to be taught simultaneously with Personal and Social Well-being) (DBE, 2011b). Considering the place and time of Natural Science in CAPS, it therefore merely forms a component of Life Skills[18].

However, when learners in South Africa enter the Intermediate Phase (Grades 4 to 7), they are exposed to a demanding science curriculum in which minimum competence requirements are drawn from the following four strands: life and living; energy and change; matter and materials, and planet earth and beyond (DBE, 2011c). As such, it is important to lay the required foundation (concepts, basic knowledge, inquiry skills and dispositions) for science during the formative Foundation Phase.

[18]The South African Curriculum and Assessment Policy Statement (CAPS) for Life Skills is available from the DBE website: http://www.education.gov.za/Portals/0/CD/National%20Curriculum%20Statements%20and%20Vocational/CAPS%20Life%20Skills%20%20English%20_%20Gr%20R-3%20FS.pdf?ver=2015-01-27-162204-953.

2.3.3 Roles of the Foundation Phase science teacher

The science teacher is both a curriculum implementer and a reform agent (Avraamidou, 2014; Boaventura & Faria, 2015; Tenaw, 2014). High demands are placed on primary school (Foundation Phase) teachers, as they are required to teach a range of subjects to a diverse group of learners (Nowicki, Sullivan-Watts, Shim, Young & Pockalny, 2013). Apart from the competencies required to teach all subjects appropriately, teachers require sound pedagogical knowledge to teach science, as well as thorough content knowledge of life, physical, earth and space sciences (Nowicki et al., 2013; Shulman, 1987; Schneider & Stern 2010).

I am aware that Foundation Phase teachers are typically not favourably inclined toward science and science teaching (Riegle-Crumb, Morton, Moore, Chimonidou, Labrake & Kopp, 2015). As a result, constraints associated with primary school science teaching are well-documented. These include teachers' lack of science background and limited subject matter knowledge; passing their own misconceptions on to children in their classrooms; limited pedagogical science content knowledge, as well as low confidence and self-efficacy-beliefs (Appleton, 2007; Bosman, 2006; Chowdhary, Liu, Yerrick, Smith, & Grant, 2014; Haug & Ødegaard, 2014; Lewis, Dema & Harshbarger, 2014; Nowicki et al., 2013; Tenaw, 2014). Limited background in science on the teacher's side may result in a negative attitude towards science as a subject, which may lead to feelings of inefficacy and anxiety, and result in less effective teaching (Riegle-Crumb et al., 2015; Smolleck & Nordgren, 2014; Tenaw, 2014).

Teachers' negative attitudes may furthermore impact their pedagogical practices and capacity to engage learners in meaningful, active hands-on, minds-on and inquiry-based activities (Riegle-Crumb et al., 2015; Smolleck & Nordgren, 2014). In this regard researchers argue that low self-efficacy beliefs may result in teachers following inappropriate pedagogies and a preference for more teacher-controlled, didactic or text-oriented teaching, focused on isolated facts for rote memorisation (Krämer, Nessler & Schlüter, 2015; Tenaw, 2014; Trundle, 2015). Teachers may also perceive science as a low-priority subject (Patrick & Mantzicopoulus, 2015), so avoiding to teach the subject. Consequently, teachers may, for example, use the time allocated for science to catch up on language or mathematics when pressured for time. Perceiving science as a low-priority subject may furthermore result in reduced effort to teach science innovatively, or to engage learners actively (Nowicki et al., 2013; Riegle-Crumb et al., 2015).

As learners often mimic teachers as their role models and authorities, they may internalise unfavourable attitudes and behaviours displayed towards science by their teachers. As a result, learners may experience science anxiety, resulting in low-efficacy beliefs in themselves that may lead to a decline in their attitudes – with potential negative consequences for their science achievement potential (Riegle-Crumb et al., 2015). However, inquiry-based learning has gained field as a positive approach to learning, encouraging engagement and understanding of what is discovered (Pedaste, Mäeots, Siiman, de Jong, van Riesen, Kamp, Manoli, Zacharia & Tsourlidaki, 2015). In the next section I discuss IBSE as one example of inquiry-based learning.

2.4 INQUIRY-BASED SCIENCE EDUCATION (IBSE) AS OPTION FOR THE FOUNDATION PHASE

As the notion of inquiry as well as existing theories underlying inquiry as approach to science education are central to my understanding of its implementability in an early childhood context, I commence this section by conceptualising IBSE in terms of its origins, essential features, and potential benefits for young learners. Next, I discuss the LAMAP programme in terms of its framework and strengths as inquiry approach. I then focus on teachers' roles in structuring a learning environment to engage children in IBSE, and dealing with associated challenges.

2.4.1 Conceptualising IBSE

Inquiry learning refers to a cluster of learning and teaching approaches where learners' inquiry or research drives the learning experience (Levy et al., 2011). Inquiry learning is not restricted to science education, yet in the context of science, it entails an educational strategy where children follow methods and practices similar to those of professional scientists in constructing knowledge (Furtak, Shavelson, Shemwell & Figueroa, 2012; Levy et al., 2011; Pedaste et al., 2015).

IBSE has a long history in education, its roots to be traced to the ideas of educators such as Rousseau (1712-1778), Pestalozzi (1746-1827), Froebel (1782-1852), Lane (1875-1925), Dewey (1859-1952), and Montessori (1870-1952), who all acknowledged the importance of children taking an active role in their learning (Harlen, 2013b; Inan & Inan, 2015). Although the philosophies of these educators were not specifically related to science, their ideas (active learning philosophy) support the role of children's curiosity, imagination, creativity and the need to interact and inquire during the education process, and to construct their own knowledge (Harlen, 2013b; Inan & Inan, 2015).

The Piagetian (1896-1980) view of learning (highlighting active interaction with material and the centrality of play and discovery in the learning processes) combined with the Vygotskian (1896-1934) view of teacher-child interaction and Ausubel's (1918-2008) theory of meaningful learning, furthermore draws attention to the important role of learners' curiosity, imagination and urge to interact and inquire into their own learning, and the importance of their fulfilling active roles in developing their ideas and understanding (Borda Carulla, 2012; Ergazaki & Zogza, 2013). These ideas in particular have shaped inquiry-based approaches to science learning.

In Qablan and DeBaz's (2015) opinion, the constructivist view to learning has had the most significant impact on science education since 1980, bringing about a paradigm change in science education, shifting away from teacher-centred transmission approaches to inquiry-based science learning and teaching (Van Booven, 2015). Stemming from active learning philosophies, inquiry is regarded as the core of the learning experience (Inan & Inan, 2015). As such, child-centred philosophies foreground the child as an active, curious thinker and meaning maker, and emphasises the role of learning by doing (Cremin et al., 2015; Inan & Inan, 2015; Qablan & DeBaz, 2015).

The National Research Council of America (NRC) describes IBSE as "… the diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work" (NRC, 1996, p. 2). IBSE therefore implies an approach to teaching and learning that engages children in the thinking processes and the activities of professional scientists when constructing knowledge (Furtak et al., 2012; Pedaste et al., 2015). Gillies and Nichols (2015) explain that when children engage in scientific inquiry, they learn to use their ideas and, in so doing, deepen their conceptual understanding as well as their skills in doing science. IBSE can thus be described as a process through which children discover new causal relations by formulating hypotheses and testing these through active participation in the investigative process. In the process of problem solving, learners themselves take responsibility for knowledge construction (Pedaste et al., 2015).

2.4.2 Essential features of IBSE

IBSE is characterised by several essential features that form the basis of my understanding of IBSE as applied for this study. These essential features emphasise a process of engagement in scientific investigation, with a specific focus on children's active thinking and doing in scientific inquiry rather than on teachers presenting scientific content knowledge. These features are applicable to children from all grade levels, and are summarised in Table 2.1 (NRC, 2000; Minner et al., 2010; Levy et al., 2011; Tan & Wong, 2012).

Table 2.1: Essential features and associated actions in scientific inquiry

	Feature	**Action**
1	Questions	Children *engage with* scientifically oriented questions. Typically, an authentic question or problem will drive the learning experience. Problems or questions may be teacher-generated, initiated by other people, materials (that spark curiosity) or children themselves (child-initiated).
2	Investigations	Children *design and conduct* science investigations (e.g. experimentation, trial and error, modelling, or document-based research) to gather evidence.
3	Evidence	Children *give priority to evidence* that can help them develop and evaluate explanations in addressing science oriented questions. Children analyse evidence.
4	Explanations	Children *formulate explanations* based on the evidence they have found, and address science oriented questions.
5	Connections	Children *connect* explanations to scientific knowledge (relate their findings to science concepts).
6	Communi-cation	Children *communicate and justify* their explanations by explaining what they have found out in different formats, e.g. show and tell, talk, draw, use graphs, write notes, etc.
7	Reflection	Children *reflect on* the inquiry process and on their learning.

From the features and associated actions, it is evident that IBSE involves the *doing of science*, which is distinctly different from *learning about science*. When *doing* science, Zhai et al. (2014) explain that “real” scientists aim to create new knowledge. On the other hand, *learning about* science involves the aim of understanding existing science. As opposed to predominant, more traditional methods that focus on the transmission of knowledge (i.e. learning about science), IBSE thus focuses on learners experiencing science and creating knowledge through action (i.e. doing) (Harlen, 2013a), by actively engaging them in an authentic scientific investigation process (Pedaste et al., 2015).

Various educational theories, pedagogical frameworks and approaches to teaching and learning exist in the field of IBSE (PRIMAS, 2011; Zogza & Ergazaki, 2013; Ireland et al., 2014). The most known inquiry-based approaches include a model of instruction known as the “learning cycle”, more specifically the 5E learning cycle, a constructivist model for planning and implementing science during the engage, explore, explain, elaborate and evaluate phases (developed by Robert Bybee in 1997) (Zogza & Ergazaki, 2013). The underlying assumptions (e.g. about scientific inquiry, learning and the goals of science education) may differ between different programmes (Delclaux & Saltiel, 2013), and the degree of children’s freedom within the inquiry process may vary (Krämer et al., 2015). As such, many different degrees of inquiry can be distinguished on the inquiry-continuum, ranging from structured to open inquiry, based on the level of participation of both the teacher and learners in the learning process (Alake-Tuenter, 2012; Levy et al., 2011). In general, the scientific investigation process is usually divided into smaller, logically connected units, or so-called inquiry stages or phases that draw attention to important features of scientific thinking, and can guide children systematically through an inquiry cycle (Pedaste et al., 2015). In applying the essential features of IBSE during this study, student teachers’ awareness of the importance of learners’ actions (active thinking and doing) throughout the inquiry process was important, so that student teachers could support learners’ active construction of understanding, rather than imparting content knowledge to learners.

2.4.3 Potential benefits of IBSE

The potential educational benefits associated with IBSE are well documented (Boaventura & Faria, 2015; Gillies & Nichols, 2014; Krämer et al., 2015; NRC, 1996; Suduc, Bizoi & Gorghiu, 2015; Tenaw, 2014). If well implemented, IBSE may be an empowering approach with the potential to develop children's higher order intellectual abilities, scientific habits of mind, scientific literacy, and equip them with skills and competencies that are required in a 21st century society (Ergazaki & Zogza, 2013; Gillies & Nichols, 2014; Harlen & Léna, 2013; Harlen, 2013a; Ireland et al., 2012; Tenaw, 2014).

2.4.3.1 Promoting learners' science content knowledge, construction of meaning and scientific inquiry skills

While learners actively engage in activities and thinking processes similar to those of real scientists (doing science), they acquire knowledge and understanding of scientific ideas, and gain understanding of how real scientists study the natural world (NRC, 1996; Siry et al., 2012). In this regard IBSE generally aims to develop children's scientific abilities and facilitate a deep understanding of the subject matter as well as of the nature of science (Alake-Tuenter, 2012).

Learning science implies a process of continually constructing and reconstructing prior knowledge (Martin, 2012). IBSE emphasises learners' use of prior knowledge (intuitive theories) to inform their investigations (Smolleck & Nordgren, 2014). In this regard, Martin (2012) emphasises the notion that learners develop a deeper understanding of science concepts when their prior knowledge is considered. As such, IBSE relies on skills that are active, persistent and based on learners' own knowledge (Suduc et al., 2015). This approach can enable learners to answer science oriented questions based on their existing previously constructed theories that may explain their experiences (Tenaw, 2014).

In the context of this study, possible benefits of promoting learners' construction of understanding are that student teachers' facilitation of IBSE could enable learners to expand their prior knowledge and skills by means of active engagement in authentic investigation. This furthermore implies that student teachers as facilitators' trust in learners' ability to investigate on their own and construct understanding would allow learners to use and develop inquiry skills to construct science knowledge during inquiry-based activities.

2.4.3.2 Fostering learners' understanding of the nature of science and how science is carried out in the "real" world

The nature of science (NOS) relates to the epistemology of science (how science works), and considers values and beliefs underlying the development of scientific knowledge. As such, NOS forms an important component of scientific literacy (Bell & Sinclair, 2015). Young learners can, through classroom activities, begin to understand what science is, by whom it is practised, and how scientists work, in support of their understanding of the NOS (Ashbrook, 2014; Bell & Sinclair, 2015; Janulaw, 2014; Lederman, 2007; Lederman, 2014). Researchers (e.g. Akerson, Buck, Donnelly Nargund-Joshi & Weiland, 2011) are of the opinion that NOS should be taught explicitly, preferably by means of inquiry. To this end, IBSE can create opportunities to direct learners' attention to NOS concepts such as that science uses a variety of methods, that all science knowledge is empirically based, and that science is a human activity (NGSS, 2013; NSTA, 2000).

In essence, IBSE engages learners in authentic investigations to answer real-life questions. Through participation in IBSE, learners may then connect their activities in the science classroom to the work of scientists, thereby contributing to their own understanding of how science is carried out in the real world (Gillies & Nichols, 2014; Tenaw, 2014). In this context, learners often experience that the answers to problems do not readily appear or are quickly answered by their teachers, but that they can be solved through investigation, by exploring available information, sharing and negotiating ideas with peers, and through reflecting on prior experiences and learning (Duschl et al., 2007; Gillies & Nichols, 2014). By being actively involved in scientific investigations, learners may realise that human input, such as creative thinking and problem solving, are needed for scientific endeavours, but also for life in general in an increasingly complex scientific and technological world (Tenaw, 2014).

Applying this potential benefit to my study implied that student teachers had to create contexts suitable for learners' inquiry, allowing learners to experience authentic investigations to solve real life problems. To this end, allowing learners to engage in scientific inquiry could assist learners in comprehending NOS concepts.

2.4.3.3 Shaping learners' motivation and self-efficacy beliefs

An important benefit of IBSE is the potential to shape learners' competency (self-efficacy) and beliefs, and to nurture positive dispositions to school science, in order to enhance their interest in science as a subject and to stimulate their curiosity and enthusiasm to learn science (Krämer et al., 2015; Minner et al., 2010; Patrick & Mantzicopoulus, 2015; Samarapungavan, Patrick & Mantzicopoulos, 2011). It is well established that early experiences will shape learners' motivation in, and the beliefs they hold about a subject, for example as hard, easy, important, interesting or boring, or as something they can or cannot do (Patrick & Mantzicopoulus, 2015).

In their study with young children, Suduc et al. (2015) found that IBSE will not only stimulate learners' research skills and enhance their construction of meaning and acquisition of science knowledge, but that such an approach will also increase learners' interest and motivation for science as a subject. Keeping this potential benefit in mind while undertaking my study implied that student teachers' implementation of IBSE activities could nurture learners' natural curiosity and stimulate their interest in science at school.

2.4.3.4 Enhancing learners' social learning skills

By working cooperatively, learners learn how to function as a scientific community during IBSE (Gillies & Nichols, 2014) and, in this way, develop scientific habits of mind (Forman & Ford, 2014). Collaboration may enhance the quality of a learning process and learning outcomes in science education (Dunlop, Compton, Clarke & McKelvey-Martin, 2015; Hand, Norton-Meier, Gunel & Akkus, 2016; Levy et al., 2011) when learners share their ideas (prior knowledge), contribute information, debate and reason, and learn to listen to and consider the ideas of others. In addition, learners may learn how to consolidate collective ideas, clarify possible misunderstandings, agree on how to go about with an investigation, and mutually generate new understandings (Levy et al., 2011; Worth, et al., 2009).

In this way, they can develop teamwork skills, learning how to share ideas, work together, take responsibilities in the group, and communicate effectively with one another. As a team, learners will get the opportunity to share their ideas with the whole class, and in this way learn to present and defend their ideas, but also to listen to, question and debate the ideas of others. Subsequently, learners may learn that different viewpoints exist, as well as a variety of ways to approach and solve the same problem (Gillies & Nichols, 2014; Worth, Duque & Saltiel, 2009). In the context of my study, this benefit implied that learners had to be given the opportunity to utilise the input of others (for example, peers, teachers, other sources of information) in order to learn science in a social and collaborative way.

2.4.3.5 Fostering learners' language, literacy and reasoning skills

IBSE provides opportunities for rich and meaningful learning in both science and language as science cannot exist without language, which forms an essential and integral part of the work of scientists (Hand et al., 2016; Krogh & Morehouse, 2014). As such, oral language, reading and writing are the backbone tools of inquiry learning (Krogh & Morehouse, 2014).

When participating in IBSE, working as a community of scientists, intellectually challenging science content will be connected to language-based activities as learners talk, listen, read and write. To this end, learners will participate in dialogical discourse and reciprocal interaction, and use language for information exchange and as a reasoning tool (Krogh & Morehouse, 2014). Through IBSE learners will furthermore get the opportunity to represent their ideas, debates and arguments using different modes such as verbal form, written notes, diagrams and models; in this way they may develop science language as well as scientific literacy (Dunlop et al., 2015; Norris & Phillips, 2003 cited in Hand et al., 2016).

In this study student teachers capitalised on this potential benefit of IBSE by allowing learners to express their views in different modes. This enabled learner responses to drive activities, and offered learners the chance to share experiences with team members, the whole class, and to record their scientific ideas in writing in the science journals.

2.4.3.6 Preparing learners for 21st century life

It is often argued that IBSE holds the potential of providing learners with a framework to develop deep understanding, adaptability, flexibility, complex communication and social skills, self-management and self-development skills, and non-routine problem-solving abilities. In addition, IBSE may develop learners' systems thinking which includes a big picture perspective on work, judgement, decision-making, analysis, evaluation and abstract reasoning. Consequently, learners may develop an understanding of the world, the power of reasoning, as well as the attitudes that may enable them to make informed decisions to lead physically and emotionally healthy and rewarding lives (Gillies, 2013; Harlen 2013b; Roehrig, Michlin, Schmitt, MacNabb, & Dubinsky, 2012).

To cultivate the potential benefits of IBSE among young learners, they need to be exposed to a programme that actively engages them in scientific investigation. In terms of the potential benefits of preparing learners for the 21st-century, student teachers in this study focused on letting learners learn science by doing science, in this way developing their scientific literacy, and consequently the competencies required for modern times.

2.4.4 The *La main à la pâte* (LAMAP) IBSE approach

The IBSE programme I applied in this study is infused by LAMAP[19], which was introduced by Georges Charpak (Nobel prize recipient in Physics, 1992) in 1996, in collaboration with Pierre Léna, Yves Quéré, and the French Academy of Sciences/Institute of France with the support of the French Ministry of Education. When launched nationally, the programme's aim was to renew and improve the quality of science and technology education for French kindergarten and primary

[19] For more information, please refer to the website of *La main à la pâte*: www.fondation-lamap.org.

school children by specifically focusing on inquiry-based activities and investigations as a way for children to study the world around them in-depth through exploration, scientific knowledge, experimentation, reasoning, the facility of language and argumentation. At its core the LAMAP programme aims to stimulate children's curiosity, creativity and a critical attitude (Borda, Lejeune & Person, 2013).

As explained by French trainer Anne Goube (LAMAP professional development workshop, November, 2012 and e-mail conversation, 16 August 2016), the French expression *La main à la pâte*, stems from cooking, literally translating into "putting one's hand in the dough" – implying the action of impromptu cooking, not following a recipe or a demonstration. As such, this expression implies participation in an activity that requires some physical and mental effort. In the context of science education, this expression refers to teaching and learning science that focuses on learners' activities and reflections, rather than following a traditional approach. As such, the focus falls on direct, active hands-on and minds-on effort (i.e. learners rolling up their sleeves, and getting their hands dirty).

The LAMAP approach is grounded in the belief that true understanding, and not mere memorisation of content and information, is at the core of science education (Worth et al., 2009). LAMAP[20] explains IBSE as follows:

> *"Inquiry-based science education is an approach to teaching and learning science that comes from an understanding of how students learn, the nature of science inquiry, and a focus on basic content to be learned. It is also based on the belief that it is important to ensure that students truly understand what they are learning, and not simply learn to repeat content and information. Rather than a superficial learning process in which motivation is based on the satisfaction of being rewarded, IBSE goes deep and motivation comes from the satisfaction of having learned and understood something. IBSE is not about quantities of information memorised in the immediate, rather it is about ideas or concepts leading to understanding that grows deeper and deeper as students get older"* (Worth et al., 2009, p.9).

Against the background of this definition, I support the implementation of LAMAP IBSE as reform approach in South African Foundation Phase classrooms, focusing on the deepening of learners' knowledge by including opportunities for exploration,

[20]Further details on the LAMAP framework, important principles and pedagogical considerations can be found in the Pollen booklet, available from www.pollen-europe.net: http://www.fondation-map.org/international-resources.

learning, experimentation, reasoning, and using language and argumentation in the context of science. In this way I support the aims of the LAMAP approach to develop learners' curiosity, creativity and critical attitude as core competencies (Borda, Lejeune & Person, 2013). I thus propagate the implementation of IBSE as innovative approach to science education.

2.4.4.1 The LAMAP framework

Figure 2.2 provides a framework for science inquiry as proposed by LAMAP.

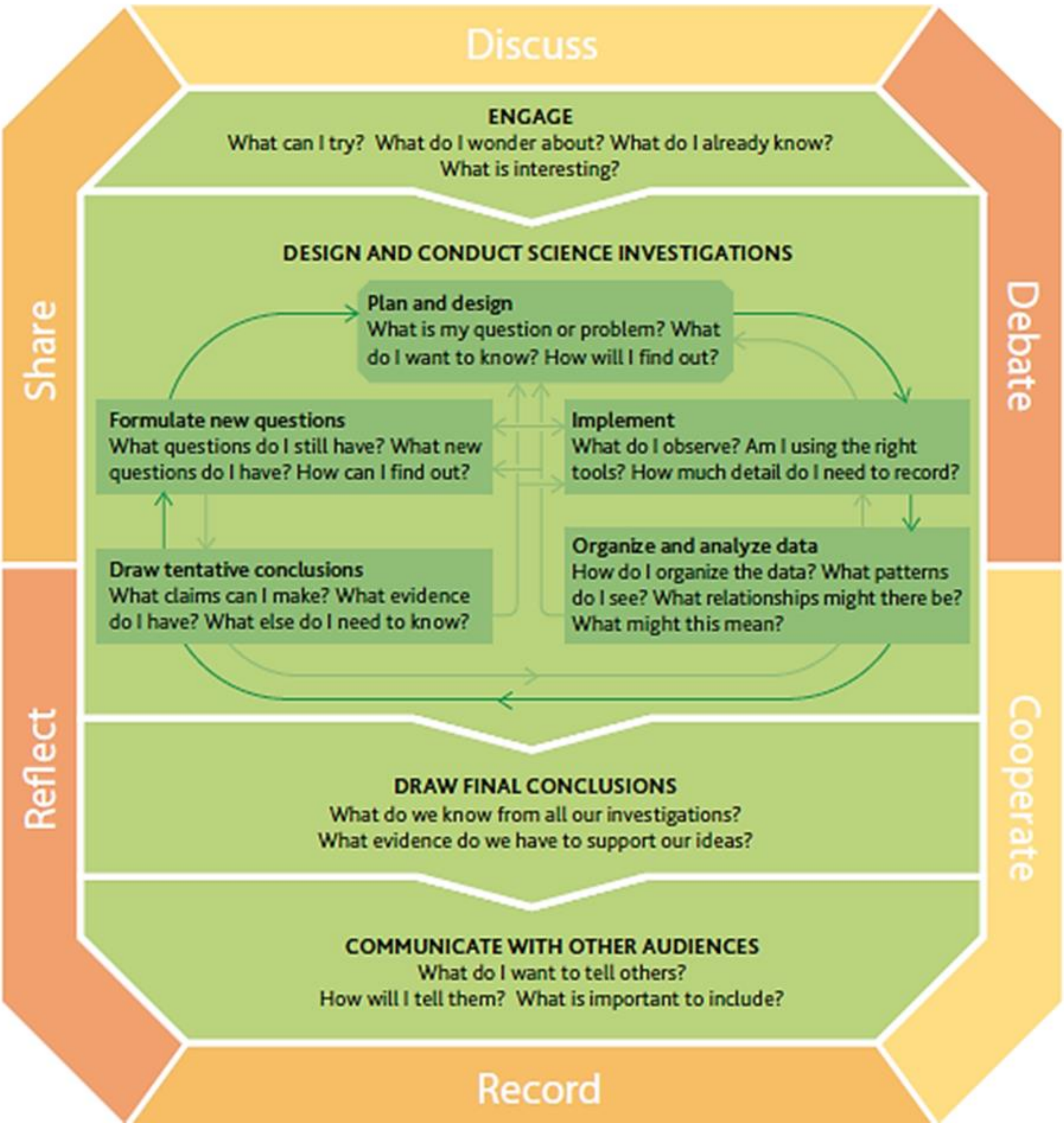


Figure 2.2: LAMAP framework for scientific inquiry (Worth et al., 2009, p. 10).

As evident from the LAMAP framework, scientific investigation is divided into smaller, logically connected phases that can guide learners through the inquiry process. According to the framework, an inquiry process starts with an exploratory phase (Phase 1) where learners get the opportunity to become familiar with a phenomenon to be studied. In IBSE as part of the LAMAP programme, all units will start off by allowing learners to express their prior knowledge by stating their own ideas verbally or noting it in a science notebook or journal. Thereafter, learners share their individual ideas in small cooperative learning groups.

The second phase, investigation, consists of different parts, i.e. plan and design; implement, organise and analyse; draw tentative conclusions, and formulate new questions. The development and use of inquiry skills, of which focused observation is seen as most fundamental, are important during this phase. Since science inquiry is a complex process, various parts of the phase offer learners the opportunity to move flexibly (see arrows in Figure 2.2) and not in a linear fashion between the different parts. During this process learners have the freedom of thinking and revisiting, dwelling upon, or even excluding certain parts completely. If the results of their investigation do not validate their initial prediction, learners are required to question their initial assumptions, and return to the start of their investigation to develop a new experiment. As such, if an investigation they planned does not deliver the required results, learners need to redesign their actions. Where a group comes to a tentative conclusion that differs from that of another group, both groups may need to redo their investigations.

Following the phase where learners design and conduct various investigations, they synthesise what they had learned and draw conclusions (Phase 3). Learners often draw final conclusions as a group, and may also come to agreed-upon final conclusions. The fourth and final phase (Phase 4) in the framework involves learners communicating their new understanding to a wider audience such as the whole class. Learners communicate their understanding in different verbal and visual formats, for example using posters or science journals. Throughout all phases the cognitive actions of discussing, sharing, debating, cooperating, reflecting and recording are intertwined in the inquiry process (Worth et al., 2009).

While the distinction between the four phases may create the impression that scientific inquiry proceeds in a linear, step-by-step fashion, this is not the case. The LAMAP IBSE framework follows a rather flexible format that may be adapted to suit the situation or problem at hand. The various phases should be viewed as involving a series of steps that guide the inquiry process, allowing for an open form of inquiry where learners engage in scientific inquiry under the guidance of teachers (Delclaux & Saltiel, 2013). In IBSE the teacher and learners share the responsibility for learning. In order for learners to engage effectively in scientific inquiry, the teacher fulfils an active guiding role throughout the various phases of the process (Ontario, 2013). The level of guidance, however, depends on learners' age, maturity and experience of IBSE (Harlen, 2012).

2.4.4.2 Translating the LAMAP framework into practice

Although LAMAP IBSE is defined as an open inquiry approach following a flexible format, for teachers-in-training and first-time implementers of the LAMAP IBSE approach, I introduce it as guided inquiry with specified steps and guidelines. In my view, such a guided-inquiry approach can provide novice teachers with the necessary structure to internalise the approach, its underlying principles, pedagogical considerations and strategies before implementing it in a more open way. The LAMAP IBSE phases, required actions in each phase and process of theory formation and revision that I use when training student teachers are provided in Figure 2.3.

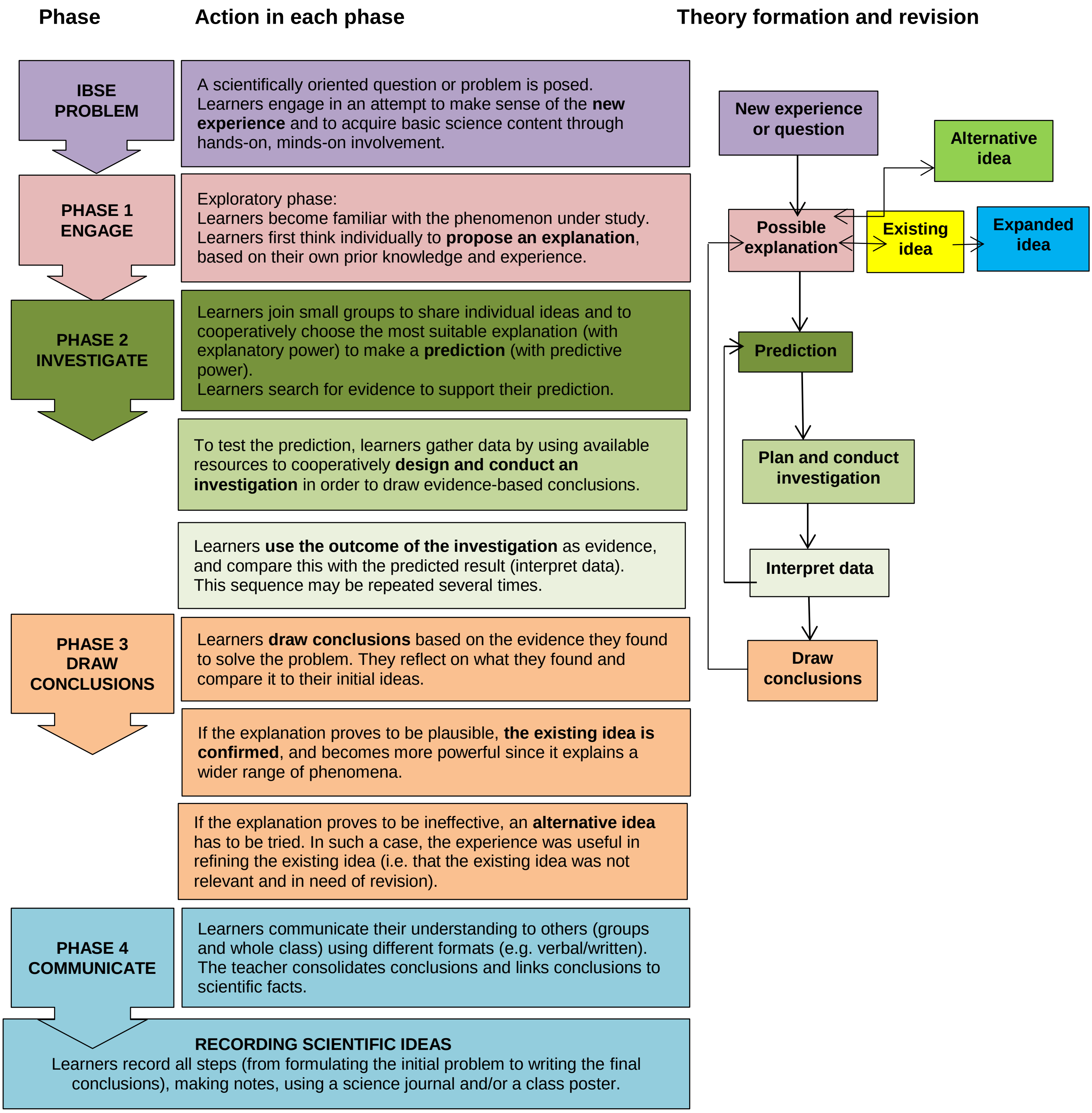


Figure 2.3: LAMAP IBSE phases, actions and theory formation and revision

(Adapted from Worth et al., 2009; Harlen, 2012; Martin, 2012)

As already indicated, the LAMAP approach is set in a framework of social constructivism and based on the assumption that the acquisition and true understanding of scientific concepts can be facilitated through curiosity, creativity and the natural desire of children to interact and inquire actively. As learners are guided throughout the inquiry process to make reconstruction of initial concepts possible, theory revision and conceptual change may be achieved if learners become dissatisfied with or challenged in their current understandings while having access to new ideas with which to replace initial understandings (Levy et al., 2011; Vosniadou & Ioannides, 1998). All inquiry tasks are therefore designed in a way that can promote new scientific ideas in an understandable, reasonable and useful way, while embracing the human and social nature of science and enhancing social learning (Delclaux & Saltiel, 2013; Worth et al., 2009). Through engagement in the process of investigation, learners do not merely experience the joy of learning, but also develop thinking and reasoning skills by collaboratively formulating and evaluating possible explanations about the phenomena they investigate (Ergazaki & Zogza, 2013).

Another important feature highlighted by Delclaux and Saltiel (2013) involves learners writing down their predictions and keeping track of their personal and collective thoughts and thinking process. For this purpose, notebooks (or science journals) are provided to note individual as well as the group's collective thoughts, allowing learners to make personal entries and record their thoughts, predictions, descriptions and findings in their own words. In addition, collective writing (for instance on a group poster), can capture the ideas of the group, as well as a synthesis of established knowledge as prepared by the whole class with the guidance of the teacher. When training student teachers to implement LAMAP IBSE, I present the process, and the facilitator's role according to the steps presented in Figure 2.4.

STEP 1: IBSE problem	Introduce investigable IBSE problem, based on IBSE-focused science outcomes.
STEP 2: Think-on-your-own	Plan time and opportunities for learners to express ideas according to their prior knowledge; acknowledge their ideas; encourage them to formulate productive ideas.
STEP 3: Share ideas in group	Structure and manage groups; facilitate discussions; encourage learners to work and exchange ideas with others; encourage them to formulate and reflect on the most suitable collective suggestion.
STEP 4: Investigation	Provide resources and material; support investigations; facilitate through questioning; encourage to reflect and reason; encourage to search for evidence that will support claims; remind to keep notes and record the scientific thinking process.
STEP 5: Draw conclusions	Guide analysis and conclusions; ask learners to state conclusions; encourage to reflect on the knowledge they have acquired, and to compare this to their initial idea; prompt for explanations; consolidate conclusions; link to scientific facts, record collective conclusion in journals.
STEP 6: Communicate	Plan format, time and opportunity to communicate science information in different ways; guide discussions and assist to articulate coherent explanations; encourage listening to other groups' explanations.

Figure 2.4: Steps followed by the teacher when implementing IBSE

2.4.4.3 Structuring the IBSE learning environment

When implementing IBSE it is important that the teacher plans a responsive environment that will support child-centred and inquiry-based learning. As I rely on Vosniadou's (2001) principles when providing guidelines to student teachers, I link the principles of how children learn to the principles and pedagogical assumptions underlying LAMAP IBSE in this section.

Stella Vosniadou (2001), an established researcher in childhood development, cognitive development, cognitive psychology, conceptual change, and learning science and mathematics, summarises good educational practices and proposes twelve principles of learning as a comprehensive framework when designing curricula and instruction, as well as learning environments that are conducive to learning. These principles are active involvement; social participation; meaningful activities; relating new information to prior knowledge; being strategic; engaging in self-regulation and being reflective; restructuring prior knowledge; aiming towards understanding rather than memorisation; helping students learn to transfer; taking time to practice; developmental and individual differences, and creating motivated children.

Vosniadou's (2001) principle of *active involvement* implies active, constructive, goal-oriented engagement, building on children's natural desire to explore, understand and master new things (Vosniadou, 2001). According to Zull (2002), concrete and authentic experiences can enable the brain to construct physical maps of the world based on information received via the senses. Aligned with this argument, Kovalik and Olsen (2010) as well as Sousa (2013) believe that conceptual development is primarily constructed through sensory input, which is required for successful learning. The notion of active involvement is implied by IBSE as learners actively engage in designing and conducting investigations to build their understanding of the world based on direct experiences (NRC, 2000; Worth et al., 2009). The IBSE learning environment should thus provide experiences, materials and sources of information that may actively and constructively engage learners, capitalising on their natural desire to explore, understand and master new things, and facilitating active hands-on, minds-on and reflective participation (Gillies & Nichols, 2015; Harlen, 2012; Vosniadou, 2001).

The next principle stipulated by Vosniadou (2001) involves *social participation* and involvement in a fruitful, collaborative and cooperative atmosphere. Since the human brain is primed to relate to and learn from others, Hinton and Fischer (2010) propose that learning environments should be community-oriented and support rich and rapid learning. In this regard, Zull (2011) acknowledges the importance of social engagement and interaction (i.e. the social nature of learning, the experiences of joint discovery, teamwork and participation) as part of the success in education. The principle of social learning relates well to IBSE as scientific knowledge-building practices are essentially viewed as social and cooperative in nature when following this approach (Gillies & Nichols, 2015; Worth et al., 2009). Within a community of scientists, communication plays a central role. To this end, communication, dialogue and collaboration are critical to learning, and can enable learners both to internalise (think and reflect on own learning) and externalise (share with others) their ideas (Cremin et al., 2015; Dunlop et al., 2015).

However, working collaboratively also poses potential challenges to both learners and teachers. Learners may, for example, experience feelings of irritation and discomfort, while teachers are continually required to employ effective strategies in support of conducive group work, as well as support strategies to manage successful group learning. In this regard the classroom culture will rely on learners' and teachers' ability to manage their own and others' motivations, feelings, social relationships, and physical movement in order to engage and learn in a mutually supportive way (Kershner et al., 2014).

Next, the principle of *meaningful activities and authentic materials* (Vosniadou, 2001) implies participation in activities that are culturally appropriate and relevant, and useful in real life. In the context of IBSE, I view *authenticity* as portraying the "culture" of a scientific community, and accompanying children into the world of science. In this regard, learners will engage in the practices of science like real scientists do, but in ways that are meaningful for them, and only with the necessary guidance and support (Levy et al., 2011). It follows that the IBSE learning environment should offer authentic experiences that mirror the processes followed by real scientists, allowing learners to *do* science and think like scientists within the context of the classroom.

With regard to the principle of *linking new information to prior knowledge*, Vosniadou (2001) explains that learners construct new knowledge on the basis of what they already know and understand. To this end, Zull (2002) regards prior knowledge as the beginning of new knowledge, and as the essential point of departure for introducing new knowledge. In this way learners' existing ideas may enable them to make predictions and conduct tests in determining whether or not their predictions are supported or contradicted by evidence, and whether or not they need to consider alternative ideas or modifications (Harlen, 2012).

In this regard IBSE proceeds from the assumption that all learners possess theories, whether naïve, incomplete or incorrect (Harlen, 2012). Investigations typically start by requiring of learners first to explore their own thinking and state their own ideas, thereby giving them the opportunity to activate their own prior knowledge (Worth et al., 2009). As the activation of prior knowledge to gain new knowledge is critical for learning, the IBSE learning environment should therefore make provision for using learners' prior knowledge as starting point, including any misconceptions they may hold.

According to Vosniadou (2001), learning furthermore depends on the use of effective and *flexible strategies* that are appropriate to the situation and can assist learners in understanding, reasoning, memorising and solving problems. When involved in IBSE, learners need to develop and use a range of inquiry skills, such as focused observation, asking questions, making predictions, designing investigations, analysing data, and supporting claims with evidence (Worth et al., 2009). For this purpose, learners will employ a range of cognitive skills and move in-between the non-linear parts of the inquiry process to plan, design, implement, organise, analyse, draw tentative conclusions, and formulate new questions by using a range of strategies to solve a problem. Sousa (2013) explains that, when faced with a problem, learners employ divergent thinking to analyse information and assess available options, thereby allowing the brain to make new connections and expand on neural pathways, find new patterns and manage more complex problems in future (Sousa, 2013). In support of this argument, Goswami (2015), reasons that brain learning depends on the development of multi-sensory neuronal networks dispersed across the entire brain.

As a result, it is important that the IBSE learning environment allow learners to develop and use a wide range of cognitive strategies (Vosniadou, 2001), activating multi-sensory networks of neurons (Goswami, 2015). The skills and strategies acquired during IBSE could most likely equip learners with the ability to develop and use a range of strategies that can assist them in understanding, reasoning, memorising and solving problems. This requires of teachers to teach learners science inquiry skills deliberately and directly, and offer multiple opportunities to use such acquired skills flexibly (Worth et al., 2009).

The principle of *promoting self-regulation and reflection* implies learners' awareness of and their ability to plan and monitor their own learning, set learning objectives, know when they go wrong, and know how to correct errors. Self-regulation includes reflection or being aware of one's own beliefs and strategies (Vosniadou, 2001). Engagement in IBSE may support learners in becoming self-regulated and reflective as the investigation requires of them to think, plan and carefully monitor their own learning throughout the process. The ultimate goal of answering initial questions or solving a problem implies built-in measures where errors can be corrected through evidence stemming from the investigation, through interaction with peers, or through questioning and feedback from the teacher (Levy et al., 2011; Worth et al., 2009).

Learners learn reflection when participating in discussions, debates and activities when required to voice and defend opinions (Vosniadou, 2001). Two main ways of involving learners in reflection experiences in IBSE include group discussions and journal writing. Reflective discussions are especially valuable towards the end of an inquiry when learners reflect on processes and new knowledge acquired during the process, and on the changes of understanding that have taken place. In this way IBSE can encourage the development of metacognitive skills (Levy et al., 2011; Worth et al., 2009).

According to Vosniadou (2001), learning furthermore entails the *restructuring of prior knowledge*. As such, learners build conceptual understandings of how the world works based on their direct experiences. However, in science, learners' understanding of natural phenomena may be naïve, incomplete or even incorrect (Harlen, 2012), and as Vosniadou (2001) explains, such understanding may prohibit learners from learning something new. As learners' prior knowledge can be restructured through a process of theory revision and conceptual change, the IBSE learning environment should be designed to enable learners to solve internal inconsistencies and restructure existing conceptions when necessary, i.e. to replace their prior knowledge with new knowledge (Vosniadou, 2001). To this end, teachers need to consider learners' existing ideas, and plan activities to "reconstruct" initial understanding through the investigation process, so that new and more coherent concepts can emerge (Charlesworth & Lindt, 2013; Worth et al., 2009).

In terms of the principle of *true understanding rather than mere memorisation* (Vosniadou, 2001), an underlying assumption of IBSE is that learners should fully own and understand the question or problem they need to solve. As such, true understanding and meaningful learning is regarded as an important prerequisite for engagement and active participation, as opposed to the mere repetition of content or memorisation of quantities of information (Worth et al., 2009). In IBSE, for direct experience to lead to true understanding and deep learning, learners are required to think and reason about their hands-on work, have thoughtful discussions with others, and represent it visually or in writing (Levy et al., 2011). It follows that the IBSE learning environment should offer opportunities for learners to think about what they are doing, to talk about it with others (peers and teacher), to clarify it, reflect on it, and understand how new knowledge applies in different situations. When learners understand information, they tend to remember, and are typically more able to transfer new knowledge to other situations (Vosniadou, 2001).

The principle of *transferring learning* implies that learning becomes more meaningful when classroom lessons are applied to real-life situations when children get the opportunity to transfer knowledge and use it to solve real-world problems (Vosniadou, 2001). In essence, the real purpose of school is to prepare children for life now, and after school, and for learners to integrate education with daily life (Sousa, 2013; Zull, 2011). To this end, IBSE holds the potential to equip learners with cognitive competencies, thinking processes and skills that can be transferred to other subjects, and consequently prepare them for the demands of the 21st century (Harlen, 2013). IBSE relies on the integration of different literacies (e.g. digital, science) and subjects such as language and mathematics during the investigation process and communication of science information (Sousa, 2013). In this way science content is processed and stored in multiple places in the brain (Kovalik & Olsen, 2010). It follows that the IBSE learning environment should be designed to enable cross-curricular approaches that integrate different kinds of subjects and literacies. To this end, IBSE should be planned with the intention of learners using and applying the knowledge and skills gained in one subject to other subjects and areas (Vosniadou, 2001).

Another important principle teachers need to consider is that learning *requires time and practice* in order to build expertise in an area (Vosniadou, 2001). In IBSE, learners become deeply immersed in investigations, exploring materials, thinking about questions or problems, considering their own and others' ideas, expressing and sharing their thinking, trying out ideas, making mistakes, reflecting on and reviewing their plans, discussing their conclusions with others and keeping record of their scientific doing and thinking (Fraser-Abder, 2011). Learners require ample time and multiple opportunities for these actions, and to practise and reinforce new skills and ideas (NSTA, 2014). As such, the IBSE learning environment should make provision for sufficient meaningful, relevant and developmentally appropriate IBSE experiences in order for learners to build their science foundations.

Vosniadou (2001) furthermore states that learners will learn best when the learning environment is designed to *accommodate their diverse learning needs*. To this end, Schweisfurth (2015) highlights individualised learning as important principle of child-centred learning, considering individual learners' existing knowledge and skills, and focusing on improved learning through incremental development. Goswami (2015) views such incremental experiences as crucial for learning and knowledge construction, where learners develop appropriate inquiry skills over their years of schooling. The activities of both teacher and learners should be cumulative to ensure that a firm foundation for future progress is laid (Harlen, 2012). As such, the IBSE learning environment should be challenging yet supportive, taking into account individual differences and providing opportunities for incremental learning in the form of sequential and constructive experiences (Harlen, 2012; Goswami, 2015; Schweisfurth, 2015).

A final learning principle that Vosniadou (2001) highlights is the importance of creating *intrinsically motivated* learners. Motivation may determine the quantity and quality of learning with emotion being the underlying determining factor and force that drives action (Patrick & Mantzicopoulus, 2015; Vosniadou, 2001). As the brain will react to the environment (e.g. fear, escape, boredom, disengagement, interest, enthusiasm), and influence the learners' state of mind, Zull (2011) believes that physical (hands-on) and mental (minds-on) challenges can act as triggers for the emotional reward system. As such advanced cognitive functions (including the use of working memory to solve problems with intentional recall functions, and decision making) can therefore be experienced as rewarding, satisfying and exhilarating. In this regard, Zull (2011) regards thinking (a process that involves work, but also fun) as rewarding, as well as the anticipation of being rewarded (intrinsic reward). Intrinsically motivated children may as a result show a passion for achieving their goals, display considerable determination and persistence, and realise that a great deal of effort is important to achieve success. To this end, motivation will be evident in learners' behaviour, choices, energy, persistence, and the care and thoughtfulness with which they approach a task (Patrick & Mantzicopoulus, 2015).

In terms of learners' motivation, IBSE typically includes novel and interesting tasks that may challenge learners' curiosity and higher-order thinking skills at the appropriate level of difficulty, and enable them to learn, understand and find pleasure in the process (Levy et al., 2011; Patrick & Mantzicopoulus, 2015). According to Cremin et al. (2015) playful experiences such as those of IBSE will have a positive effect on learners' attitudes and affective engagement. In this way, motivation may stem from the satisfaction of having learned and understood something (i.e. intrinsic reward) (Worth et al., 2009).

2.4.4.4 Challenges typically associated with the implementation of IBSE

IBSE implementation implies several potential challenges (Harlen, 2013b; Yoon, Joung & Kim, 2011). It is important for in-service, beginner and pre-service teachers to plan for and address such challenges and for student teachers to be prepared in terms of the challenges they may encounter when implementing IBSE. As the student teacher participants in this study implemented IBSE in practice, I had to consider literature on expected challenges as basis for my own understanding and interpretation of the results I obtained.

An important challenge associated with IBSE relates to the uncertainty in terms of what the approach entails and how it can be implemented (Smolleck & Nordgren, 2014; Tenaw, 2014). In this regard, Haug and Ødegaard (2014) state that, irrespective of the fact that inquiry learning is emphasised across the world, it is not self-explanatory, and consequently does not show teachers exactly how to implement it. As a result, teachers typically display a poor understanding of this form of inquiry, and are thus often hesitant to implement it in their classrooms (Chowdhary et al., 2014; Haug & Ødegaard, 2014; NRC, 2000).

Researchers agree (Harlen, 2013a; Qablan & DeBaz, 2015; Tenaw, 2014) that innovative inquiry-based classroom activities place high demands on teachers. To this end, Tenaw (2014) notes that IBSE activities are typically harder, busier, noisier and more demanding in terms of classroom organisation and management. Crawford (2007) similarly refers to the complexity and sophistication of IBSE as teaching approach, and the demands placed on teachers' understanding of scientific inquiry, the nature of science, as well as inquiry-based approaches. Building on this argument, Capps, Crawford and Constas (2012) contend that if teachers are expected to implement IBSE, they would require deep science content knowledge, understand inquiry, be experienced in both conducting a scientific inquiry themselves and teaching through inquiry, and finally, be skilled in "inquirising" lessons (i.e. adapting lessons to become more inquiry-based). It follows that, in order to create IBSE learning environments, teachers need to adopt complex roles and use a range of teaching strategies flexibly (Qablan & DeBaz, 2015).

Another challenging task associated with IBSE relates to the teacher's role of organising effective group work, and creating an environment for inquiry where learners can work as a community of scientists. In this regard, the teacher's role is to model and facilitate skilful thinking, mediate, and act as knowledge resource, co-enquirer and as discourse guide (Dunlop et al., 2015; Levinson, Hand & Amos, 2012). As such, teachers are required to encourage exploratory investigations and discussions, work with learners' ideas, and scaffold their critical and reflective thinking in order to draw evidence-based conclusions (Gillies & Nichols, 2015). In addition, teachers need to be responsive to learners' inquiries so that they can appropriately identify, interpret, evaluate and respond to their inquiries (Louca, Tzialli, Skoulia & Constantinou, 2013). Moreover, the teacher needs to guide learners to express their views, listen, ask questions and reflect upon their own viewpoints (Dunlop et al., 2015; Levinson et al., 2012). Teachers also need to reconsider their own role in classroom discussion and find ways to engage learners more actively in participatory classroom discussions, taking on a more child- and learning-centred stance (Tan & Wong, 2012). In this way the teacher's role will shift from being a transmitter of science content to becoming a facilitator of learning

(Wilson & Kittleson, 2012; Zhai et al., 2014), managing learning as a democratic process (Dunlop et al., 2015).

IBSE is furthermore often believed to imply challenges related to lack of resources, equipment and appropriate curriculum materials; time constraints; and the pressure to cover the curriculum; difficulties managing the classroom; lack of skills to facilitate all phases of the IBSE process; and lack of confidence in learners' ability to engage in IBSE (Hand et al., 2016; Krämer et al., 2015; Ødegaard et al., 2014; Seung, Park & Jung, 2014). Constraints related to traditional teaching beliefs and teacher-centred approaches may furthermore inhibit teachers to shift their locus of control and implement child-centred inquiry learning (Krämer et al., 2015; Seung et al., 2014). These challenges, exacerbated by teachers' perceived lack of content knowledge, limited skills with regard to using inquiry-pedagogy, and a general discomfort with science, may potentially inhibit the successful implementation of IBSE (Ødegaard et al., 2014).

2.4.4.5 Implications for teacher training

Despite the challenges teachers may face in implementing IBSE, international consensus has been reached that learners, for both educational and socio-economic reasons, can benefit from learning experiences through inquiry (Levy et al., 2011). Implementing a reform-oriented approach such as IBSE requires considering a number of aspects, among others, how teachers should be prepared to implement IBSE (Avraamidou, 2014; NRC, 2011). Based on national and international research and experience, the LAMAP foundation recommends that in-service teachers undergo professional development, involving initial training and follow-up and support initiatives over a period of three years, in order to sustain development and foster progress from beginner to autonomous user. Ideally, a professional development action plan of between three and six years is recommended. Furthermore, a network of continuous support and access to training resources such as science content, teaching units, and learning sequences is important. In this regard the LAMAP foundation provides extensive guidelines for international partners to launch, coordinate and support IBSE implementation in their countries (Delclaux, Marin-Micewicz & Pérez, 2012).

Apart from the LAMAP guidelines provided to support in-service teachers to implement IBSE, Avraamidou (2014) regards the development of "reform-minded" (p. 14) teacher identities as priority for teacher training. As such, shaping beginner teachers' identities for science teaching needs to capacitate them to implement science reform expectations. Avraamidou (2014) specifies the competencies required of teachers, stating that teachers are expected to (1) understand the initial ideas (prior knowledge) that learners bring to the context, and how they may best develop an understanding of science (and engineering) practices; (2) construct science-specific pedagogical content knowledge; (3) understand the subject as a discipline with its associated crosscutting concepts and core ideas; (4) understand how children learn; (5) develop a variety of instructional strategies to best support learning, and (6) learn how to take a child-focused approach to formative assessment as basis for further instruction (NRC, 2010). Adding to this, Loughran (2014) argues that teachers' pedagogical content knowledge (PCK) is core to teacher education. In this regard Cofré et al. (2015) confirm a positive relationship between primary school teachers' knowledge and their confidence to teach science innovatively, as opposed to limited content knowledge often resulting in a preference for teacher-directed traditional approaches.

Another important consideration for teacher training programmes relates to student teachers' attitudes to science and science teaching, often stemming from their own experiences at school. In this regard, it is often found that student teachers tend to articulate knowledge and beliefs about science education that may be inconsistent with reform initiatives (Dickson & Kadbey, 2014). As the beliefs teachers hold about science education may impact the way they teach the subject to young learners, teacher training programmes should encourage student teachers to confront their own beliefs about science teaching and learning, and in this way cultivate a reform-mindedness (Cofré et al., 2015; Dickson & Kadbey, 2014; Forbes, 2011; Qablan & DeBaz, 2015). In my view, shaping such reform-mindedness requires awareness of the importance of science at early childhood level as well as young children's potential for IBSE. Likewise, Lewis et al. (2014) regard an understanding of the value and potential benefits of IBSE for children as important considerations in teacher training programmes.

It is furthermore important for student teachers to learn inquiry through inquiry and to reflect on this way of teaching. Smolleck and Nordgren (2014) as well as Kazempour and Amirshokoohi (2013) explain that, in order for teachers to feel confident about teaching science as inquiry, they require first-hand positive experiences of learning science as inquiry. Of further importance is that student teachers need to engage in continuous reflective practice. In this regard Flores (2015) and Forbes (2011) contend that a close, purposeful link between the theoretical components of teacher education and the practical realities of a real classroom (e.g. translating theory into authentic teaching practice), coupled with critical reflective practices, may enhance student teachers' professional practice as well as their self-efficacy beliefs and views of themselves as transformational science teachers (Lewis et al., 2014).

Preparing teachers to teach science also requires preparation in terms of the national curriculum. In this regard Forbes (2011) views curriculum materials as important practical guidelines that can bridge the gap between curriculum planning and enactment, as a means to support student teachers' learning about teaching and learning. However, South African curriculum guidelines (CAPS) provide limited specifications in terms of the science outcomes relevant to each grade in the Foundation Phase, and do not specify IBSE as approach to curriculum implementation. As such, teacher training programmes should also prepare student teachers to analyse and adapt the curriculum, and in the case of science teaching, to plan for the implementation of IBSE in the school context.

From the discussion in this section, the requirements for shaping reform-minded, well-prepared, self-efficacious beginner IBSE teachers seem demanding. In South Africa, as in many other countries, Foundation Phase student teachers are prepared as generalists, with little time being devoted to preparing reform-oriented science teachers. Due to the perceived challenges often associated with IBSE implementation, teacher training programmes cannot be expected to produce beginner teachers who are perfectly able to implement IBSE when they enter the teaching profession (Krämer et al., 2015), yet basic training in this area is both important and beneficial to future science teachers. My study, involving student teachers in implementing IBSE in authentic Foundation Phase classrooms –

following a reflective practice approach – may contribute to the existing body of knowledge in this field by exposing real-life experiences in the South African context, and suggesting guidelines for teacher education programmes for more effectively preparing teachers to implement IBSE.

2.5 UNDERLYING THEORETICAL PERSPECTIVES AND CONCEPTUAL FRAMEWORK

For the purpose of investigating, and based on the specific focus, the LAMAP IBSE framework (Worth et al., 2009) formed the centre of my conceptual framework. In addition, I drew from early childhood and science education theories to construct a conceptual framework representing a multi-layered approach. I integrated contemporary constructions and views on children, based on current childhood theories (among others those of James & Prout, 1997; James, Jenks & Prout, 1998; Mayall, 2002; Qvortrup, Bardy, Sgritta & Wintersberger, 1994). I furthermore integrated the theory theory (TT) of Gopnik et al. (1999) to explicate science development from a cognitive constructivist perspective, as well as some perspectives from constructivist theories (Piaget, Vygotsky and others) to explicate the teacher's role in learners' science knowledge construction in IBSE. In this section I foreground the different perspectives and theories I relied on and then explain how I integrated these to construct a conceptual framework that could guide my thinking, planning and subsequently my interpretation of the results I obtained.

2.5.1 Children, childhood and learner views against the background of current childhood theories

The concept *childhood* is socially constructed, culturally and historically situated, contextually negotiated and defined, and consequently subject to change (Dahlberg et al., 2013; James & James, 2008; Morrow, 2011). In the South African Children's Act 38 of 2005, a "child" is defined as a person below the age of 18 (South Africa, 2005). In the South African schooling context, a "learner" is defined as any person receiving education or who is obliged to receive education in terms of the South African Schools Act (No. 84 of 1996). The concept of a child, and subsequently also of a learner, is however not only described in terms of a specific age group, but as representative of a specific image. As such, Foundation Phase children participating in this study cannot only be viewed in terms of their age (i.e. between six and nine years), but also in terms of a specific image.

Contemporary thinking of childhood reveals a kaleidoscope of emerging conceptualisations and theories that shape present-day images of what children, childhood and learners entail. Various developments contributed to reconceptualising childhood; for example, the United Convention on the Rights of the Child (UNCRC, 1989), and the work of James and Prout (1990); James et al. (1998); Mayall (2002); Montgomery (2009); and Qvortrup et al. (1994). The influence of three major fields, i.e. developmental psychology, anthropology and sociology has culminated in the current discipline pertaining to childhood studies (Kellet, 2014; Morrow, 2011). This interdisciplinary approach to the study of children and young people specifically evolved from critique against disciplines treating children as a social minority group, lacking independence, rationality, intelligence, autonomy and confidence (Morrow, 2011; Smith, 2011). As evolving field, childhood studies continue to reconceptualise childhood, and consequently also education practices that are suitable for contemporary complex, diverse and rapidly changing societies (Kellet, 2014; Taguchi, 2010; Yelland, 2010).

The implementation of IBSE places the child (or learner) at the core of the education context. Consequently, clarification of the concept of child-centredness requires a clear understanding of who the child is on whom practice is centred. In this regard childhood theorists (Dahlberg et al., 2013; Morrow, 2011; Moss, 2013) generally argue that adult conceptualisations of children and of childhood are *productive* in that they determine the institutions and pedagogical choices that are being made, based on the relevant conceptualisations. For this reason, to elucidate the child (or learner) on whom LAMAP IBSE is centred, I considered some of the current debates and discourses stemming from childhood theories that currently dominate the childhood landscape. Throughout this section I highlight how these perspectives informed my conceptualisation of children (or rather learners) as well as their participation in IBSE and in my research.

2.5.1.1 Childhood as a social category

Modern perspectives indicate that children are a social group with a recognised and independent place in society. Accordingly, childhood is not regarded as a preparatory or marginal state, but as a structure of society, and as an important stage of the life course (Dahlberg et al., 2013). From this perspective children are not viewed as empty vessels whose development is determined by biological and physical processes and input from others, but as competent to co-construct knowledge, culture and their own identity in interaction with others and their environment (Dahlberg et al., 2013; Malaguzzi, 1993; Morrow, 2011; Rinaldi, 2006). This notion requires a shift beyond an interest of what children are *becoming* to an understanding of the child as *being* (Morrow, 2011). In contrast to the "becoming" child, who is conceptualised as an "unfinished adult", the "being" child is viewed as a social actor in his or her own right with views and experiences about being a child (Uprichard, 2008). As Morrow (2011) explains, in education contexts in particular, children are mainly understood as *learners* and *citizens-in-the-making*, and thus as *becoming* adults. In this regard current theory requires a shift beyond viewing the child as citizen-*in-the-making* to viewing the child as worthy citizen of today (Dockett et al., 2011; Kellet, 2014).

In applying this theory to the context of my study, children (or learners) participating in IBSE are not conceptualised as scientists-*in-the-making*, but as scientists in their own right. In agreement with Uprichard (2008) who contests the assumptions of being and becoming as conflicting constructs, I viewed the child-participants both as being (i.e. *is*) and becoming (i.e. *will be*) scientists. While I accept the notion of children being scientists in their own right, I also regard them as social actors who are actively busy constructing both their being scientists (present), and their becoming scientists (future) based on their participation in IBSE.

2.5.1.2 Children as social actors who can take agency

The emphasis on children's status as beings and social actors in their own right, underpins the notion of agency (Kellet, 2011; Morrow, 2011). Children's agency, or the capacity to act, implies that children (or learners) are capable of taking an active and a central role in the IBSE learning and knowledge-construction process. In this regard, learners can take agency when engaged in IBSE as members of a community of scientists, employing the cultural tools of science (for instance, the nature of science, knowledge, skills, dispositions, available materials, language of science) not only to construct science knowledge, but also their identities as scientists (Chen, 2009; Rubbia, D'Addezio, Marsili & Carosi, 2015; Smidt, 2013). As such, within the context of this study, I acknowledged child-participants' agency in co-constructing knowledge, culture and their own identities (Dahlberg et al., 2013; Morrow, 2011).

2.5.1.3 Children's ability to develop and refine theories

Theory theory (TT), or theory of mind (ToM), was initially formulated by Morton (1980) as resulting from cognitive development psychologists' attempts to frame a constructivist set of ideas about cognitive development and conceptual structure (Carey,1985; Gopnik, 1988; Gopnik & Meltzoff, 1997; Gopnik & Wellman 1992; Wellman, 1990; Wellman & Gelman 1992). Carey (2009), Gopnik and colleagues as well as other developmental psychologists support the view of "theory" theory of child development, stating that children experiment in, and theorise about their worlds in the same way that scientists do. As such, TT theorists argue that all human beings have the ability to think scientifically, and to seek the truth about the world (Gopnik et al., 1999; Rhodes & Wellman, 2014; Saracho, 2014). As such, TT is based on the assumption that children develop theories about the world from infancy onwards by using the same cognitive strategies that scientists use, and that these theories are defeasible, revised and restructured in important ways as the child accumulates more evidence about the world (Bonawitz, Van Schijndel, Friel & Schulz, 2012; Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1992; Saracho, 2014).

In recently reconstructing constructivism, Gopnik and Welmann (2012) describe a more precise and formal theory of children's learning mechanisms, grounded in the computational framework of probabilistic causal models and Bayesian learning. This view supports the idea that children and adults learn through a process of theory revision, meaning that they hold prior beliefs about the world, but revise these beliefs as they encounter contradictory evidence, depending on the power of the evidence

(Gopnik, 2012). While many developmental psychologists support and use TT (Saracho, 2014), I focus on Alison Gopnik and colleagues' conceptualisation of TT as their work has shaped my image of children being ever-exploring little scientists, who are, from a very young age, naturally curious, and equipped with powerful learning mechanisms to construct understanding of realities within their life worlds (Goswami, 2015). The application and relevance of TT to this study lies in its central tenets, doing justice to the complexities of human cognitive development, as well as the cognitive processes involved in science learning. Moreover, as TT theorists support learning through inquiry as opposed to learning through passive transmission, I believe that TT can explain and ultimately provide a theoretical grounding for the inclusion of practices such as IBSE in early childhood education contexts.

According to TT theorists, children's intuitive theories form the basis upon which further information is incorporated, consequently determining how they make sense of new evidence (Vosniadou & Ioannides, 1998). To this end, children bring their self-constructed theories into the science classroom, many of which could interfere with learning (Gooding & Metz, 2011; Goswami, 2015; Naudé, 2015; Vosniadou & Ioannides, 1998). As such, children may build explanations, solve problems, and accumulate knowledge based on "faulty reasoning" that was unconsciously and intuitively created (Gooding & Metz, 2011). As passive transmission (classroom talk, verbal explanations, or demonstrations) have little power to change self-constructed theories, children need to reconstruct their prior knowledge through their own effort (Worth et al., 2009; Vygotsky, 1987). This implies that children need to restructure their knowledge through active hands-on, minds-on inquiry as proposed by IBSE.

It follows that quality inquiry experiences that provide opportunities for rigorous exploration, using inquiry skills in a scientific manner, may contribute towards theory formation and modification (Borda Carulla, 2012; Harlen, 2012). In my view TT supports notions such as active inquiry as essential to theory revision and conceptual change. As such, TT highlights the importance of active learning experiences that can enable children to acquire knowledge by actively exploring the environment where information is embedded in meaningful contexts.

2.5.1.4 Children as socially and relationally active in their science learning

In essence, science is a human and cooperative endeavour (Worth et al., 2009). Similarly, Gopnik et al. (1999) propose the idea of a "social brain" where humans work as part of a social complex network. In real life, scientists learn about the world by analysing statistical patterns in data, doing experiments, but also from the data and ideas of other scientists. Similarly, children learn from statistics, experiments (playful exploration) and other people (Gopnik, 2012). Consequently, Gopnik and colleagues (1999) emphasise that children are socially and relationally active in their learning.

With regards to experimentation, Gopnik (2012) argues that children's intuitive, spontaneous, playful experimentation is specifically designed to facilitate their science learning. In this regard, while playing, children's actions will enable them to acquire causal knowledge and discover causal relationships by receiving causally relevant and informative evidence that may enable them to make accurate causal inferences. Moreover, through play, they learn from others by observing and mirroring their actions. Apart from learning to behave in a particular social and physical world through a process of imitation, children are dependent on adults and peers to form a system in which knowledge about the world is shared. To this end, just like scientists, children depend on their individual theory-formation abilities, but also on a social network of shared information in uncovering the truth more likely (Gopnik et al., 1999).

A further analogy that Gopnik et al. (1999) draw between scientists and infants is that they share some of the same emotions and motivations. Both scientists and infants are naturally driven to explore and explain the world, and experience intense pleasure in gaining new understandings. Gopnik et al. (1999, p. 164) state that such distinctly human cognitive emotions, specifically "the agony of confusion and the ecstasy of explanation" drives humans, particularly the very young, to develop theories of the world in search of explanations that will result in pleasure.

2.5.2 Constructivist perspectives on teaching IBSE

In order to support children's development in science, and to highlight the roles of teachers in IBSE, I integrated constructivist theory in my conceptual framework. As IBSE implementer, the teacher plans and facilitates a child-centred, active learning approach to science education. Within the context of this study I considered constructivist and social constructivist theories as important to science knowledge construction in IBSE as well as the role of the teacher in supporting learners' constructive engagement in IBSE (Inan & Inan, 2015; Martin, 2012; Piaget, 1972; Qablan & DeBaz, 2015; Van Booven, 2015; Vygotsky, 1987).

2.5.2.1 Teachers as facilitators of learning

IBSE proposes learners' active participation in doing science (Worth et al., 2009). Existing theory on the role of teachers involving inquiry-oriented investigations (NRC, 1996) supports this idea. Accordingly, constructivist views on teaching and learning of science implies that teachers will allow learners to have direct hands-on experiences, doing science (Inan & Inan, 2015). Consequently, an important role of the teacher is to create an environment suitable for inquiry (Dunlop et al., 2015).

Teachers need to provide contextually meaningful and concrete experiences to learners, allowing them to engage constructively in the inquiry process (Howe, Jacobs, Vukelich & Recchia, 2012). This notion consequently demands of teachers to offer learners sufficient opportunities to make meaning from hands-on (concrete) experiences (Koch, 2013). In this regard teachers are facilitators of learning, strategically guiding learners' thought processes throughout the inquiry phases to support their knowledge construction (Dunlop et al., 2015; Gillies & Nichols, 2015; Howe et al., 2012; Levy et al., 2011; Wilson & Kittleson, 2012; Zhai et al., 2014).

The conceptualisation of learners as active constructors of knowledge and the important influence of social experiences for learning is a hallmark of Vygotsky's work or sociocultural theory (Vygotsky, 1987) that emphasises the influence of social contexts on the ideas individuals construct while interacting and communicating with others (Koch, 2013). Vygotsky's work also highlights a cultural context as important in viewing learning as a fundamentally social and cultural process (Wild, 2013). As Stetsenko (2010) points out, sociocultural theories that centre on active inquiry and guided discovery emphasise learners' knowledge construction through active exploration of their environments where information is seen as embedded in meaningful contexts. In agreement with Howe et al. (2012), I acknowledge the fundamental role of a community of classroom learners and the importance of social interaction and exchange of ideas in knowledge construction. Consequently, in the IBSE classroom, both teachers and learners use language that is socially and culturally accepted within the community of scientists in order to support knowledge construction (Koch, 2013).

2.5.2.2 Teachers supporting the active construction of legitimate knowledge

The key assumption of constructivism is that knowledge is *constructed* (Koch, 2013). More specifically, constructivists believe that learners construct meaning for themselves by relating new information to already existing knowledge, experiences or conceptualisations (Martin, 2012). This implies that knowledge is not passively received, but that learners actively construct knowledge from experience, and that learning is a result of learners' own thinking and processing (Cremin et al., 2015; Koch, 2013; Martin, 2012). Piaget's (1896–1980) theory on cognitive development has contributed to current thinking on children being constructors of their own knowledge, by taking information from people and their environment, and by making meaning from their experiences. In addition, theorists supporting constructivist principles highlight children's natural curiosity as well as the significance of play as fulcrum for learning and knowledge construction (Aubrey & Riley, 2016; Wild, 2013).

Even though Piaget's stage-based cognitive development theory is currently being criticised, many of his ideas (e.g. child-centred approach to education) continue to influence current childhood curricula (Aubrey & Riley, 2016). Evidently, in the context of this study, the constructivist notion of learners constructing their own knowledge requires a move away from teachers being knowledge transmitters to teachers being facilitators of learner-centred science inquiry, giving explicit attention to the nature of science (Zhai et al., 2014). This notion furthermore requires teachers' understanding of learners not being empty vessels, passively awaiting enrichment, but rather being active co-constructors of knowledge (Dahlberg et al., 2013).

The constructivist view of learners possessing prior knowledge demands of teachers to view learners as *knowers* who enter the IBSE situation with knowledge based on their prior experiences (Koch, 2013). The notion that learners' prior knowledge provides a framework for the construction of new ideas furthermore emphasises the need for teachers to understand and use learners' existing ideas as basis for supporting them to construct more comprehensive ideas (Harlen, 2012; Koch, 2013). In this regard the teacher considers children's current knowledge, interacts with them, and helps them formulate sound conclusions by guiding individual children to reconstruct information in ways that are valid and meaningful to them (Martin, 2012).

In Dahlberg et al.'s (2013) opinion, constructivist theories eschew the socially constructed nature of knowledge, and therefore favour social constructivist perspectives that view learners as producing *alternative* constructions. In critiquing constructivist perspectives, these authors argue that "[t]he consequence is a valuing of children's thoughts and values as right or wrong according to whether they agree with a predetermined definition of knowledge and a pedagogy which never gives children the chance to explore their own theories" (Dahlberg et al., 2013, p. 59-60). These authors state that postmodernity disregards knowledge that is universal, unchanging and regarded as absolute truth. While I acknowledge the importance of learners taking responsibility for their *own* learning and meaning-making, I do, however, also acknowledge the importance of self-constructing scientifically legitimate knowledge (i.e. the consensus version of science) through inquiry, in interaction with others and in a supportive context, with the purposeful guidance of a skilled teacher.

2.5.3 Integration of existing theory into a conceptual framework

The key concepts and theories that guided me in undertaking my study are summarised schematically in Figure 2.5 (repeated here from Chapter 1 for ease of reference). In support of the LAMAP IBSE framework I integrated three theoretical perspectives as discussed in the preceding sections. These are (1) themes emerging from current childhood theory; (2) tenets central to theory theory (TT) (Gopnik, Meltzoff & Kuhl, 1999), and (3) constructivist perspectives on teaching IBSE (e.g. Piaget, Vygotsky, and others). In this section I explicate how I integrated these constructs and principles from existing theories to elaborate on the LAMAP IBSE framework.

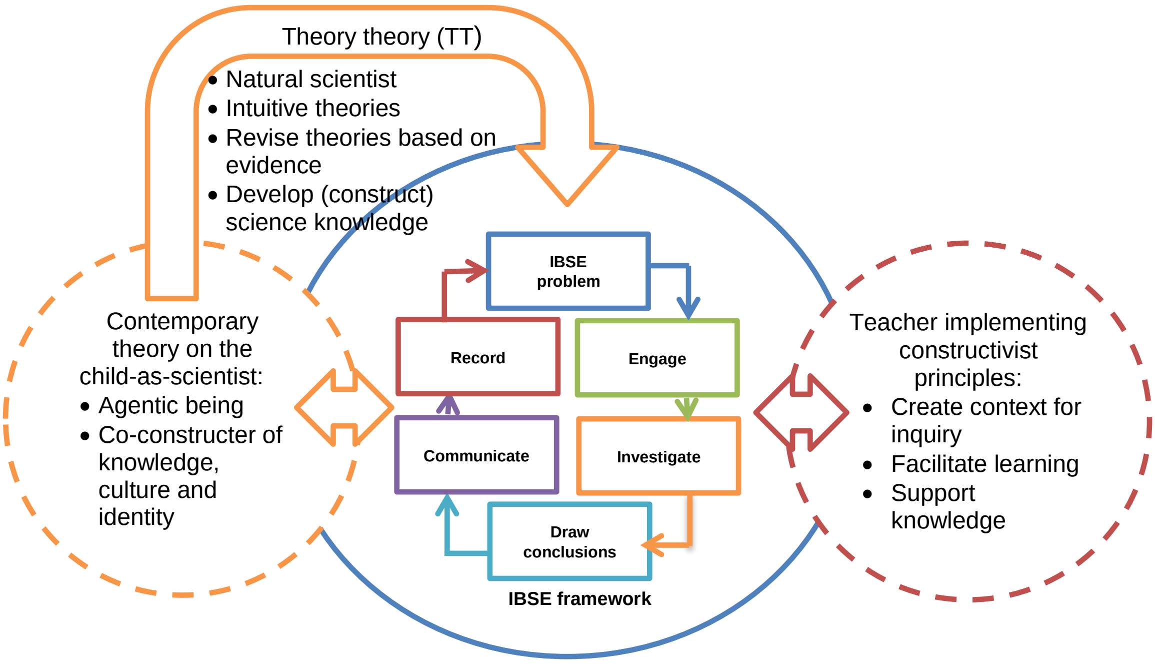


Figure 2.5: Integration of theories into a conceptual framework

The underlying theories I integrated in my conceptual framework have some linking qualities that guided me in undertaking my study. For example, IBSE positions the learner as core participant in the education context (Worth et al., 2009). The contemporary emphasis on children as beings rather than becomings requires a view that children are agentic beings, and consequently able to take the centre stage in any teaching-learning situation (Smith, 2011). Similarly, constructivist perspectives on teaching (e.g. Piaget, Vygotsky) favour child-centred approaches where children are awarded the opportunity to construct knowledge actively from experience (Koch, 2013; Martin, 2012). In the context of IBSE, current childhood views as well as TT theorists thus confirm children's potential to enter the IBSE situation as young scientists, and their agency in the learning and knowledge-construction processes, with the support of constructivist theories suggesting that teachers fulfil the roles of facilitator and supportive agent.

On entering the IBSE cycle, children are confronted with a scientifically-oriented question or problem (Worth et al., 2009). In this regard, TT theorists (Gopnik et al., 1999) regard children's inherent human qualities (for instance, curiosity, motivation, the agony of confusion and ecstasy of explanation) as distinct human cognitive emotions that drive young children's constructive attempts to make sense of and develop theories about their world. To this end, TT supports children's natural disposition towards exploration as important driving force for becoming cognitively committed to an investigation. Similarly, constructivist perspectives (e.g. Piaget and Vygotsky) acknowledge children's natural curiosity as well as the significance of play as important forces of learning, which once again emphasises the teacher's role as a supportive role, creating learners' curiosity that can act as motivator for cognitive engagement in IBSE.

IBSE furthermore engages learners in experiencing science by doing science like real scientists, so as to construct knowledge through action (Furtak et al., 2012, Harlen, 2013a; Pedaste et al., 2015). In supporting LAMAP IBSE, the central tenet of TT (i.e. that the processes of cognitive development in children correlate with cognitive development in scientists), is grounded in the assumption that children are cognitively capable of engaging in investigations to develop theories about the world around them by using the same cognitive strategies that scientists use (Gopnik & Meltzoff, 1997). The notion of children as social actors implied by current childhood theorists furthermore supports children's ability to take agency and contribute to knowledge-construction. This implies that children will take an active and central role in the learning process by making decisions, providing evidence, and influencing change (Kellet, 2012). Consequently, constructivist perspectives assume the teacher's responsibility as being aware of children's competence, but also as one who facilitates an inquiry process (Martin, 2012).

Moreover, both childhood theorists (for example, Malaguzzi, 1993; Rinaldi, 2006; Smidt, 2013) and TT theorists (for example, Gopnik & Meltzoff, 1997) suggest that children possess a wealth of theories about the world around them since infancy, entering the IBSE situation as competent learners (Fisher, 2013). Similarly, the constructivist idea of prior knowledge demands of teachers to see children as *knowers* who enter the IBSE situation with funds of knowledge (Koch, 2013; Martin, 2012). In the IBSE situation, this notion consequently implies that teachers are required to support children to construct knowledge, based on the richness of their prior knowledge and experience they bring into the classroom (Harlen, 2013a; Malaguzzi, 1993).

LAMAP IBSE furthermore assumes that children's prior knowledge may enable them to propose possible solutions to the posed IBSE problem (Worth et al., 2009). In support of this notion, TT implies that children incorporate new information on the basis of their prior theories (Gopnik et al., 1999; Goswami, 2015; Kyriakopoulou & Vosniadou, 2014). Since learners' intuitive theories may be less useful in solving scientifically-oriented problems, LAMAP IBSE proposes direct, active hands-on, minds-on experiences as essential to supporting children's construction of understanding (Harlen, 2012; Worth et al., 2009). In this regard, theoretical modification as proposed by TT implies that children continually and cumulatively build and modify intuitive theories as a result of new evidence (Gopnik et al., 1999). It follows that children's knowledge accumulates through a continuous process of editing, improving, and creatively modifying theories, so that theories become more useful, effective, comprehensive and appropriate to make meaning of the phenomena children encounter (Hedges, 2014). In support of this idea, TT furthermore supports active inquiry as essential to theory revision and conceptual change (Gopnik & Wellman, 2012). This relates to constructivist principles assuming that teachers will facilitate and support learners' construction of understanding, based on their experiences of learning by doing (Cremin et al., 2015; Inan & Inan, 2015).

LAMAP IBSE also supports the human and social nature of science, and evidently engages children in activities that require cooperative work to solve scientifically-oriented problems (Worth et al., 2009). In support of this, TT acknowledges human development as an active social and relational endeavour (Gopnik, 2012). IBSE involves children as citizens who function as a community of scientists, where they acquire and use knowledge practices and skills relevant to science. In further support of this notion, contemporary emphasis on children being social actors who have agency implies that children's scientific development may be culturally mediated. Consequently, working as a community of scientists, using the tools and language of science, may enhance children's development as scientists (Smidt, 2013). Accordingly, sociocultural-constructivist perspectives view learning as social and cultural process (Wild, 2013), and consequently emphasises the role of the teacher in creating constructive environments that will allow for active inquiry in meaningful contexts (Koch, 2013; Stetsenko, 2010; Vygotsky, 1987).

In terms of children being and becoming scientists through engaging in IBSE, both TT and current childhood theories imply that children are beings in the here and now, but also that they hold the capacity to change (i.e. to become). In addition to childhood theorists' constructions of children as beings or becomings, TT theorists' explanation of children as little scientists has contributed to my understanding of children-as-natural-scientists. For this study, I therefore conceptualised children (or learners) both as being scientists, and as scientists-in-the-making (Gelman & Brenneman, 2012). It follows that constructivist teachers should facilitate learners' learning processes and support their knowledge construction in a meaningful context. Consequently, children's capacity to change may explain how their science knowledge accumulates, based on learning by doing in a sociocultural context.

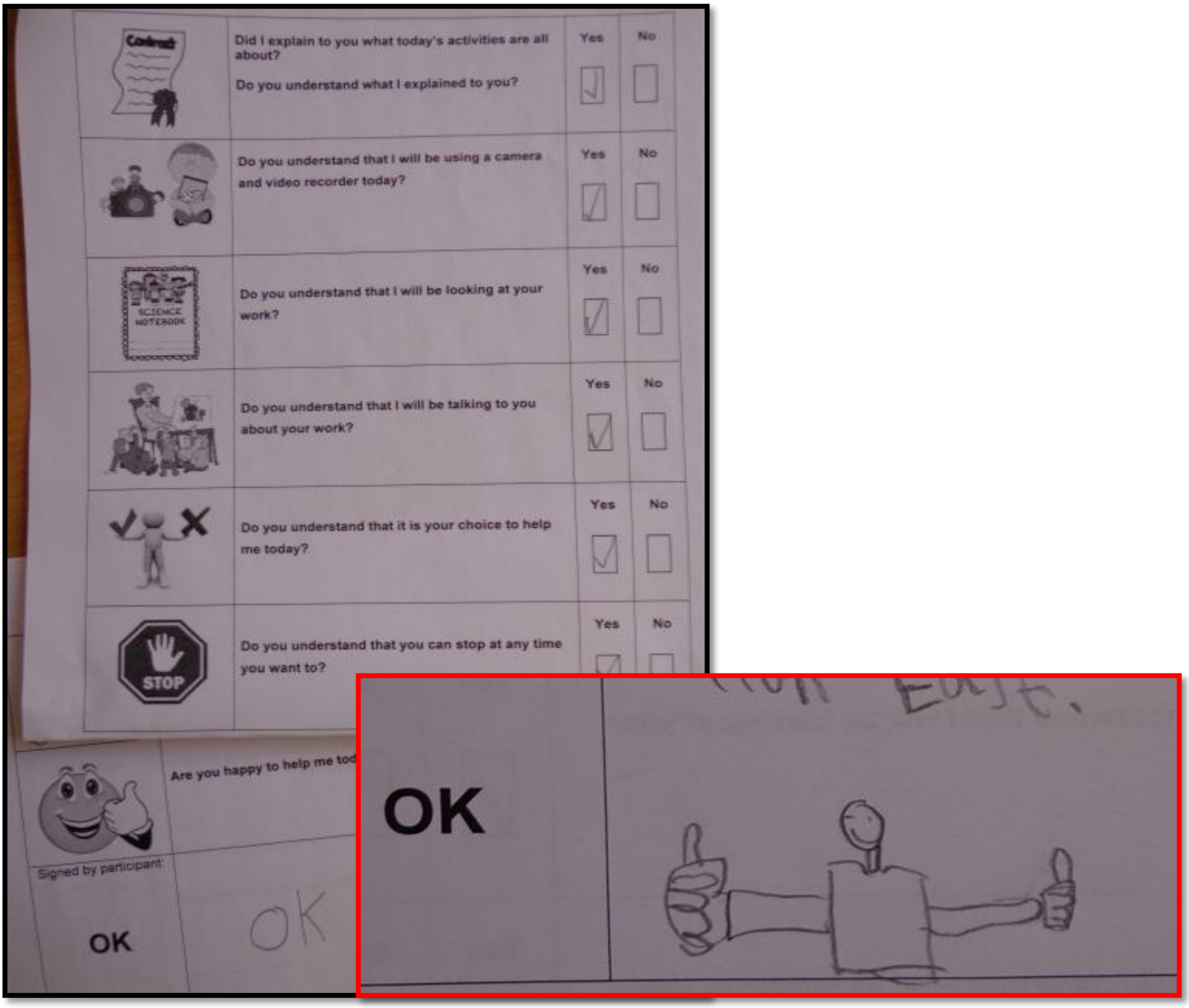
2.6 SUMMARY

In this chapter I discussed existing literature relevant to IBSE. After describing the need for quality science education at Foundation Phase level, I explored the ability of young learners to engage in scientific inquiry, and described the current status of science in early primary curricula. This discussion was followed by an overview of existing definitions and interpretations of the term "inquiry" in the context of science education, followed by an exploration of the essential features and principles of inquiry-based learning. I also explored the teacher's role in planning a child-centred learning environment that is conducive to IBSE, and the role of teacher training programmes in preparing teachers to implement IBSE. I concluded with an explanation of the conceptual framework of the study.

In the next chapter I discuss the methodological choices I made and justify these against the purpose of my study and the research questions I formulated in Chapter 1. I describe the selected paradigms, the multiple case-study research design I followed, and the data collection, documentation, analysis and interpretation procedures I relied on. I furthermore discuss the measures employed to ensure rigour, and the ethical guidelines I adhered to.

Chapter 3

RESEARCH METHODOLOGY AND DESIGN



Contract	Did I explain to you what today's activities are all about? Do you understand what I explained to you?	Yes	No
	Do you understand that I will be using a camera and video recorder today?	Yes	No
SCIENCE NOTEBOOK	Do you understand that I will be looking at your work?	Yes	No
	Do you understand that I will be talking to you about your work?	Yes	No
	Do you understand that it is your choice to help me today?	Yes	No
STOP	Do you understand that you can stop at any time you want to?	Yes	No
	Are you happy to help me tod		
Signed by participant:			
OK	OK		

OK

(Grade 2 learners' assent to participation in the research project, School B, Pretoria, 2015)

3.1 INTRODUCTION

In the previous chapter I articulated the theoretical background and literature pertaining to this study. This background served as basis for the way I planned and conducted an empirical inquiry, focusing on the meanings the participants attached to their experiences, thereby enabling me to connect my findings to theories in the field of early childhood and inquiry-based science education, and to locate, explain and interpret the substance of my investigation.

In this chapter I relate the methodological choices I made to the purpose of my study and the research questions. As introduction, I provide an overview of the main research components and their interconnectedness. I describe and justify my selected paradigms, research design, data collection, documentation, analysis and interpretation procedures. I conclude the chapter with discussions on the measures I implemented to ensure rigour as well as ethical clearance for the research.

Designing a research project requires the researcher's careful consideration of the nature of the phenomenon under study (ontology), the nature of knowing (epistemology), the purpose of the research (e.g. contributing to knowledge, informing policy or transforming lives), and the exemplification of human values (ethical considerations) (Hammersley, 2014). I support Creswell's (2014) view that there should be congruence between the researcher's paradigmatic assumptions, the research methodology – that is related to the chosen world view – and the specific methods of research that translate the approach into practice. Figure 3.1 provides a schematic overview of the methodological approach (qualitative), philosophical paradigm (interpretivism), research design (case study) and research process I followed in addressing the research questions.

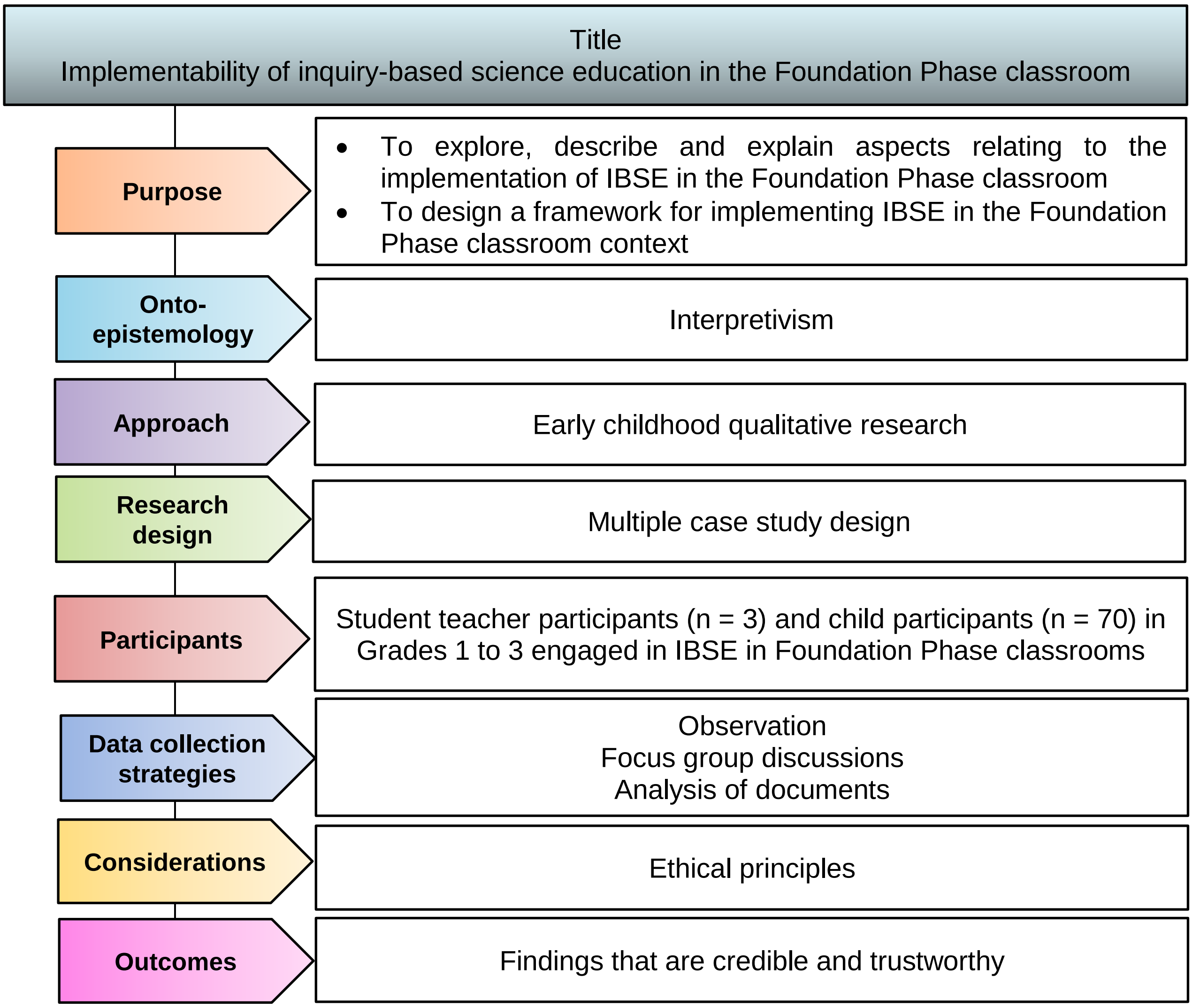


Figure 3.1: Interconnectedness of the components of the study

3.2 PARADIGMATIC CHOICES

A paradigm is defined by Patton (2015, p.89) as “a worldview – a way of thinking about and making sense of the complexities of the real world”. Hammersley (2014) defines a paradigm as a set of ontological, epistemological, political and ethical assumptions that drives the researcher’s decisions about the methodological approach and research process, based on the underlying paradigmatic assumptions. Adopting a paradigm therefore attaches the researcher to a particular world view that prescribes how specific systems of meaning and ways for interpreting reality will be approached (Lincoln & Guba, 2013).

3.2.1 Onto-epistemological paradigm

Understanding humans as social constructs shaped by interaction in particular contexts, calls for flexible and sensitive research approaches that study people in real world settings (Fraser et al., 2014; Rule & John, 2011). As such, understanding how people make sense of themselves, their actions and their surroundings inevitably also relies on the inquirer's experience of sociocultural worlds, as well as the capacity to uncover participants' construction of meaning in particular contexts (Fraser et al., 2014; Gray, 2014; O'Reilly et al., 2013). Hammersley (2014) regards this notion as the starting point of interpretivism.

3.2.1.1 Utilising interpretivism as onto-epistemological paradigm

The overall purpose of this research was to gain insight into how the theory of IBSE can be applied to Foundation Phase education practice. As I attempted to gain insight into the experiences and reflections of the participants (both learners and facilitators of learning), their actions and interactions within the context of inquiry-based science, and the meaning they attached to their experiences (as expressed through verbal, visual and written means) I adopted an interpretivist paradigm. In accordance with the underlying philosophy, I attempted to interpret reality as constructed by the participants based on their experiences, and the meanings they attached to these experiences during inquiry-based practice in an early childhood education context.

In taking an interpretivist stance, I did not consider the participants as objects to be studied according to fixed or measurable qualities, but approached them as social actors, experts in their own lives, and as young citizens with a voice and rights that should be respected (Cristensen & Prout, 2002; Fraser et al., 2014; Groundwater-Smith et al., 2015; O'Reilly et al., 2013; Smith, 2011). Furthermore, I studied their experiences in the real world education context, and not under experimental conditions (Hatch & Coleman-King, 2014).

Interpretivists assume that individuals develop subjective meanings of their experiences, and that these meanings may be multiple and multi-dimensional

(Creswell, 2014). In agreement with Groundwater-Smith et al. (2015), I accepted that the participants were not a homogenous group with consensus views of their worlds, but rather expected them to bring their own intentions, attitudes, beliefs and values into the research context (Creswell, 2014). As such, I acknowledged and appreciated their ideas, perspectives, feelings, and reports on their experiences as honest and trustworthy data (Harcourt & Conroy, 2011; Schurink, Fouché & De Vos, 2011).

In order to "get into their shoes" and to understand (*verstehen*) (Patton, 2015) the participants' constructed reality, I was personally present through classroom visits and observation of the IBSE activities. In the attempt to conceptualise how the children behaved as scientists, how they voiced their experiences, and how the student teachers (as facilitators of science learning) interpreted their experiences of the IBSE context, I worked alongside them, and generated meaning from the data I collected first-hand in the field. To understand their reality, I utilised interpretive methods such as asking them questions, and engaging them in reflective and focus group discussions (Nieuwenhuis, 2007; Creswell, 2014; Schurink, et al., 2011).

3.2.1.2 Addressing the challenges associated with interpretivist research

Lincoln and Guba (2013, p. 40) describe the relationship between the "knower and the knowable" as "highly person- and context-specific". Therefore, I assumed that realities created in this study depended on the transaction between me as researcher and the "to-be-known" (Lincoln & Guba, 2013, p. 40) in a particular context. In my view, meaning would arise during participants' engagement in the IBSE situation, and also during interactions between the participants and me. As such I believe that reality was co-constructed through an interactive and inseparable symbiosis (transaction) between the participants and me, thus reflecting both of our interpretations (Lincoln & Guba, 2013). I realise that this transaction may be subjective and influenced by both sides' prior knowledge and experience, background and interpretation of the contexts (Lincoln & Guba, 2013).

Taking an interpretivist stance, I also remained aware of the fact that I might not detect true meaning easily (De Vos, Schultze, Strydom & Patel, 2011). Therefore, even though I worked in a familiar context, and alongside the participants, I could not merely assume that I understood how they viewed and experienced their worlds (Hammersley, 2014). Keeping this possibility in mind, I employed considerable effort in trying to understand the research activities, in order to comprehend the reasons for participants' actions, and how this reflected the way they experienced their worlds (Hammersley, 2014). In the attempt to unravel the meanings participants ascribed to their IBSE experiences, I therefore employed a range of flexible and interpretive methods. I namely drew from observations, reflection and focus group discussions, visual strategies (e.g. videos, photographs, drawings, field notes and a research journal), to add different layers of information. I conducted a detailed study of the meanings and non-verbal messages conveyed by the participants, contemplating their messages and searching for connections between different parts (Neuman, 2003 cited in De Vos et al., 2011).

As Hammersly (2014) points out, not just anyone can study human behaviour in a particular context. Consequently, this author views the humanness of interpretivist researchers and their capacity, as co-humans, to interpret and reflect on peoples' actions as an advantage. In taking an interpretivist stance, I therefore had the advantage of drawing on my background knowledge and capacity to interpret and reflect on the participants' construction of meaning in the IBSE context. While being an advantage, this, however, also implied a risk of subjectivity. Consequently, being human, I remained aware of the fact that my interpretations of the participants' verbal and non-verbal messages could be subjective and might be influenced by my intuition, values or personally constructed beliefs and opinions of the phenomena under study (Creswell, 2014). As an assumption of interpretivism is that reality is socially constructed and not objectively determined, I relied on reflexivity in my attempt to gain an in-depth understanding and interpret the meanings constructed by the participants in a way that would provide a trustworthy reflection of the particular context (Nieuwenhuis, 2007).

I also remained aware of the fact that I could not claim to generalise the findings of this study beyond the research setting. Once again, the aim of interpretivism is not to generalise, but rather to offer a rich, in-depth description of a particular situation, in order to improve comprehension of the whole (Nieuwenhuis, 2007). Nonetheless, I trust that a holistic picture of the participants' perceptions, and interpretations of their experiences with regard to IBSE may enhance the transferability of findings to other educational contexts (Nieuwenhuis, 2007; Suter, 2012).

3.2.2 Methodological paradigm

I followed a qualitative approach based on my belief that the nature of reality is socially constructed, and that research findings are created rather than discovered (Hatch & Coleman-King, 2014; Nieuwenhuis, 2007). Expanding on Shank's (2006) assertion of qualitative research as a "systematic empirical inquiry into meaning" (cited in Hatch & Coleman-King, 2014, p. 442), Hatch and Coleman-King explain *systematic* as carefully planned and ordered, *empirical* as the collection of data grounded in the world of experience, and *inquiry into meaning* as the researcher's desire to understand how their participants make sense of their experiences. I therefore regard this study as a systematic empirical inquiry (involving both children and adults) into the implementability of a specific practice (IBSE) in the education setting of Foundation Phase children (aged six to nine) in an attempt to understand the meanings participants attached to their experiences.

3.2.2.1 Following a qualitative approach

Silverman (2014) explains qualitative research as the process of describing real-life situations verbally. As such, qualitative research seeks to understand phenomena in the context of the real world, and is generally carried out in real-life situations (Creswell, 2014). As context matters (Hatch & Coleman-King, 2014), I did not set up a contrived environment or laboratory, but collected data directly from the *natural setting* of a Foundation Phase classroom while the participants (learners and student teachers) were engaged in IBSE. Therefore, to capture the enactment of the LAMAP IBSE programme in the Foundation Phase classroom, and to gain insight into participants' experiences, as well as the effects of the programme as experienced by them, I sought to make sense of the complexity of IBSE in a real world context (Creswell, 2014; Hatch & Coleman-King, 2014; Patton, 2015).

A qualitative research approach allowed me to take the complexity of the real world into account and strive to understand the situation as a whole (Patton, 2015). In order to get a comprehensive view (*holistic picture*) of the implementability of IBSE in Foundation Phase classrooms and insight into the teaching and learning situation, I involved both learners and student teachers as participants. Throughout, drew from my own background knowledge and experience. As such, I was a *key instrument* in the research process, from the initial design of the data collection instruments, throughout the process of data collection, analysis and interpretation (Creswell, 2014; Hatch & Coleman-King, 2014).

I relied on *multiple sources of data* (Creswell, 2014). To assist me in uncovering the participants' experiences, I thus observed their behaviour, engaged in reflective discussions with them and examined the documents produced by them. I made field notes from my observations, transcriptions of discussions and analysed the documents, photographs, and children's work that represented the context, identifying themes embedded across all the data sources (Creswell, 2014). To this end I illuminated their constructed *meanings* as revealed through the data I collected from them (Hatch & Coleman-King, 2014; Merriam, 2009; Patton, 2015). Consequently, I regarded the data as authentic representations of the participants' experiences of their participation in IBSE (Hatch & Coleman-King, 2014). As qualitative research is characterised by an *inductive nature*, working from specific to general (Hatch & Coleman-King, 2014), I collected specific examples of IBSE implementation, and used inductive analysis processes to uncover the patterns, categories and themes I found embedded in the data (Creswell, 2014; Hatch & Coleman-King, 2014).

Another important characteristic of early childhood qualitative inquiry is the use of a *flexible and emergent design* (Creswell, 2014; Hatch & Coleman-King, 2014). As Patton (2015, p. 13) puts it: "… things seldom go as planned. Much of what was anticipated never occurs, and things that are never intended, and never even imagined, do occur". Consequently, while I followed a research design as my blueprint, the open-endedness of qualitative research enabled me to use methods flexibly in response to what I found during the data collection and processing phases (Hatch & Coleman-King, 2014). Following Patton's (2015) suggestion, I documented the anticipated as well as unanticipated consequences of the fluid research process.

3.2.2.2 Involving children in early childhood qualitative research

With regard to early childhood qualitative research, Hatch and Coleman-King (2014) explain that this type of inquiry focuses on individuals (both children and adults), practices, policies and institutions that are involved in the care and education of young children between birth and eight[21]. Early childhood qualitative studies hold the potential of offering meaningful insights into the lived realities of young children, as well as the adults who work with and on behalf of them (Saracho, 2014). They can also lead to rich and contextual understandings that are not likely to be found with quantitative studies (Hatch & Coleman-King, 2014; Saracho, 2014). As qualitative research can provide a framework for investigating the experiences of young children and the adults who work with them in their educational settings, as well as the tools to help uncover the meanings they attach to their experiences, I viewed a qualitative approach as suitable for this study. As such, qualitative research enabled me to capture information about the perspectives and experiences of young children as well as the student teachers that facilitated IBSE with them in an early childhood school context.

The landscape of early childhood research has been transformed over the last twenty years (Lundy & Swadener, 2015). Changed views of children and childhood, combined with a renewed universal focus on children's rights, have prompted the reconceptualisation of children's involvement in research (Dockett & Perry, 2014; Shier, 2001). The shift from adults acting as experts in the lives of children doing research *on* or *about* children to research *with* or *by* children, regarding them as the experts in their own lives, is now well established (Hammersley, 2014). Nowadays it is generally acknowledged that children are in the best position to provide knowledge about themselves (Bucknall, 2014; Dockett & Perry, 2014). As Bucknall (2014, p. 82) states: "Far from being vulnerable, incompetent and unreliable, children are now widely acknowledged to be competent and rights-bearing social actors whose voice increasingly appear in social research". Consequently, it has, over recent years, become more common for young children to participate in research, policy and decision-making on issues that are relevant to them (O'Reilly et al., 2013). It follows

[21] In the South African context, early childhood spans the age range of birth to nine years.

that children's voices are imperative in the case of child- or childhood-related research (Bucknal, 2014).

Regardless of the level of participation in the research process, Fraser et al. (2014) contend that the driving force for research involving children should be to understand their lives, focusing on the recognition of children as the experts when their own lives or contexts are concerned. To this end Lundy and Swadener (2015) argue that key to involving children in research ultimately depends on the adult's image of children. Perceiving children as rights-holders, recognising their competence and agency, and acknowledging their entitlement to influence decisions affecting them, inevitably ties researchers to the commitment to take children's views seriously, and to act upon them wherever possible (Dockett & Perry, 2014). As such I viewed the child participants in this study as primary informants and the experts of their own lives.

I involved the child participants as consultants, and employed elements of participation and reflection wherever possible (Hill, 2006; Lansdown, 2005). I thus did not merely rely on my own observations or interpretations of their experiences, or on the student teachers' perspectives on the implementability of IBSE in Foundation Phase classrooms, but involved children through a process of consultation. Although consultation may represent limited child-participation, the information that I obtained may influence policies and practices that can in turn directly affect children, and contribute to knowledge about young children's potential to engage in IBSE, based on their voices as experts (Groundwater-Smith et al., 2015). As such I was committed to give children a voice by allowing them to express their views on their engagement in IBSE.

3.2.2.3 Addressing the challenges associated with qualitative research

In following a qualitative approach, I faced several challenges, including the possibility of being subjective. In addition, my own intellectual shortcomings, possible misinterpretations, and the methods I used could lead to misunderstandings. As qualitative researcher, I was immersed in the study. I constantly focused on being reflexive in an attempt to limit the level of subjectivity. However, I admit that my feelings, thoughts, ideas, opinions and attitudes may have unduly influenced the research process and findings (O'Reilly et al., 2013). Stake (1995) regards the researcher's subjectivity as an essential element in qualitative research, in understanding a phenomenon under study. In this regard, I acknowledge the value of my intuition and personal interpretation as essential element in this study.

Relying on multiple sources of data implies that this study, like other early childhood qualitative studies, generated bulky and voluminous data, which, in turn, required ample time for processing, analysis and verification of conclusions (Hill & Millar, 2014; Miles et al., 2014). With regard to data analysis, I indeed faced the challenge of lengthy and time-consuming analysis activities, due to the amount of data that I had collected. I furthermore found data analysis and interpretation – especially the data generated by child participants – challenging (O'Reilly et al., 2013). In addressing this challenge, I set aside ample time, thereby devoting undivided attention to processing, analysing and interpreting the data.

Qualitative research furthermore implies threats to issues of quality, as it is challenging to determine the credibility and trustworthiness of findings (O'Reilly et al., 2013). In my attempt to counter potential misinterpretations of the data due to personal shortcomings, I relied on triangulation by validating my observations and interpretations from various data sources, and took deliberate effort to disconfirm my own interpretations. Moreover, I alert readers to possible subjectivity, and invite them to make their own interpretations based on the true-to-life representation of the participants' experiences I provide in this research report. In addition, regular reflections and debriefing sessions with my supervisors assisted me in guarding against subjective interpretations (Stake, 1995).

With regard to the potential challenge of not being able to generalise the findings of a qualitative study, I relied on multiple cases as well as multiple units of analysis in order to strengthen the possibility of transferability. Although more cases usually imply a greater chance of addressing the challenge of limited generalisability, generalisability was never my purpose, based on the interpretivist paradigm that I selected (Creswell, 2014; Merriam, 1998).

3.3 RESEARCH DESIGN AND SAMPLING PROCEDURES

In this section I explicate the various steps I followed in carrying out the empirical part of my study. I discuss the research design I implemented, and explain how I selected the cases and participants.

3.3.1 Research design: Multiple case study

I selected a case study design (Stake, 1995) that guided all decisions regarding the collection, processing and analysis of the data, thereby enabling me to answer the research questions and produce ethically sound and trustworthy findings (Creswell, 2014; Hammersley, 2014; Patton, 2015). Stake (1995) regards case study research as a choice of what is to be studied, rather than as methodology. In his conceptualisation of a case, Stake depicts some attributes of a case as “a specific, a complex, functioning thing”, more specifically, “an integrated system” with specified boundaries and “working parts” (1995, p. 2). As such case studies are often used as a strategy of inquiry in qualitative research to systematically explore up-close and in-depth the activities and processes of real-world issues in the context of their natural settings, in order to generate new knowledge (Rule & John, 2011; Yin, 2012). My study was driven by my curiosity to answer how-questions in an early childhood educational context (Hill & Millar, 2014; Yin, 2012).

Creswell (2007, p. 73) defines case study research as an approach whereby a researcher investigates a “bounded system (a *case*) or multiple bounded systems (*cases*) over time, through detailed, in-depth data collection involving *multiple sources of information* (e.g., observations, interviews, audio-visual material, and documents and reports), and reports a case *description* and case-based themes”. While variation exists among methodologists in defining a case, Patton (2015) sees the process of boundary setting as essential in determining the particular case and focus of an inquiry.

I regarded a case study design as suitable choice for this study as I was interested in the holistic picture of how children as scientists, and the facilitators of learning would reflect on their experiences during participation in IBSE in the (natural) context of a Foundation Phase classroom (i.e. early childhood education context) (Yin 2012; Hill & Millar, 2014). Aligned with the interpretivist stance I adopted, I acted as interpreter, and gatherer of interpretations, and attempted to construct knowledge of the participants' perceptions of a particular experience (IBSE) by interpreting their perceptions and experiences (Stake, 1995). My study is defined within the parameters of multiple case study research (Yin, 2012), as I selected three examples of implementing IBSE in the Foundation Phase classroom as cases. To allow for breadth and depth of focus (Rule & John, 2011) and to add to the trustworthiness of the findings (Miles et al., 2014), I thus used multiple cases (different Foundation Phase classrooms) with multiple units of analysis (student teachers as facilitators as well as learners in each Foundation Phase classroom) (Yin, 2012).

In my view these cases represent a heterogeneous sample of Foundation Phase inhabitants (Rule & John, 2011). Through replication (Yin, 2009), the possibility of increasing the "precision, validity, stability and trustworthiness" of the findings could also increase (Miles et al., 2014, p.33). To answer the questions related to "what my case is" and "where my case leaves off" (Miles et al., 2014, p. 28), I articulate the unit of analysis (the focus of the study) as well as the boundaries of the cases schematically in Figure 3.2.

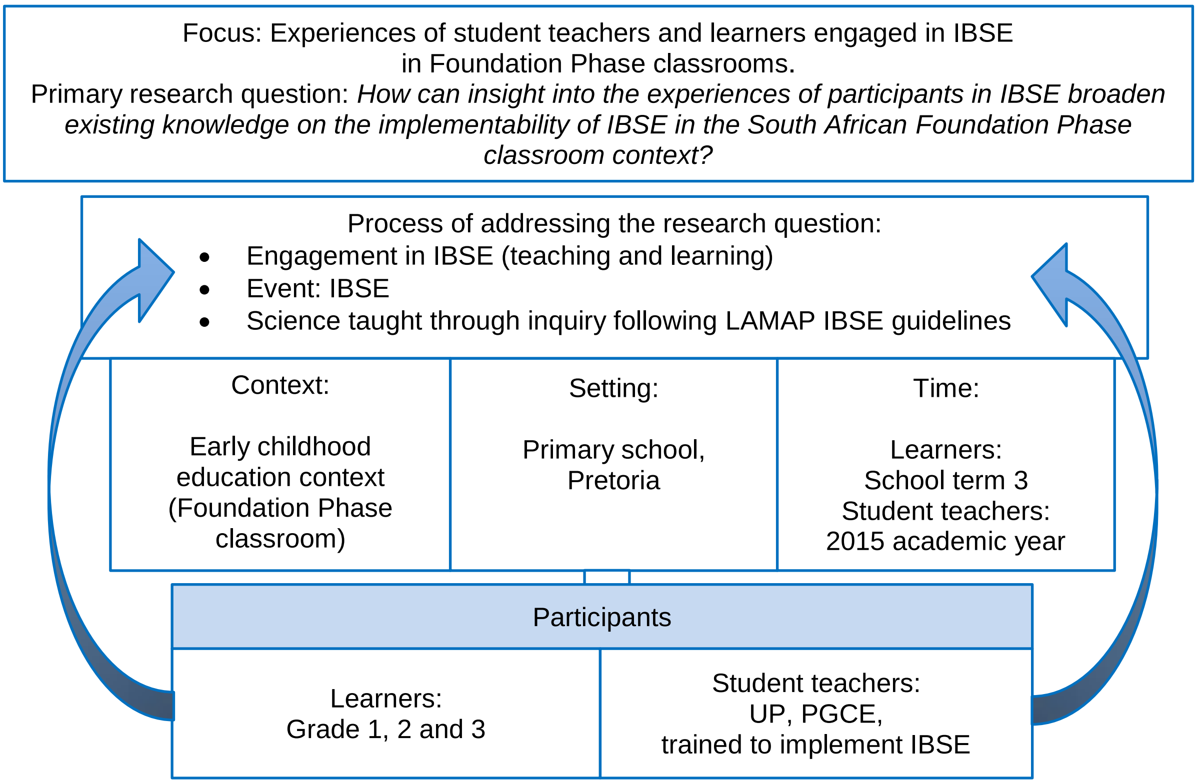


Figure 3.2: Focus and delimitation of boundaries of the study
(adapted from Miles et al., 2014; Patton, 2015; Rule & John, 2011)

Another important consideration that guided my design decision relates to case study research emphasising the importance of the child in context (Hill & Millar, 2014). As such, a case study design enabled me to explore up-close and in-depth a particular context (Foundation Phase classroom), as well as the conditions that may shape teaching and learning in an IBSE setting, involving the actions and interactions of the participants (Hill & Millar, 2014). In this way, I could gain insight into some education concerns (more specifically, science education), and consequently produce knowledge about the world, more specifically, the world of educational practice (Merriam, 1998). Subsequently case study research allowed me to disseminate research in an attempt to impact IBSE practice, and refine the way practice is theorised, i.e. to contribute to knowledge about implementing IBSE in the Foundation Phase classroom (Hill & Millar, 2014).

Selecting a case study research design, however, posed some challenges. Firstly, typical adult images of children, childhood and their position in society, often viewing children as vulnerable innocents in need of adult protection, may assume adult authority in terms of decision-making on behalf of children (Hill & Millar, 2014). Keeping this possibility in mind, I constantly focused on Nieuwenhuis's description of "powerless and voiceless" as a reminder of my view of children as capable social actors with the ability to engage constructively in matters that affect their lives. This idea reminded me to listen to the children's voices, recognise and value their perspectives, and respect their right to participate. In turn, I was able to take them seriously in the recommendations stemming from my research (Lundy, 2007; Nieuwenhuis, 2007).

Secondly, case study designs are often criticised for the inability to generalise findings (Stake, 1995). However, as Nieuwenhuis (2007, p.76) puts it, "a well-selected case constitutes the dewdrop in which the world is reflected". Moreover, Stake argues that the true emphasis of case study research is "particularization, not generalization" (1995, p. 8), implying that the emphasis should be on understanding each unique case. In addressing this potential challenge, I followed Creswell's (2014) suggestion first to provide a detailed description of each case (a within-case analysis; see Chapter 4), followed by a description of the themes within the case (cross-case analysis; see Chapters 4 and 5), as well as an interpretation of the meaning of the cases. Although I can thus not claim to generalise findings, I anticipated that the insight and understanding generated from the three cases selected for this study may contribute to an understanding of the potential (possibilities and challenges) of implementing IBSE in the Foundation Phase classroom. As such, this may potentially have wider application value in the South African context and findings may be transferred to similar school contexts.

3.3.2 Research context

This study was carried out in Foundation Phase classrooms while student teachers were completing their teaching practice in primary schools. Background context includes the higher education setting in which the student teachers have been enrolled for the Postgraduate Certificate in Education (PGCE), with their specialisation lying in Early Childhood Development/Foundation Phase (ECD/FP). As lecturer in the PGCE programme, I have trained students in IBSE as part of their preparation as teachers in an early childhood context. To elucidate the context of my study, I offer some background information about both groups of participants, namely the student teacher participants (in training at a higher education institution) who facilitated IBSE, and the Foundation Phase learners as scientists-in-the-making.

3.3.2.1 Background on the PGCE teacher education programme and student teacher participants at the time of data collection

All three student teacher participants were enrolled for the PGCE (ECD/FP). The PGCE (ECD/FP) is offered over one year during which students qualify as early childhood and Foundation Phase teachers. Through the course of the year they are prepared as generalist teachers (i.e. being able to teach all subjects) for children aged six to nine years. Students selected for the PGCE programme typically hold a Bachelor of Arts (BA) degree. Psychology and/or Education III are an entry requirement, yet most students do not have any science background.

As stated, the PGCE programme prepares student teachers to teach the entire spectrum of subjects of a well-rounded curriculum (Language, Mathematics, Life Skills, Natural Science and Technology, Social Sciences, Physical Education, Art, Music, Drama) – not limited to the South African national curriculum (CAPS). Apart from academic training, the programme follows a reflective-practice approach in support of students' professional development as teachers. In this regard, an internship and mentorship approach is followed, where students spend approximately 18 weeks of teaching practice in schools in Pretoria during school terms[22] two and three. For this purpose, students are placed individually with mentor-teachers and also assigned mentor-lecturers to guide their professional development.

As part of their training as generalist teachers, time is devoted to science education. The science education programme covers a number of themes in early childhood science education, with a specific focus on the way in which science as inquiry can

[22]Schools in South Africa generally follow a four term system. Each term comprise of approximately 10 weeks.

be taught by implementing the LAMAP IBSE framework and guidelines. The training, provided by me as lecturer (also researcher for this study) involves the following:

- Lecture sessions focusing on essential science content (e.g. what science is and entails at ECD/FP level, the components of science, how young children learn science, different approaches to teaching science, etc.)
- A variety of hands-on activities for students to experience the IBSE approach first-hand (i.e. learning inquiry through inquiry)
- DVD[23] sessions (showing Kindergarten and primary school children in action, followed by reflective discussions where important aspects of IBSE are foregrounded)
- Workshops (exploring LAMAP IBSE principles, pedagogical strategies, etc.)
- Group work sessions (using CAPS to design IBSE lessons according to the prescribed themes for specific grades, followed by presentation of these lessons to the whole class for them to respond and make suggestions)
- Students implementing IBSE activities with learners (reception year and Grades 1 to 3) and reflections during the teaching practice period
- Compilations of teaching practice portfolios to, *inter alia*, demonstrate how classroom activities were focused on developing learners' scientific abilities and awareness of themselves as scientists. Amongst other tasks, students include science lessons plans according to the national CAPS requirements, but following the LAMAP IBSE approach.

In preparation of reaching these goals and completing the required activities for science education, students' study material comprise of LAMAP resources[24] (a variety of booklets), a chapter in a prescribed book on teaching science through inquiry, a reader with articles and practical ideas on IBSE (compiled by me as lecturer), as well as links to websites and ideas on IBSE. With regards to the three student teacher participants' experience in IBSE at the time of data collection, the research for this study took place during the third term in Foundation Phase

[23]DVD entitled *Learning Science and Technology in School* that formed part of my initial training by LAMAP in 2012.
[24]Available from the website: http://www.fondation-lamap.org/en/international-resources.

classrooms in primary schools while student teachers were completing their second teaching practice cycle.

Prior to this time, the whole group of PGCE student teachers received training in IBSE, which provided them with the necessary background information on the implementation of IBSE following the LAMAP approach. The three student teachers who volunteered to participate in this study had therefore received some basic training in IBSE when starting to participate, and gained some experience in applying the IBSE approach with reception year children (aged five to six) during the first teaching practice cycle. However, student teachers were still teachers-in-training, being viewed as novices in planning and implementing IBSE. For the purpose of this study, the three student teachers each selected, planned and presented one of the required activities for teaching practice as IBSE lesson.

3.3.2.2 Background on the child participants as scientists-in-the-making

Altogether, 70 Foundation Phase learners (six to nine years) from three classrooms (Grade 1 to 3) participated in this study (one classroom each from three primary schools in Gauteng, South Africa). I view the learners as scientists-in-the-making as I assume that children have inherent scientific potential, waiting to be unlocked. The children involved in this study participated as learners engaged in an inquiry-based investigation, but also as primary informants and experts in terms of their experiences of IBSE.

In South Africa, science forms part of the Life Skills (Beginning Knowledge) subject for Foundation Phase learners. Although CAPS Life Skills allocates two to three hours of teaching time per week to Beginning Knowledge for Grade 1 to 3 learners, the priority for science in the Foundation Phase curriculum is low, and the likelihood that learners are exposed to science on a regular basis is low. The Foundation Phase learners who participated in this study therefore presumably had limited exposure to science activities in their own classrooms, and had not been exposed to LAMAP IBSE prior to the data collection phase. At the time of the classroom observation (towards the end of the teaching practice cycle), learners would however have had some exposure to science activities presented by their student teachers.

During IBSE activities, learners are often required to work in small cooperative learning groups of five to six, where they individually and cooperatively need to employ inquiry skills in order to solve a scientifically-oriented problem. In IBSE, learners' ideas are carefully recorded throughout the process, usually in a science journal and/or on posters. Practices generally followed in South African classrooms however do not allow for active (hands-on, minds-on) engagement and social participation.

At the outset of my study I thus assumed that the actions and interactions of the participants during engagement in IBSE in a classroom context could potentially impact on the way they behaved (learning and teaching). I therefore attempted to study every action and event as they occurred during my investigation. To explore IBSE from children's viewpoint (learning), I utilised methods to collect evidence of their participation throughout the IBSE process (thoughts and actions), but also how they reflected on themselves as scientists during the IBSE activity. In addition, I documented learners' scientific ideas as expressed (communicated) in verbal discourse, individual written communication in science journals, group recordings and class recordings.

3.3.3 Selection of cases and participants

I studied a small sample of people, nested in their contexts (Miles, Huberman & Saldaňa, 2014). To this end, I relied on non-probability sampling strategies to select three Foundation Phase classrooms at different schools, with the learners, as well as the corresponding student teachers placed in those classrooms (Strydom & Delport, 2011). For this purpose, I combined principles of convenience and purposive sampling.

Convenience sampling involves the process of selecting participants based on considerations such as geographical proximity, availability of settings or participants at a certain time, accessibility, or the willingness of people to volunteer (Maree & Pietersen, 2007). Patton's (2015) interpretation of convenience sampling as doing something that is fast, convenient and cost-effective, was however not the main factors I considered in using this strategy to select the cases for my study. I rather relied on convenience sampling to select the three participating schools, based on their geographical proximity (Pretoria, Gauteng), their availability at a certain time (accommodating PGCE student teachers during a teaching practice cycle) as well as accessibility. I also relied on convenience sampling in selecting student teachers as participants, i.e. student teachers that formed part of my PGCE class at the time and who were willing to participate.

In cautioning against the use of proximity, convenience or familiarity when selecting the research context or participants, Hatch and Coleman-King (2014) state that: “The central consideration for an early childhood study should be the likelihood that data will be available to answer the research questions adopted by the researcher” (2015, p.449). Similarly, Patton (2015) alerts researchers to be aware of problems typically associated with convenience sampling. He views convenience sampling - connoted with easy access - as “lazy and largely useless” (Patton, 2015, p. 309), with the possibility of being information-poor, dangerous (for validity reasons), limited in usefulness (taking advantage of unanticipated opportunities), and low in credibility. As I set out to specifically explore the implementability of IBSE in Foundation Phase classrooms, I focused on an in-depth understanding of this phenomenon. Involving schools where student teachers whom I have trained in this approach were teaching in accordance with the training they had received, justifies my choice to follow this strategy, as this allowed me to best address the research questions.

Following Hatch and Coleman-King (2014) as well as Patton’s (2015) argument, I opted to integrate purposeful and strategic sampling principles. Although my cases were conveniently available, my central consideration was thus to seek out settings in which the phenomenon I set out to explore would most likely occur, and where the data I collected could answer my research questions (Hatch & Coleman-King, 2014; Silverman, 2014). As stated, the PGCE student teachers had been trained to facilitate LAMAP IBSE, and therefore, the classrooms in which they implement IBSE to Foundation Phase learners could best address the purpose of my research. For this reason, I conveniently, yet also purposefully selected three Foundation Phase classrooms from different primary schools in Pretoria.

With regards to the criteria I applied in selecting the schools and student teacher participants, I selected three student teachers from the PGCE class of 2015, based on their willingness to participate, as well as the following criteria:

- Participants had to be University of Pretoria students, PGCE (ECD/FP) from the 2015 cohort
- They had to have received training to implement IBSE according to LAMAP, and attended all training sessions
- They had to provide informed consent for their participation
- They had to be placed in English-medium primary schools in Pretoria Gauteng for the teaching practice period
- They had to be placed in such a way that I could involve one class from each grade to cover the formal Foundation Phase (i.e. one Grade 1, one Grade 2, and one Grade 3 class).

Apart from involving three student teachers as participants, I included the learners from the three classes as participants. All the learners in all three classes participated, following implementation of the following criteria:

- Parents of the learners had to provide informed consent
- Learners had to provide informed assent and participated voluntarily.

In addition, I purposefully selected one small group of learners from each class to participate in follow-up focus group discussions after the lessons had been facilitated. With regard to these small groups (five to six learners each) I selected, I relied on the quality of the data I collected when observing implementation of the IBSE lessons, but also consulted the classroom teachers and student teachers in making my decisions. Further criteria I applied were that consent had to be provided by parents, and that learners had to be willing to participate in the focus group discussions and provide informed assent. Their availability on the days of the sessions was also considered as a criterion. I attempted to include groups of a diverse nature.

The cases, schools and participants I selected are summarised in Table 3.1.

Table 3.1: Summary of cases and participants

Case	School	Grade	Student-teacher	Number of learners per class	Number of children per focus group
1	A	1	Bronwyn[25]	25	5
2	B	2	Jean	30	6
3	C	3	Monique	15	5
N	**(3)**	**(3)**	**(3)**	**(70)**	**(3 groups)**

3.4 DATA COLLECTION AND DOCUMENTATION

In order to investigate the cases under study in their complexity and entirety, I relied on multiple sources of data, utilising several qualitative methods and tools to collect and document data. In my attempt to gain insight into how the theory of IBSE can be applied to Foundation Phase practice, I thus collected and documented data on the experiences and reflections of both learners and facilitators of learning (i.e. the student teachers) in terms of the meanings they attached to their experiences of actions and interactions in the context of inquiry-based science. I utilised data collection and documentation methods associated with interpretivism to reveal the participants' perspectives (Hatch & Coleman-King, 2014; Hill & Millar, 2014; Nieuwenhuis, 2007; Stake, 1995).

As early childhood researcher implementing methodology that embraces social research with children and young people, I attempted to include a variety of innovative, more inclusive, child-friendly methods, which contained elements of participation and reflection (Birbeck & Drummond, 2014; Hill & Millar, 2014). Although I considered the age of both groups of participants, I designed methods that would most likely yield relevant and useful data that could answer the research questions – giving the participants a voice (Birbeck & Drummond, 2014). I attempted to build sound relationships of trust with both groups of participants, and to create accepting, encouraging and non-threatening environments in which I viewed all participants as the experts of their experiences (Birbeck & Drummond, 2014).

[25]I used names chosen by the student teacher participants in referring to them when reporting on the study. Pseudonyms are used to refer to the child participants that formed part of the focus group discussions.

3.4.1 Pre-data collection phase

In this section I explain the activities that occurred prior to commencing with data collection on the implementation of IBSE in Foundation Phase classrooms.

3.4.1.1 Gaining access and permission to conduct research in the school context

Involving school children in research evidently requires cooperation and permission from several gatekeepers (Fargas-Malet, McSherry, Larkin & Robinson, 2010). Apart from obtaining permission from the Gauteng Department of Education and the University of Pretoria, I requested access to the schools, and sought permission to conduct research in the classrooms from school principals and teachers. For this reason, I visited each school on several occasions to have discussions with the principals and classroom teachers, explaining the purpose of my research, the research process and what the schools' involvement would entail. I also used these visits to get acquainted with the various school and classroom contexts, as well as the learners who participated.

3.4.1.2 Planning meetings with student teacher participants

After obtaining informed consent from the three student teacher participants (see Appendix B for the consent letters), and before commencing with data collection, I conducted several planning meetings with them (three to four visits per school). Although student teachers had freedom in making their own decisions about the topic and type of IBSE activity they wanted to present, I offered assistance in terms of their planning and collection of resources for the activities. Although I had several discussions with the students about their lessons and lesson planning, I was neither prescriptive nor corrective. I guarded against influencing them as I wanted to explore the student teachers' implementation of IBSE based on what they had learned during the course of the teacher education programme.

3.4.1.3 Preparing classrooms for observation

Prior to commencing with the IBSE activity, a final meeting with student teachers involved decisions about the organisation of the classrooms for the IBSE lessons, displays of resources to ensure easy access, procedures for grouping learners, colour-coding groups, and organising individual name tags according to the colour of each group. For the purpose of the IBSE lessons, children thus worked in small groups of five to six learners involving four to five groups per class.

This practice aligns with the principles of LAMAP IBSE involving small cooperative learning groups. With the student teachers' help, we divided the groups according to colour (red, blue, yellow, orange, green, etc.). Tables (groups) were numbered and colour-coded. Photograph 3.1 captures he classroom organisation.

Photograph 3.1: Layout of classroom (School B, Grade 2), with group placement done according to numbers and colours

To help me keep track of individual learners' participation, and of each group's participation, the learners' names were written on labels representing the various groups' colours. These labels were pasted onto learners' shoulders where they were easily detectable, even in the video recordings. Photograph 3.2 captures an example of a colour-coded group number and name labels.

Photograph 3.2: School C, Red Group, showing a colour-coded group number and label

3.4.1.4 Setting up digital equipment

As I relied on digital equipment for observation and documentation purposes, I set up the recording devices in the most appropriate locations prior to commencement with the IBSE activities. I used a GoPro video recorder to capture wide lens views of entire classroom events. In addition, I made several other recordings using a mobile device and digital camera.

Before the commencement of the IBSE sessions, I introduced the digital equipment to the learners, explaining that I would use these as tools for observation, and how these would be utilised. I also had additional recording devices available, and invited child participants to utilise these should they wish to record important events during their participation in the activities.

3.4.1.5 Obtaining informed consent and assent

In addition to gaining permission from the principals and student teachers (see Appendix B), I obtained informed consent from the child participants' parents and informed assent from learners themselves. Seeking learners' assent to voice their experiences was an important first step before the data collection process. I devoted an entire session prior to the commencement of the IBSE activity to explaining the research project to the learners, and the central role they would fulfil. Based on this session, child participants could act as informed young citizens about their right to assent, dissent and/or withdrawal. An overview of the assent sessions is provided in Table 3.3, and examples of the informed consent and assent forms are included in Appendix B. All sessions included reading, completing and "signing" of the assent letters by means of the OK-sign (Harcourt & Hägglund, 2013).

Table 3.2: Summary of assent sessions with learners

School	Grade	Date	Venue	Duration
A	1	21/08/2015 (08:30)	Grade 1 classroom	30 min
B	2	27/08/2015 (10:00)	Grade 2 classroom	35 min
C	3	15/09/2015 (09:30)	Grade 3 classroom	40 min

3.4.2 Data collection with child participants

To answer the questions on how Foundation Phase learners engage in IBSE, how they reflect their experiences of IBSE and how they view and express themselves as (natural) scientists, I regarded the child participants as primary informants who are competent and worthy to contribute unique and valid information, thereby adding value to my understanding of the phenomenon under study (Harcourt & Conroy, 2011). To enable them to express themselves freely, I employed a variety of child-friendly data collection methods and relied on children's active participation in co-constructing data. An overview of the data collection methods I utilised with the child participants is presented in Table 3.2

Table 3.3: Overview of data collection methods utilised with child participants

Data collection method	Description
Observation	Interactive observation, captured by means of digital equipment and observation (field) notes.
Whole group reflection session	Interview-type semi-structured questions to elicit reflections on participation in IBSE activities.
Focus group discussion	Reconstruction of IBSE events in PowerPoint, used as prompt to elicit discussions.
Document analysis	Science journals, drawings and unintended documents.

3.4.2.1 Observation

Qualitative observation involves the process of gathering information by observing people and places at a research site by taking field notes on behaviour and activities occurring on site (Creswell, 2014). I observed participants in the context of the real classroom (natural school environment) in which IBSE was enacted (O'Reilly et al., 2013; Patton, 2015). Table 3.4 provides an overview of the observation sessions of the three cases.

Table 3.4: Overview of observation sessions

School	Grade	Date	Venue	Duration
A	1	21/08/2015 (10:00)	Grade 1 classroom	150 min
B	2	27/08/2015 (10:30)	Grade 2 classroom	120 min
C	3	15/09/2015 (10:00)	Grade 3 classroom	120 min

In order to obtain first-hand information, I entered the classroom (authentic context) and was present while the student teachers facilitated IBSE with their classes (Patton, 2015). Thus, observation enabled me to study the actions, reactions and interactions of the two groups of participants. I was able to capture and portray the vivacity and situatedness of actions, interactions and behaviour in the teaching-learning situation (Rule & John, 2011). Capturing participants' engagement in this context furthermore provided me with a holistic perspective of how IBSE occurred in the Foundation Phase classroom (Hatch & Coleman-King, 2014; Stake, 1995; Rule & John, 2011; Yin, 2012; Patton, 2015).

Although I was present in the classroom and could observe the implementation of IBSE from both a teaching and learning perspective, my observations focused more strongly on how child participants responded to the IBSE approach than on the reactions of student teachers. In this regard, my research questions required of student teachers to reflect on their experiences of facilitating IBSE, and not of me to evaluate their performance. Being there and scrutinising the visual materials after the IBSE lessons allowed me to observe the actions and interactions of both groups of participants, and enabled me to gain an understanding of their engagement (teaching and learning) in the IBSE activities (Creswell, 2014).

Observation in early childhood research settings may take different levels of involvement with the participants (Hatch & Coleman-King, 2014). During observation I did not intend to be unobtrusive, relying on a structured format (non-participant observation), but I was also not fully participating (participant-observer) (O'Reilly et al., 2013; Patton, 2015). I viewed my role as that of "interactive observer" as I engaged with learners and interacted with them during the classroom activities. In this way I could combine non-participant observation to study children's activities from a distance and comprehend something of the overall pattern of their activities, and participant observation by interacting with learners and asking them to explain their thinking, actions and feelings while being engaged in IBSE. The latter enhanced my understanding of what particular children or groups were doing, how they responded to the activity, the materials, to one another and to me (Hammersley, 2014).

In addition to relying on my own senses to collect data onsite, I supported my observations by documenting what I observed via digital video and camera technologies. To capture evidence of the learners' participation in IBSE, I moved in-between individuals and groups of learners, listened to their conversations, asked them to explain specific events or comment on their participation, and then recorded these contributions digitally and in the form of field notes. My role as interactive observer thus involved interacting with, and capturing learners' actions, behaviour and conversations, by using a mobile recording device as depicted in Photograph 3.3.

Photograph 3.3: Researcher's role as interactive observer

One advantage of using digital instruments to capture my observations relates to the data I may have missed during direct observation without any recordings (Hatch & Coleman-King, 2014). Being involved as interactive observer in the classroom events, I did not have the time to make comprehensive descriptive notes on all the events and conversations I observed; however, the recorded observations enabled me to review what I had observed many times after the sessions in order to better understand my observations and to revisit these when I needed to. Another benefit of recording my observations digitally is that it presented a creative avenue for me to represent learners' engagement in IBSE visually, during facilitation of the focus group discussions (Hatch & Coleman-King, 2014).

In addition to gaining insider knowledge during observations (Patton, 2015), I thus gathered digital data to use during follow-up focus group discussions, in stimulating further discussions and enhancing learners' participation. As interactive observer, I moved around among the groups, and made short video-recordings of each group's participation in the activities. I asked questions and encouraged children to explain what they were doing, and to clarify specific events (with specific individuals and with the group as a whole). I also took pictures of important incidents occurring during my observation, using both the mobile device and digital camera.

I furthermore invited learners to take any of the available equipment (video-camera, mobile device or camera) should they wish to use this to record important events (Hammersley, 2014). Even though I intended to use these pictures or recordings during focus group discussions, learners were so immersed in the IBSE activities that most of them did not use this opportunity. It was only in School A (Grade 1) where children stayed in during break that they used the equipment to make some recordings. I was subsequently able to use these recordings for the follow-up focus group discussion at School A.

Transcripts of the video-recorded interactions between participants during engagement in IBSE provided copious amounts of rich and useful data. However, as Hill and Millar (2014) caution, it left me with loads of data that I had to store and analyse. In capturing the observation data, I opened case folders for each school (clearly labelled), and created a number of sub-folders, labelled according to its contents (e.g. classroom layout, resources, etc.). I also created sub-folders for the groups that participated in each classroom (e.g. Red, Blue, Yellow, etc.) and thus downloaded the digital data on my computer, and stored the video clips and photographs in the folders I created for each group. Thereafter I watched and labelled each video clip, and numbered them according to the sequence of the actual events I observed. I then transcribed a selection of the onsite interactive videos (more specifically the groups I selected to participate in follow-up focus group discussions).

Creswell (2014) highlights possible challenges associated with qualitative observations, i.e. that the researcher may be experienced as an intruder, that the researcher may lack the necessary skills to complete proper observations, and that some participants may find it difficult to establish rapport. As inexperienced qualitative researcher, I therefore relied on an observational protocol (see Appendix C) to record information. I used this protocol to record my descriptive and reflexive field notes, and to capture demographic information (e.g. time, place and date of the classroom setting) (Creswell, 2014). In addition to my observation notes, I compiled a reflexive diary and made transcriptions of the recorded data (Maree & Van der Westhuizen, 2009). As Yin (2012) suggests, I presented the observational evidence I gathered with a clear description of my intent of the data collection as a neutral, factual and objective representation, a representation of the views of the participants, or my subjective interpretation of what I had observed.

Although the use of digital equipment during observation may be experienced as intrusion by participants (Creswell, 2014), I did not find this to be the case in this study. Learners responded positively when asked for a picture or recording to be made of their participation and interaction. With regard to the student teacher participants, as they were assessed on several occasions by mentor-lecturers, mentor-teachers or peers, they were used to having a third party present in their classrooms. However, for this study, I took on the role of researcher, and not as lecturer or mentor, and I was not involved in student assessment of the activity in any way. The student teachers were well informed about the research project and their additional role as associates, working with me in a collaborative and participatory way to implement a specific approach in Foundation Phase classrooms, and to reflect on their experiences.

3.4.2.2 Whole group reflection sessions (group interviews)

Following the classroom observations, I conducted a reflection session in the form of a group interview with each class as a whole, to explore learners' experiences of the IBSE activities I had observed. Interviewing as strategy involves asking the participants questions and recording their answers. Interviews may take several forms, for example, formal, informal, structured, semi-structured or unstructured, depending on the character of the data the researcher wishes to collect (Hammersley, 2014). I focused on the group as a whole as I was interested in gaining insight into learners' collective experiences of participating in the IBSE activities, striving towards obtaining a holistic view. In this regard, I believe that the involvement of the entire class generated richer responses than what individual interviews or small focus group discussions would have (Hatch & Coleman-King, 2014). Furthermore, as group interviews can potentially generate multiple viewpoints on a specific topic, I regard this method as suitable for obtaining data on learners' experiences of engaging in IBSE (Greeff, 2011).

I facilitated the reflection sessions within a week after the IBSE activities had been completed (depending on the times that were allocated to me by the classroom teachers), in the learners' familiar classrooms (Greeff, 2011). In addition to prompting the views of participants, I also noted the interaction between group members (Greeff, 2011; O'Reilly et al., 2013). Table 3.5 provides an overview of the whole group reflection sessions I facilitated.

Table 3.5: Overview of whole group reflection sessions

School	Grade	Date	Venue	Duration
A	1	24/08/2015 (11:30)	Grade 1 classroom	30 min
B	2	27/08/2015 (12:30)	Grade 2 classroom	35 min
C	3	16/09/2015 (13:00)	Grade 3 classroom	40 min

Before starting the sessions, I reminded learners of the nature, aim and significance of their participation in this study. I also requested their permission to record the sessions, explained the rationale and importance of the recordings, and again indicated how the digital instruments would be used. For this session I posed a set of pre-determined questions (see Appendix C for whole class reflection session schedule), set according to the phases of the LAMAP IBSE process, with my research questions as background. Despite following a semi-structured schedule, my agenda was also informed by the specific dynamics and occurrences in each class. I therefore included questions that focused on specific individuals, groups or incidences that were pertinent to the different cases. In this manner, I was able to elaborate on specific events or clarify issues, e.g. learners' behaviour, thoughts and feelings occurring as a result of their participation (Greeff, 2011; Rule & John, 2011).

Hatch and Coleman-King (2014) explain that individuals think, behave and talk differently when responding in groups. As I was interested in the interaction among learners, as well as their dialogues in the context of their classrooms, I remained flexible and made provision for engaging with the responses provided by the child participants. To gain deeper insight I prompted learners to elaborate on or explain their responses, or to give examples to substantiate their responses where required (Greeff, 2011).

The whole group sessions enabled me to gain insight into learners' experiences as voiced in their own language, using their own words (Creswell, 2014). It created an avenue for a variety of opinions and experiences to be voiced, and a space for different ideas to be challenged by others. In addition it helped me gain insight into classroom culture and dynamics, as well as the hierarchical positions that existed within groups (O'Reilly et al., 2013). I transcribed all discussions verbatim and stored the transcriptions electronically for data analysis.

Involving children as informants and capturing their perspectives individually or in group discussions may, however, be challenging (Hatch & Coleman-King, 2014). During the discussion sessions I faced the potential challenge of some learners' dominating the conversations, and of shy learners being reluctant to contribute (O'Reilly et al., 2013). As I was aware of this possibility, I allowed as many as possible learners to answer each question, and then redirected the questions to engage quieter learners and hearing their views. I was reluctant to silence learners who wished to elaborate or take the lead in discussions, thereby providing more information than others.

I scheduled the sessions during suitable times of the school day with learners seated comfortably on a carpet (Hill & Millar, 2014). Even though all of the schools were very accommodating, the times available were not always ideal. For example, in School A the session was scheduled for 30 minutes before closing time, resulting in my having limited time at the end of the school day. Learners were tired and restless, excited to talk at the same time, with a high noise level outside. For this session, I used my video equipment (GoPro and mobile device) as recording devices, and asked the student teacher to compile verbatim transcriptions of the learners' responses. Due to the noise level, the video recording was of poor sound quality, and some of the responses could not be captured in detail. Following this first round of discussions, I used voice recorders as "microphones" at Schools B and C, for learners to use when they wanted to respond. Child participants responded very well to this approach, and were eager to use the microphone to capture their voices, providing me with accurate and high quality recordings on the information shared.

3.4.2.3 Focus group discussions

In further support of my quest to gain insight into learners' experiences of IBSE, and to create a space for them to express their voices and perceptions, I selected one group from each class, consisting of five or six learners, to participate in a follow-up focus group discussion. I opted for focus group discussions as an avenue for learners to share their experiences and views in the presence of group members who participated cooperatively in the IBSE activity. I believe that focus group discussions assisted me in uncovering some factors that influenced learners' opinions, behaviours and motivations as a result of engaging in IBSE (Greeff, 2011).

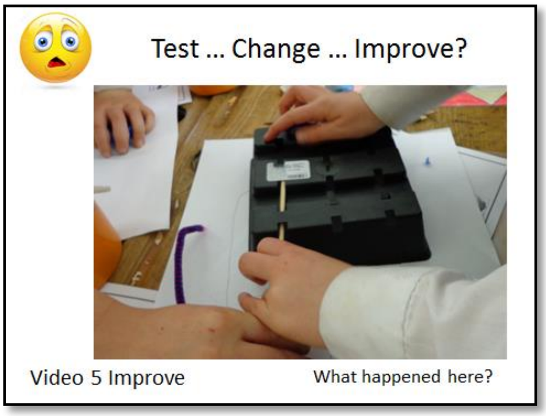
I conducted the discussions a few days after the IBSE activity and my initial observations. The time lapse was necessary to allow sufficient time for me to work through the data I had collected, and reconstruct the IBSE events as authentically as possible for all groups. In addition I wanted to explore learners' recall of the IBSE events after some time had lapsed. Table 3.6 provides an overview of the focus group discussions I facilitated.

Table 3.6: Summary of focus group discussions

School	Grade	Focus group	Date	Venue	Duration
A	1	Green group	25/08/2015 (09:00)	Foyer of the school hall	30 min
B	2	Orange group	02/09/2015 (13:00)	Grade 2 classroom	35 min
C	3	Blue group	21/09/2015 (11:00)	Unused classroom	40 min

In preparation of the discussions I reconstructed the IBSE events by using PowerPoint presentations based on the data I had collected. For this purpose I compiled a selection of video clips, photographs, and science journals that I had collected for each group. I attempted to reconstruct the events by thoroughly scrutinising the data and first getting an overview of the whole class's participation in the IBSE events. Based on the selection criteria I applied (stipulated in Section 3.3.3), I selected one group per class.

Before commencing with the focus group discussions, I reminded the learners of the project and explained the purpose and procedure of the session. I followed the same agenda, and used the same protocol (see Appendix C) for all three cases, yet tailor-made to suit the specific events of the different IBSE lessons. All the presentations contained the names of the group members, with video clips, photographs and reproductions of their work to represent the sequence of events and foreground important activities. The presentations contained visual media, scripts and prompts to stimulate discussion and enhance participation (Groundwater-Smith et al., 2015). I guided the child participants through the presentations, and then asked questions based on the presentation concerning their participation and experiences of the IBSE experiences. Photograph 3.4 displays a slide that was constructed for the Grade 2 focus group discussion, based on their participation in the IBSE activity. The PowerPoint presentation can be viewed on the compact disc, as part of Appendix C.



Photograph 3.4: PowerPoint presentation, School B, Orange Group, Grade 2 (Slide 8/23)

As I regard learners as experts of their own experiences, I was interested in hearing their voices on their participation (Lundy, 2007). For this reason I invited them to participate in the discussions and to "co-present" the sessions. I thus used these sessions as platform for children to comment on their participation, and further elaborate on the events that had occurred in the group during their engagement in the IBSE lessons. Where I needed further elaboration, I conducted informal conversations with individual learners, and invited them to elaborate in their own words on their participation (Wallerstedt et al., 2011). As the PowerPoint presentations represented my interpretation of the events that had occurred, these sessions also served as member checking opportunities, allowing learners an opportunity to comment on or confirm my interpretation of their experiences of the IBSE activities.

Throughout I had to be an active listener, not listening only to the spoken words of the learners, but also to the ways in which they expressed themselves (Rinaldi, 2006). In order to make notes on the sessions and contributions – verbal and non-verbal) – I printed a notes page of my presentations to document responses on the printout as I proceeded with the presentations. The conversational nature of the discussions made comprehensive note-taking impossible. Consequently, I relied on the audio- and video-recordings of the sessions to revisit the discussions, and to add my notes to my field journal.

The interactive and conversational nature of the group discussions also complicated the transcription of the sessions (Groundwater-Smith et al., 2015). I subsequently summarised the discussions, indicating the times of the recordings so that I could revisit the recordings should the need arise. As such, I transcribed only the parts of the focus group discussions that directly related to the research, yet stored all recordings for further reference as needed.

Conducting focus group discussions with young children implies some potential challenges. Wallerstedt et al. (2011) for example, mention that adults may experience difficulties to interpret the true meaning of children's perspectives, since children may have limited ability to articulate their ideas. I remained aware of my limited experience in this regard, yet did not experience this as a challenge as the child participants were generally well versed and proficient in articulating their ideas in an understandable way, despite some grammatical errors.

Another potential challenge pointed out by Hill and Millar (2014) relates to the possibility of ideas being influenced by the group, making it difficult to identify individual children's perspectives. In the case of school B I experienced this challenge in one of the groups, where group members seemingly experienced difficulty to work together during the IBSE activity. Videos and photographs of the IBSE activity that I shared via the presentation stimulated renewed conflict in the group, and as a result, the dynamics during the focus group discussion produced some negative energy that seemingly impacted on individual children's contributions. My encounter with this challenge emphasised the importance of applying ethically sound principles in accepting all participants' voices, and treating them equitably and justly at all times, recognising that they are not a homogenous group, and to treat all different types of participants without prejudice, regardless of one's own experiences (O'Reilly et al., 2013).

Working with children posed another challenge, namely that responses from a child's perspective could potentially differ from my perspective as researcher (Wallerstedt et al., 2011). To this end I attempted to co-construct meaning with the child participants, encouraging elaboration and further discussions when representing their meanings (opinions, ideas and theories). My aim is for readers to be able to reflect on and debate the meanings I present in this report (Harcourt & Conroy, 2011).

3.4.2.4 Document analysis

Document analysis involves the study of existing documents such as personal, official, mass media or archival material in order to understand their substantive content or to illuminate their deeper meanings (Strydom & Delport, 2011). Documents may include text (e.g. reports and journals) as well as images (e.g. photographs and drawings) (Hammersley, 2014). I collected a range of documents produced by learners as a result of their participation in the IBSE activity; for example, their science journals (or notes), group posters (recording scientific ideas) and drawings. I regarded learners' written and visual documents as a valuable source of information, and analysing them offered me the opportunity to gain insight into their experiences as expressed in their own language and words (Creswell, 2012).

During IBSE children systematically record their thinking throughout the investigation process, using a notes page, science journal and/or a poster. Analysing these documents enabled me to gain insight into learners' ability to record their scientific ideas in writing, as well as the ways in which they recorded their ideas (drawings, symbols, text). As the format and instructions for recording ideas were designed by the student teachers, this analysis provided me with some insight into the suitability of the designed format. I collected 70 science journals in total, which I sorted and labelled according to the group colours and participant numbers[26].

In addition to the science journals, I collected the child participants' drawings of their participation in the IBSE activity, viewing this as an additional avenue for young children to express their experiences in an informal and relaxed way. Advantages of child-drawings include that they do not require language skills, and can furthermore create an avenue for children to represent their ideas about events to creatively express and represent unconscious views and beliefs (Harrison, 2014; Rule & John,

[26]For example, SJ_BG_L1 refers to Science Journal, Blue Group, Learner 1.

2011). In this regard I specifically requested the student teachers to facilitate a drawing activity where learners drew themselves as scientists during their participation in the IBSE activities, requesting them to highlight events that they regarded as important. The drawing activity was conducted in the early weeks following the IBSE activity, in my absence. I furthermore requested student teachers to either make notes on the drawings on behalf of the learners, or to allow learners to add their own thoughts in writing. As such, I regard the drawings and accompanying notes as representation of the learners' expressions of their experiences of the IBSE activities.

Apart from the requested drawings, I found examples of the draw-a-scientist activity in the teaching practice portfolios that student teachers collected from learners prior to their exposure to IBSE. As these documents unexpectedly shaped my understanding of the learners' views on science and scientists (prior to any IBSE exposure), I decided to include this as data. However, I interpreted these drawings with caution, only focusing on the most obvious evidence due to me not being able to ask learners to explain the drawings. I captured all learners' drawings electronically by means of photographs, which I then analysed.

Another incidental document I eventually included as raw data was a booklet made for the student teacher at School B by the mentor-teacher, containing letters and pictures from the 30 Grade 2 learners in her class. This booklet was presented to the student teacher on the last day of the nine week teaching practice cycle, thanking her for the time she had spent with the class. The messages included represent the learners' experiences of the student teacher and the contribution she has made. Quite a number of the letters refer to the science activities presented by the student teacher. As such, this unexpected data source provides evidence of learners' experiences and voices, providing some insight into the potential of IBSE in shaping orientations and learner motivation for science as a subject. An excerpt of the booklet and learners' messages is included in the form of photographs on the compact disc as Appendix I.

3.4.3 Data collection involving student teachers as facilitators of IBSE

In order to address the research questions related to student teachers' experiences of facilitating IBSE with Foundation Phase learners, I collected data by means of document analysis, as well as reflection and focus group discussions with participating student teachers. In addition, students completed several innovative reflection exercises (as supplement to the focus group discussion) that I took as raw data (see Appendix C). An overview of the various data collection strategies I used with the student teacher participants is presented in Table 3.7

Table 3.7: Data collection activities involving student teacher participants

<table>
<tr><th>Data collection method</th><th colspan="2">Description of activities</th></tr>
<tr><td rowspan="2">Document analysis</td><td rowspan="2">Teaching practice portfolio</td><td>Lesson planning</td></tr>
<tr><td>Post-lesson reflection</td></tr>
<tr><td rowspan="3">Reflection and focus group discussions</td><td colspan="2">Reconstruction of events presented in a show-and-tell activity</td></tr>
<tr><td colspan="2">Small group interview (focus group)</td></tr>
<tr><td colspan="2">Optional reflection documents</td></tr>
</table>

3.4.3.1 Document analysis

Analysing personal documents enables researchers to probe written accounts of participants. Document analysis offered me the opportunity to gain insight into student teachers' perceptions and interpretations of IBSE as articulated in their own language and words (Creswell, 2014; Strydom & Delport, 2011). I included relevant sections of the extensive teaching practice portfolios that students compiled according to specific teaching practice guidelines as data source in this study. These portfolios contain evidence of activities presented by students in the schools where they completed the teaching practice internship period and are supplemented with reflections on the included activities. A section of the portfolio is specifically devoted to science, and contains evidence of science activities (including the IBSE activity that formed part of this research project) conducted by student teachers and presented in accordance with the teaching practice guidelines.

Contained in the students' portfolios, I analysed the participating student teachers' lesson planning documents (completed in the university lesson plan template) for the IBSE activity as part of this research. This enabled me to gain insight into aspects such as the planned science outcomes, inquiry and other skills, as well as other relevant components of the lesson included in the lesson planning documents. Moreover, the lesson plans reflected student teachers' understanding of the IBSE approach, underlying learning theories supporting IBSE, the IBSE framework and steps, underlying principles, pedagogical considerations, as well as specific pedagogical strategies of IBSE. They furthermore provided me with insight into the resources they used to plan for the IBSE activities. Analysis of the lesson planning documents therefore contributed to my understanding of student teachers' ability to plan for IBSE, as well as of potential limitations, which would require ongoing attention.

Since a reflective-practice approach is followed in the PGCE-programme, all student teachers are requested to write reflections (using different formats, depending on the activity) on the activities they present in school. For the science activities, I provided student teachers with the option to complete reflection checklists[27] (see Appendix C) to record their experiences when implementing IBSE. With regard to the IBSE activity that forms part of this study, Bronwyn and Jean completed long reflections, recording their views, beliefs and experiences, while Monique completed the reflection checklists, as well as a short narrative reflection. I analysed these reflections as part of the raw data on student teachers' experiences when facilitating IBSE.

Analysing the student teachers' reflections not only enabled me to gain insight into their experiences of implementing IBSE, but also provided information on their awareness of their own competencies and limitations with regard to IBSE teaching, and their ideas for self-improvement on the aspects they felt needed expansion. As such, their reflections contributed to my understanding of both the positive experiences and the challenges that the participants experienced. In addition, I could

[27] Self-reflection tool for teachers, focusing on the teacher's role (Borda Carulla, 2012).

gain insight into the contribution of IBSE in shaping their professional identity as science teachers.

In including the teaching practice portfolios (specifically the section focusing on science) as data source, I was thus able to analyse the students' views and understandings of teaching in general, and IBSE in particular, as articulated in writing (Creswell, 2014; Strydom & Delport, 2011). In this way, I was offered a glimpse into the holistic picture of their classroom experiences, not only in terms of their IBSE experiences, but also of other experiences that shaped their professional identities. What I found especially meaningful was the descriptions of specific learners' participation in other classroom activities, which assisted me in better understanding their involvement in the IBSE activities I observed. In this way, working through the teaching practice portfolios, added to my background knowledge of the classroom context as well as its inhabitants. This knowledge in turn assisted me in interpreting the data I collected.

3.4.3.2 Focus group discussion

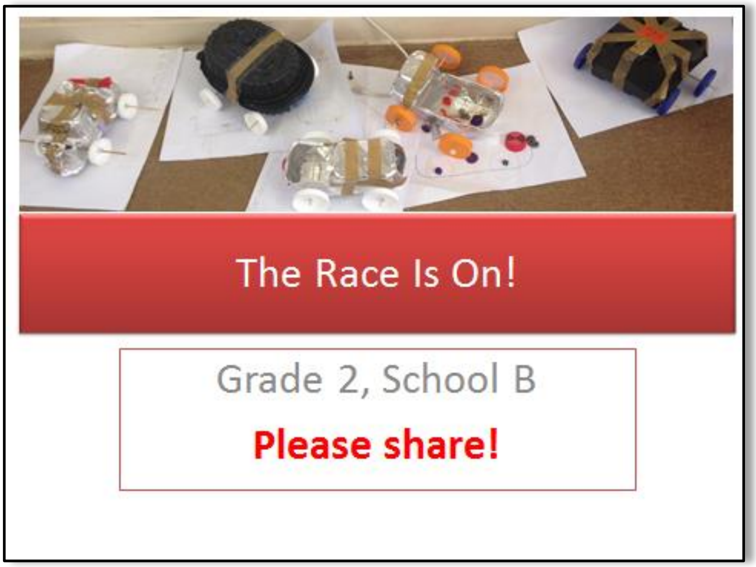
I facilitated a focus group discussion with the three student teacher participants after completion of their teaching practice period, on campus at the end of the academic year. I used this opportunity to thank them for their participation and further explore their experiences on the implementation of IBSE in the South African Foundation Phase classroom.

I conducted this discussion in the form of a small group interview, more specifically with the intention of exchanging views between or among participants and me (thus, "inter"-"view") (Flewitt, 2014). I arranged the session as a relaxed social interaction, but with the aim to construct data in the process of exchanging questions and answers relating to student teacher participants' experiences of implementing IBSE (Flewitt, 2014; Greeff, 2011). An overview on how I structured the focus group discussion is presented in Table 3.8.

Table 3.8: Overview of focus group discussion

Date: 30/10/2015 Time: 10:30			**Duration**
1	Show-and-tell opportunity	Reconstruction of IBSE events in PowerPoint format to share experiences of IBSE implementation, and children's voices with student teachers as audience.	60 min
2	Discussion	Gaining insight into participants' experiences of facilitating IBSE in the classroom.	90 min
3	Completion of reflection documents	Adding to focus group discussion.	Own time

For the first activity of the meeting with the participants, I used the same agenda as for the learners by reconstructing the IBSE events for the three classrooms in a 20-minute PowerPoint presentation (using videos, photographs and excerpts), yet focusing on the student teacher this time. As the student teacher participants were based at different schools, and worked with different age groups in the Foundation Phase, I opened the session by creating a "show-and-tell" platform for the three participants to share their activities with one another and myself. Photograph 3.5, for example, provides an image of the slide that invited Jean to share a description of and her rationale for presenting the car-race activity in the Grade 2 classroom.



Photograph 3.5: Reconstruction of case 2, focusing on the student teacher (Slide1/35)

While presenting the PowerPoint (see Appendix C), I asked questions on the participants' facilitation, as well as their experiences of learners' participation. I asked them to co-present during the discussion session, and to explain and elaborate on events, portraying their authentic experiences. The visual show-and-tell presentation furthermore stimulated discussions and feedback on one another's activities. In addition, student teachers could share similar or contradictory experiences and discuss IBSE and its implementation possibilities in the school context. In this way the interaction between participants, and also between the participants and me, added to my understanding of IBSE as it occurred in their classrooms. As part of the discussion I shared the learners' voices with the student teacher participants for the sake of their own careers as future teachers.

As the PowerPoint presentation represented the IBSE events from my perspective, I also used this discussion as member checking opportunity, and pertinently asked the participants to verify the authenticity of my interpretations. I involved the student teachers as "associates" and experts, allowing me to discuss my observations, intuitions and concerns with them. I depended on their input to agree, contradict, expand or clarify my interpretations.

Following the show-and-tell activity, I facilitated a discussion, guided by a set of semi-structured questions, included in Appendix C (Flewitt, 2014). The interview questions were generated based on my research aims and classroom observations (Flewitt, 2014). As the student teachers implemented a new approach in an authentic classroom setting, I believed that their "lived" experiences could contribute towards my understanding of the practicalities involved in a real classroom and school context, and thus elicit the characteristics that may predict the effective implementation of IBSE.

Although I was guided by pre-formulated questions, I remained flexible and relied on the social nature and dynamics of the group to contribute to the richness of the data (Flewitt, 2014; Hatch & Coleman-King, 2014). As captured in the focus group questions (see Appendix C), I guided participants to reflect on their experiences of science education practices when facilitating IBSE; their planning following CAPS; classroom organisation and management, and learners' engagement in IBSE. I further focused on their perspectives in terms of the challenges they experienced, and the consequent support they could benefit from in order to implement IBSE more effectively. I invited student teachers to elaborate on their lesson planning documents, their reflections, and any evidence I collected from their teaching practice portfolios. Throughout I made field notes, as well as audio- and video-recordings that I transcribed verbatim, following the data collection session.

In addition to the focus group discussion I formulated reflection documents that participants could complete individually and voluntarily. This entailed questionnaire-type documents with a range of questions, e.g. tick-box, rating-scale, visual response scales and open-ended questions. I provided the participants with stickers and sticky notes for their use if preferred by them. Bronwyn and Monique completed and returned a selection of the reflection documents, which I copied as part of the raw data of the study.

3.4.4 Researcher's field notes and research journal

An important purpose of qualitative observation is to take the readers into the research setting, and to help them understand the research context (Patton, 2015). Based on the onsite observations I completed, I provide in-depth and detailed descriptions of what I experienced in this research report. I took photographs of the classroom settings and made notes on the layout of the classrooms in which IBSE took place; the behaviour, events, actions and interactions I witnessed; and any indicators of learners' engagement in scientific inquiry. As I took an interactive role during classroom observation, I found it challenging to make comprehensive notes during my observations; nonetheless, I collected supplemental data by means of audio- and video-recordings which I could later review in order to add detail to my observation notes, and to present a clearer picture of the context. My field notes therefore represent a window into the IBSE classroom for readers to enter and gain insight into what occurred, and how it occurred (Patton, 2015).

I compiled field notes on my observations, experiences and thoughts during the course of collecting and reflecting on the data I obtained (Greeff, 2011). My field notes included factual information, e.g. the dates, times, locations and duration of field work sessions, as well as notes, captured by means of photographs, of the layout of the classrooms and display of resources. My notes also contain notes on my experiences during field work, on the events, activities and interactions I experienced while in the research field. I furthermore compiled field notes on specific events or things that sparked my interest and ideas (Patton, 2015). As Stake (2005) suggests, I kept a precise record (written and digital) of events, documenting my observations in the form of field notes, photographs and video recordings.

In addition to field notes, as an obligation of my “ethical mindfulness” (Cameron, 2014, p. 280), I used an electronic research journal to note my decision-making throughout the research process and to reflect on my research practice. I transferred handwritten and electronic field notes to my research journal in order to have one final electronic document (see Appendix E). My journal therefore contains field notes with factual information, decisions, interpretations as well as personal reflections (O’Reilly et al., 2013). Reflexive notes captured my experiences, thoughts and feelings about my encounters with the participants (learners and student teachers) as well as my emerging insights, intuitions, and broader ideas that emerged during my observations (Creswell, 2012; Maree & Van der Westhuizen, 2009).

Lincoln and Guba (2013) view a reflexive journal as a “formidable tool” in providing insight into constructions made tacitly while in the research field. As Lincoln and Guba (2013) suggest, I thus returned to my journal on a regular basis, both during and after fieldwork sessions. This revealed insight into the understandings I constructed that I had not previously recognised. The data from my research journal (based on my observations of and encounters with the participants) was useful during the data analysis phase, and also supported trustworthiness and rigour (Cameron, 2014). Throughout I engaged in critical self-reflection and remained aware of how my background, assumptions, and positioning behaviour could have impacted the research process I followed (Callan & Reed, 2012).

3.5 DATA ANALYSIS AND INTERPRETATION

Stake (1995) describes data analysis as the process of taking apart one's impressions and observations. Merriam on the other hand, explains data analysis as "the process of making sense out of data" (2009, p 175). Patton (2015) similarly regards the analysis process as transforming data into findings. Consequently, analysing data requires an understanding of how to make sense of data collected in order to answer research questions (Creswell, 2012).

Following an interpretivist paradigm, my intent was to gain insight into and to make sense of a particular phenomenon and its complexities (Stake, 1995). For this purpose, I generated descriptions of the learners' and student teachers' engagement in IBSE in the early childhood education setting, more specifically Foundation Phase classrooms (Creswell, 2014). I based my interpretations on the inductive thematic analysis I completed, as this strategy can be regarded as epistemologically free from and compatible with interpretivism (O'Reilly et al., 2013).

As such, I used thematic analysis to reduce and organise the data, synthesise and search for significant patterns, discover relevant pieces of information, and eventually construct a framework for communicating the findings (Creswell, 2014; Schurink, et al., 2011). More specifically, I first provided a comprehensive and detailed ("thick") description of each case (within-case analysis), where after I conducted thematic inductive analysis across the three cases (cross-case analysis) (Hammersley, 2014). In doing this, I inter-related themes and descriptions for each individual case and also across the different cases (Creswell, 2014). An overview of the data analysis and interpretation process I followed is provided in Figure 3.3.

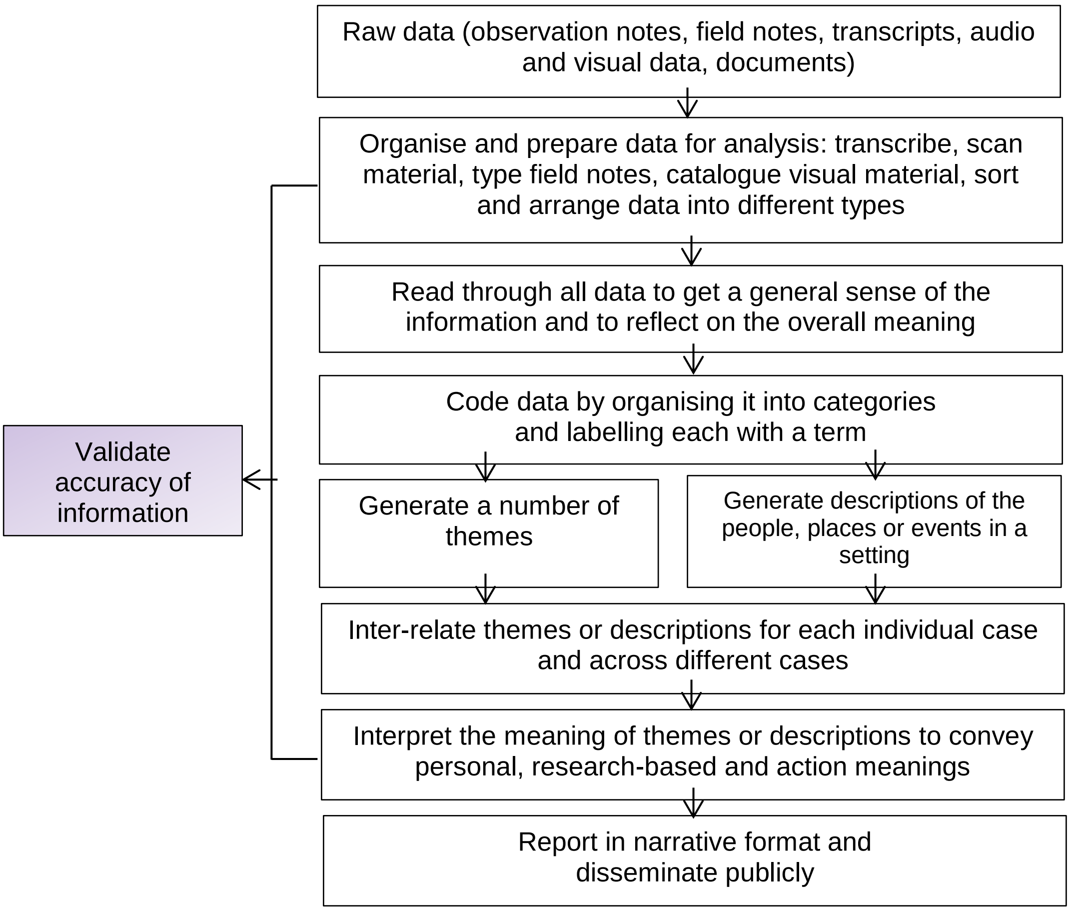


Figure 3.3: Data analysis and interpretation process (Adapted from Creswell, 2014)

For data analysis and interpretation I implemented the steps and guidelines provided by Creswell (2014). The first step entailed collection of data for analysis purposes in order to answer the research questions. Raw data consisted of observation notes, field notes, recordings (audio and video), visual data, focus group discussions and documents collected from child and student teacher participants (Miles et al., 2014). Secondly, I had to organise and prepare the raw data for analysis. As expected when conducting qualitative research, my study generated voluminous data sets (Hatch & Coleman-King, 2014). Making sense of the bulk of data required careful and systematic processing. I therefore organised and prepared the data for analysis by transcribing recordings, scanning material, taking photographs of existing documents, typing field notes, cataloguing visual material, and sorting and arranging the data into different types (Creswell, 2014).

Transcribing the data myself enabled me to get acquainted with the data and already note interesting ideas that emerged (O'Reilly et al., 2013). I used a format with numbered lines, wide spacing and margins that could allow for highlighting and making notes (see Appendix D for examples). After completing the transcriptions, I used the Word review function to add comments to the transcriptions, before I even started with the coding process. It was important to set up a consistent data management system from the outset in organising and storing the raw data. As much of my data was in the form of text and electronic images, I relied on computer programmes to help me manage, organise and store data in easily identifiable files in clearly labelled folders (Hatch & Coleman-King, 2014). Although I am familiar with the qualitative data analysis programme Atlas.ti, I chose to analyse all data sources manually.

During the third step of the analysis process, I read, reread and reflected on the data. To get a general sense of the information and to reflect on overall meanings, I listened to the recordings, watched the videos and read through all the documents several times, reacquainting myself with the data sets (Creswell, 2014; Hatch & Coleman-King, 2014). As expected, the data, especially coming from image and text, was dense and rich, and I had to "narrow down" by deciding what to include and what to disregard (Creswell, 2014). My aim was to reduce the data, but without any significant loss of information. To this end I continuously consulted my research questions and was guided by the focus of the investigation (O'Reilly et al., 2013).

During step four I employed a first cycle of coding by assigning initial codes to all data, sentence by sentence (Miles et al., 2014). During this step, I analysed individual pieces of data to identify segments that held relevance to my study, and assigned a code that represented the meaning I attached to each data piece. I used basic descriptive coding to summarise words and short phrases. As I prioritised and honoured the participants' voices, I used in vivo coding to code words and phrases in terms of their own language. I furthermore applied emotion coding to code interpersonal and intrapersonal experiences and actions (Miles et al., 2014). During the first cycle of coding I worked through the transcripts numerous times and revised and changed the assigned codes several times. A large number of codes initially emerged, which I reduced at a later stage (O'Reilly et al., 2013).

Following the first cycle of coding, I completed a second cycle as a fifth step of analysis. I captured larger segments of text, grouped codes together and organised these into more meaningful categories. I had to rethink the relevance of some of the previously assigned codes in addressing the research questions, and organise all data into categories, labelling each with a term (Creswell, 2014; Hatch & Coleman-King, 2014; O'Reilly et al., 2013).

Next, I generated a number of themes, reviewing the codes for potential connections or relationships (Creswell, 2014). This required of me to search for patterns across the initial codes. I continued reducing the number of themes by keeping track of potential patterns and relationships that emerged. I then summarised the significant patterns I identified, and created a conceptual outline that summarises the themes and subthemes (Hatch & Coleman-King, 2014; O'Reilly et al., 2013).

During step six I started interrelating themes. I deductively conducted a careful search of the entire data set to search for evidence that supported, discarded or modified the hypothetical categories I had generated thus far. This process enabled me to indicate generalisations, patterns, and categories or themes that were supported by the data set (Hatch & Coleman-King, 2014). I extracted excerpts that support the themes and pasted these onto the summary documents I had created (O'Reilly et al., 2013). Step seven involved my interpretation of the meaning of themes and descriptions to convey my personal, research-based and action meanings. Since meaning is dependent on context, I analysed and interpreted all meaning-making within the context it was observed (Stake, 1995).

The concluding step of my data analysis process involved dissemination in a narrative research report that can contribute to the creation of new knowledge, as well as to compiling documents of a more informal nature to raise public awareness. Working with children's voices, I was responsible for making their voices known to an audience beyond the research community, in order to maximise the potential impact on policy and practice (Robb, 2014).

3.6 QUALITY CRITERIA

Qualitative researchers conceptualise the research process in a fundamentally different way than quantitative researchers. Hatch and Coleman-King (2014) consequently argue that qualitative researchers should not attempt to justify their work in terms of criteria determined by positivist research assumptions, but rather according to the metaphysical assumptions underlying their chosen paradigms, and rather use constructs such as trustworthiness to justify the legitimacy of their work. The trustworthiness of qualitative research is measured against the criteria of credibility, transferability, dependability, confirmability and authenticity (Lincoln & Guba, 1999; Suter, 2012). Case study researchers working in early childhood settings need to ensure rigour in their representation of children's voices and their reports on early childhood education settings (Hill & Millar, 2014).

3.6.1 Credibility

Credibility in qualitative studies equates internal validation in qualitative studies and refers to the believability of the data (Schurink et al., 2011). In Seale's (1999) view, credibility can be seen as an extent to which results provide a true reflection of the truth, thereby implying the researcher's professional integrity, methodological competence and rigour. Credibility therefore implies the demonstration of "truth value" of a study by providing evidence of multiple representations of reality, and evidence that the reconstructions of the data are credible to the participants who provided the original data (Hatch & Coleman-King, 2014). Suter (2012, p. 364) defines credibility as an "overarching criterion for judging the trustworthiness of the qualitative data analysis". As such I had to ensure that my observations, data interpretation and conclusions are supported by the raw data, and correspond with the participants' perceptions.

To enhance the trustworthiness of my study, I used triangulation as proposed by Stake (1995). In order to cross-check my interpretations of meaning, I thus used more than one source of information, and multiple methods to collect data on the participants' experiences of IBSE. In addition I employed investigator triangulation by involving colleagues, critical friends, and my supervisors to comment on my perceptions and interpretations of the events. I furthermore included member checking as triangulation procedure by asking the student teacher participants to review my interpretations of their actions as well as those of the learners, and by checking my interpretations with the learners during the final series of data collection activities (Hatch & Coleman-King, 2014; Hill & Millar, 2014; Rule & John, 2011; Stake, 1995).

3.6.2 Transferability

Transferability (applicability) is concerned with the generalisation of findings to other contexts (Suter, 2012). It relates to whether or not the findings of a study are applicable and can be transferred to other contexts. Case study research is often criticised for the inability to transfer or generalise findings to other populations or settings (Suter, 2012). In this study, I focused on a small number of participants in a specific context (three Foundation Phase classrooms at primary schools in Pretoria). I can therefore not claim that the findings are generalisable or transferable to other contexts.

Lincoln and Guba (2013) suggest the use of thick descriptions to address transferability concerns. They also propose an inquiry audit and audit trial as a way of enhancing transferability. To this end I include examples of my analysis and of all records generated during the various stages of the study. I also kept a reflexive journal that recorded my day-to-day reflections and decision-making processes during the study's implementation, and include this as Appendix E. To counter the potential challenge of transferability further, I clearly state the theoretical underpinnings of the study in this thesis. This enabled me to stay within the theoretical parameters throughout the study, and leaves it open to researchers conducting studies within similar perimeters (i.e. readers) to decide whether or not my findings are transferrable to other settings, or how the findings may fit into a broader body of theory (Schurink et al., 2011).

3.6.3 Dependability

Dependability (consistency) is concerned with the reliability of findings (i.e. the replicability of a study) and considers whether or not the same findings would emerge if a study were to be repeated (Rule & John 2011; Suter, 2012). As qualitative researcher following an interpretivist paradigm, I assumed that knowledge was being constructed in an ever-changing social world (Merriam, 2009; Nieuwenhuis, 2007). This assumption, however, complicates the concept of replication (Schurink et al., 2011).

I employed qualitative strategies in attempting to ensure that the research process was "logical, well documented and audited" (Schurink et al., 2011, p. 420). I kept audit trails, developed rich documentation, verified my interpretations with participants and used critical peer reviews as strategies to enhance dependability (Suter, 2012; Rule & John 2011).

3.6.4 Confirmability

Confirmability in qualitative research concerns objectivity, neutrality and unbiased interpretation of the findings by the researcher. It answers to the question whether or not the findings can be related to its sources, as opposed to merely being a biased interpretation of the researcher (Suter, 2012).

I acknowledged my own biases from the onset of the study, and remained aware of how these may influence the way in which I interpreted the data. I strived to present the data and my interpretations as truthfully and genuinely as possible, and as closely as possible to the experiences of the participants. I followed Creswell's (2014) suggestion to present rich, thick descriptions that convey the findings to readers in such a way as if they were personally present in the setting. In cases where I found negative or discrepant information that might counter the themes I detected, I communicate such contradictory evidence in Chapter 6.

3.6.5 Authenticity

Authenticity is used in a qualitative study to determine whether or not the researcher provides a balanced view of the various perspectives, beliefs and values of the participants, and includes criteria such as fairness, empowering participants to act, and respecting their perspectives (Hill & Millar, 2014; Lincoln & Guba, 2013). Authenticity of a qualitative study implies ontological, catalytic and tactical authenticity; in other words, a true description of participants, contexts and events (Lincoln & Guba, 2013).

Since this study was guided by the interpretivist paradigm, various meanings, beliefs and values were derived from participants' own experiences of IBSE. In order to adhere to the criterion of authenticity (genuineness), I entered the worlds of the participants and spent prolonged time in the setting to develop an in-depth understanding of the case and of student teacher and child participants' experiences. The methods I employed with participants (including the child participants) allowed them to share their personally constructed perspectives, using their own voices (Creswell, 2014; Harcourt & Conroy, 2011; Wallerstedt et al., 2011).

To enable participants to share their ideas, perspectives and feelings, I presumed that their answers were rational and relevant to their understanding, and I therefore accepted these contributions as genuine and valid (Creswell, 2014; Harcourt & Conroy, 2011; Wallerstedt et al., 2011). I furthermore attempted to maintain balance and fairness by portraying participants' multiple realities in a true-to-life way, also reporting on contradictions and conflicting values. In addition I employed member checking and an audit trail (Lincoln & Guba, 2013).

3.7 ETHICAL CONSIDERATIONS

Ethical research involving child participants as well as the adults who work with them in an early childhood education context raises questions, concerns and challenges. In this study my ethical responsibility was centred on the protection of the two groups of participants (children and student teachers) from any form of physical, mental, emotional or social discomfort that could potentially arise due to their involvement in the project. As researcher, I attempted to practise ethically guided decision making and humane and sensitive treatment of the participants at all times (De Vos et al., 2011).

As I explored children's engagement in and response to a specific pedagogical approach, their involvement played a central role. Throughout I regarded the child participants as competent agents with a right to be heard (Christensen & Prout, 2002; Dockett et al., 2011; Graham & Powell, 2015) – which inevitably implies ethical considerations (Hammersley, 2015). Throughout I had to consider the complexities implied when involving children in research, and attend to protecting and advancing their best interest at all times (Birbeck & Drummond, 2014; Harcourt & Conroy, 2011). In undertaking this research, I was guided by the core ethics principles of autonomy, non-maleficence, beneficence and justice (Alderson, 2014; O'Reilly et al., 2013). I adhered to the ethical principles as stipulated by the Faculty of Education of the University of Pretoria (http://www.up.ac.za/en/faculty-of-education/article/30611/research-ethics).

3.7.1 Permission to conduct research

I obtained ethical clearance from the University of Pretoria, and permission to conduct research from the Gauteng Department of Education (GDE) (see Appendix A), as well as the principals of the three selected primary schools. Principals received letters explaining the research project in detail and requesting their permission to conduct research at their schools (see Appendix B). After permission had been granted, I submitted examples of the parent consent and child assent letters (see Appendix B) to the principals for any changes they wished to make. In some of the schools the principal added the official school stamp on the parent consent letter, indicating the school's approval of the project.

I approached the schools with an awareness that I did not have a natural place in the classrooms, and attempted to minimise any complications to the school and teachers' lives (File & Midthun, 2015). I considered File and Midthun's (2015) suggestion to provide feedback and facilitate follow-up visits with the schools and teachers for my research not to be merely a one-way presentation of findings, but as something that could motivate teachers to participate with researchers in future.

3.7.2 Respect for autonomy

Respecting the participants' autonomy was a central ethical principle during this study, which foregrounded my obligation of obtaining informed consent and respecting participants' right to withdraw (O'Reilly et al., 2013). Consent, assent and dissent are responses that are either signalled verbally, behaviourally or emotionally (Dockett et al., 2012). With regard to the student teacher participants, I first consulted with them to determine their willingness to participate in this study. I explained the purpose of the research, the research procedures as well as their expected part, providing details of voluntary participation and the freedom to withdraw without any penalty. I furthermore explained how data would be used, and how confidentiality and anonymity would be addressed. I prompted student teacher participants to take an active part in deciding whether or not they wanted to participate in the project. The three students I approached were keen to participate, and remained participants throughout the study. I obtained voluntary informed consent from them (see Appendix B) prior to their involvement in the study (Elias & Theron, 2012; Schurink et al., 2011; Suter, 2012).

With regard to the child participants, I respected their autonomy, despite their age, to make their own decisions in the research processes they were involved in, including their choice to participate and/or to withdraw from the research (Cameron, 2014). In respecting parents' (including guardians and/or legal caregivers) autonomy in decisions concerning their children's participation, I provided full details about the project in an information (parent consent) letter (see Appendix B), requesting their consent by signing and returning a tear-off slip (Cameron, 2014; O'Reilly et al., 2013). All parents in all three schools consented to their children's participation.

Since I realised that parental consent did not necessarily imply children's agreement to participate, and based on my view of children being competent contributors, I acknowledged children's decisional power and authority. I requested their assent to participate, by their lack of legal capacity to give consent (Birbeck & Drummond, 2014; Cameron, 2014), as captured in Appendix B. As I was aware that children may experience difficulty in grasping the concepts involved in providing assent (Cameron, 2014), I devoted a 30 to 40 minute session to explain the research project, as well as their central role. Children's assent letters were written in a child-friendly and accessible format (simple text with explanatory pictures and a Yes/No tick box), and I guided the child participants through each of the questions by either reading together, or asking children to read, depending on their competency level, and at the same time checking their responses and following-up in cases of uncertainty. As Harcourt (2011) suggests, I accepted an "OK"-sign as signature to indicate agreement and understanding of the involvement in the project. Most children, however, opted to add their own "signature".

Dockett, Einarsdóttir and Perry (2012, p.254) define dissent as "children's disinclination to participate, expressed verbally and/or non-verbally". With regard to children's rights to assent and dissent, a small number of children ticked the no box at the question: "Do you understand that you can stop at any time you want to?", which I followed up as a possible sign of dissent. During follow-up discussions those children responded that they did not want to stop – referring to participation in the IBSE activity. As I was aware that children may signal distress in different ways, I remained on the look-out for any verbal, behavioural or emotional signs of dissent in all the settings I involved them in (Dockett et al., 2012). Furthermore, I continually reminded them of their right to participate, but also their right to withdraw as the study unfolded (Cameron, 2014).

3.7.3 Justice

I was furthermore guided by my moral obligation to treat the participants equitably and justly (O'Reilly et al., 2013). As this research involved my students as well as young children, avoidance of coercion was a particularly important ethical consideration to ensure justice. As the student teachers had been trained in IBSE, their inclusion was instrumental in my study. Being their lecturer I realised that the asymmetric power relationship that typically exists between a lecturer and students as well as my status, roles and expectations, could inadvertently lead to exploitation and harm. Therefore, I had to take special precautions not to coerce them into participating in the project (Elias & Theron, 2012; Schurink et al., 2011). In this regard, I assured them that their decisions were free from pressure or persuasion, and that refusal to participate or withdrawal from the project at any stage would not yield any negative consequences (Alderson, 2014; Elias & Theron, 2012). As a safety measure, I included the names and contact details of the Head of Department (ECE), the PGCE-coordinator, as well as my supervisor on the student consent letter as avenue to report any signs of misuse of my influence or possible misconduct on my part.

Establishing a respecting, trusting, and reciprocal research relationship with the student participants was particularly important. I relied on them to provide the context of the study (i.e. facilitate IBSE with learners), and we worked cooperatively during certain stages of the research process to share and exchange information (e.g. planning of the IBSE activity, collection of resources, layout of the classroom, suitable times, dates for visits, focus group and reflection sessions, etc.). To this end I attempted to employ accuracy, honesty, objectivity and sensitivity at all times in updating them on aspects related to the research project (Elias & Theron, 2012).

Similarly, due to disparities in power and status between adults and children, child participants are more likely to be coerced into participation than adults. Therefore I had to take special care not to coerce children explicitly or implicitly into participation, but to respect their autonomy to take part willingly (O'Reilly et al., 2013; Te One, 2011). While the IBSE activity was presented as a regular classroom activity during school hours and consequently involved all learners in their respective classes, their participation in the research part of the project was by choice. Moreover, I had to engage in critical self-reflection to consider how my status, age, authority or role might inadvertently coerce child participants into participation (O'Reilly et al., 2013).

I followed Harcourt and Conroy's (2011), as well as Smith's (2011) suggestion to establish respectful, reciprocal and trusting research relationships with the child participants. I took time to explain in a child-friendly way what their involvement in the project would entail. In order to maintain these trusting relationships, I engaged in regular discussions with the participants about their involvement and kept them informed about any changes or amendments that occurred. I provided child participants with the space to withdraw, and reassured them that such withdrawal would not have any consequences. In addition, I was on the look-out for any signs of dissent, and kept reminding participants of the opportunity to discuss any concerns in terms of their involvement with their classroom teacher, their student teacher or other staff members at school (Dockett et al., 2012; O'Reilly et al., 2013).

3.7.4 Beneficence

Beneficence relates to the researcher's ethical obligation to act to the benefit of others (O'Reilly et al., 2013). As explained, research involving one's own students as well as children inevitably carries some degree of risk. I had to consider whose interests I was serving with this study, and clearly define potential benefits for the participants (both students and children), as well as how the outcomes of this research may translate into tangible benefits.

With regard to student teachers I did not offer incentives in the form of financial compensation as I felt that payment could be a contentious ethical issue and increase the risk of coercion. As students were completing an academic qualification, the development of their professional skills was a justifiable reason to include them in this study. Consequently, the process of collaboratively planning, facilitating and experiencing learners' responses to IBSE, and engaging in sharing and reflective discussions with me and co-participants, could potentially expand their reflective and professional practice. For the child participants, their participation in IBSE created a platform to exercise their voices in terms of being scientists, thereby justifying their participation in the study.

Although my intention was to "do good" and to contribute to the participants' development and the wider education community, I had to remain cautious of not making promises to the participants that were beyond the scope of my influence. I remained aware that the contribution of this study can mainly build on existing evidence, and may not necessarily bring about any change for participants directly (Alderson, 2014; O'Reilly et al., 2013).

3.7.5 Non-maleficence

Applying the principle of non-maleficence implies strategies of avoiding harm (physiological, physical), putting contingency plans in place to minimise risks, and safeguarding participants' confidentiality and anonymity (O'Reilly et al., 2013). Anonymity implies the removal of all identifying features when disseminating and representing data, ensuring that no names or any other identifying characteristics appear in print in any form. To this end O'Reilly et al. (2013) define confidentiality as a means of assuring participants' privacy. To ensure privacy I took precautions to protect the raw data and keep any confidential identifying information (i.e. names of participants, schools, teachers, or any other identifying information) from documents that can be viewed by people other than myself or my supervisors. I furthermore anonymised all published records and reports (Alderson, 2014).

To ensure anonymity and confidentiality of the participants, I thus did not include any information (names or visual media) that revealed their identities or the schools in which the research was undertaken (Elias & Theron, 2012; Suter, 2011). I informed child participants and their parents about the research process as well as the measures I employed to protect their privacy. While video and photograph data generate rich data, these strategies imply ethical risks as it is challenging to protect the identity of participants as well as their settings in visual data (Alderson, 2014). I therefore clearly communicated the potential uses of the visual and video footage to the participants, and implemented strategies such as reducing the pixel counts, blurring out recognisable features and clothing and converting photographs into drawings (Alderson, 2014; Robson, 2011).

Although the topic of the study did not require participants to disclose sensitive personal information, I nonetheless had to consider the possibility of distress caused during the study carefully (O'Reilly et al., 2013). While it was impossible to anticipate all forms of potential harm, I had contingency plans in place to minimise risks (O'Reilly et al., 2013). I closely observed any behaviour that could perhaps signal signs of distress. No need arose to refer any participant for professional support. Any behaviour I witnessed during classroom observations that could potentially discredit or humiliate a participant or lead to emotional, intellectual or social discomfort was excluded from the data (Schurink et al., 2011; Suter, 2011).

Regarding the student teacher participants, I remained mindful of the fact that involvement in a research project while completing a qualification could contribute to stress. I attempted to fulfil a supportive role during the research process, and facilitated a debriefing session at the end of the study, encouraging the participants to reflect on their participation and contributions. During the final focus group discussion, I deliberately included questions about their own well being to ensure that they had not been harmed by the research process in any way.

3.8 SUMMARY

In this chapter I described the empirical investigation I undertook. I explained the interconnected components of the study and justified the selected paradigms, multiple case study research design, and methodological procedures I implemented. I concluded the chapter by explaining the measures I employed in ensuring rigorous and ethically sound research.

In the next two chapters I present and report on the results of the study. Chapter 4 focuses on the experiences of the student teacher participants, while Chapter 5 presents results pertaining to the experiences of the child participants.

Chapter 4

RESULTS: THE EXPERIENCES OF STUDENT TEACHER PARTICIPANTS

"They're doing scientific things and they don't even know it".
(Student teacher, School B, Pretoria, 2015)

"…you feel like you have accomplished something … by them accomplishing something on their own".
(Student teacher, School A, Pretoria, 2015)

"I'd tell anyone who is listening that this is the way forward in creating independent learners".
(Student teacher, School A, Pretoria, 2015)

"I think it was important to constantly link what is a scientist, and you know… what you're doing is scientific".
(Student teacher, School A, Pretoria, 2015)

"IBSE should be implemented in all schools as it is a great way to improve the learners' cognitive and practical skills and it will be beneficial to the learners in all aspects".
(Student teacher, School A, Pretoria, 2015)

4.1 INTRODUCTION

In the previous chapter I described the empirical study I completed, the research design I followed and the methodological strategies I utilised. I justified my choices against the background of the research questions and purpose of the study. In the next two chapters I present the results I obtained. This chapter focuses on the experiences of the student teachers, and Chapter 5 captures the experiences of the child participants. I thus present the results as indicated in Figure 4.1.

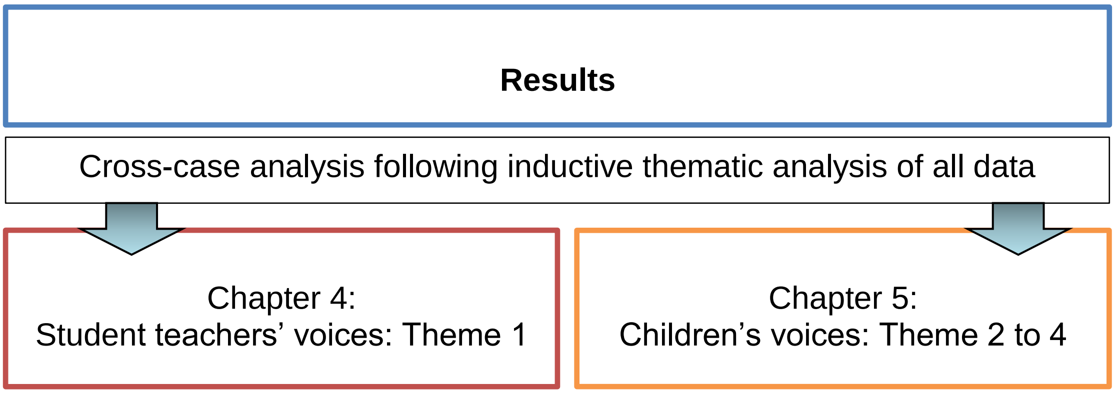


Figure 4.1: Presentation of results

Based on the cross-case analysis I completed, five themes emerged. As background to my discussion of the results in the following two chapters, I commence this chapter by providing an overview of the three cases that were involved. In addition, I refer to the planning and implementation of IBSE in the three related classrooms. I then report on the student teachers' voices in terms of their experiences of the implementability of IBSE in Foundation Phase classrooms. This represents the first theme I identified during data analysis, focusing on student teachers' views regarding IBSE and its implementation in schools. As background to this and the following chapter, Figure 4.2 provides an overview of the themes I identified.

RESULTS

STUDENT TEACHERS' VOICES (Chapter 4)	
THEME 1: STUDENT TEACHERS' EXPERIENCES OF IMPLEMENTING IBSE IN FOUNDATION PHASE CLASSROOMS	
Sub-theme 1.1	Being an IBSE facilitator
Sub-theme 1.2	Challenges experienced when implementing IBSE
Sub-theme 1.3	Potential value of IBSE implementation in Foundation Phase classrooms
CHILDREN'S VOICES (Chapter 5)	
THEME 2: LEARNERS' ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE	
Sub-theme 2.1	Understanding the problem and taking ownership of the learning process
Sub-theme 2.2	Identifying ways to investigate and solve the problem
Sub-theme 2.3	Engaging in the investigation as part of a team
Sub-theme 2.4	Gaining new insight and drawing conclusions
Sub-theme 2.5	Sharing and documenting experiences
THEME 3: LEARNERS' EXPERIENCES OF SOCIAL LEARNING	
Sub-theme 3.1	Perceived value of social learning
Sub-theme 3.2	Dealing with associated challenges
THEME 4: LEARNERS PERCEIVING IBSE AS AN EMPOWERING APPROACH	
Sub-theme 4.1	Value of owning the learning process
Sub-theme 4.2	Feeling competent and motivated
Sub-theme 4.3	Acquiring science-related knowledge, skills and dispositions
Sub-theme 4.4	Becoming aware of the broader application of science
Sub-theme 4.5	Being and becoming scientists

Figure 4.2: Overview of the themes and related sub-themes

Theme 1 therefore reflects student teachers' experiences, and represents their voices on the implementability of IBSE in Foundation Phase classrooms. Themes 2 to 4 represent learners' voices based on their engagement in IBSE. Before discussing Theme 1, I provide a brief overview of the three cases.

4.2 OVERVIEW OF CASES

In agreement with Miles, Huberman and Saldaňa (2014), I believe that cases should be understood on their own. As such, to understand each case as a holistic entity and to capture the uniqueness of each case, I present a brief overview of each single, bounded context in this section. I contextualise the cases by presenting a concise narrative description of the IBSE event as it occurred in each classroom (Miles et al., 2014; Patton, 2015). For each case I introduce the student teacher and her class, and thereafter provide a brief synopsis of the lesson she facilitated. Formal lesson plans are included in Appendix H which elicited the main aspects of the IBSE lessons (e.g. outcomes, IBSE problem, etc.). I also include visual data of the layout of the classroom and materials displayed for the activities, and present a brief account of the IBSE phases as they occurred in each classroom[28].

4.2.1 Case 1: Implementation of IBSE in a Grade 1 classroom

Bronwyn, a 2015 PGCE student teacher, was placed in a Grade 1 classroom at School A during the second teaching practice period. She planned her IBSE lesson around the theme “Pets” (session focus: Fish). In planning the lesson, she conceptualised the unit herself according to the LAMAP IBSE approach, keeping the learners’ developmental level, the lesson theme and CAPS for Grade 1 in mind.

The class included 26 learners, aged six to seven years. The classroom represented a diverse constitution of learners in terms of language, gender and culture. All learners participated in the research project, and contributed to the whole class interview data, focus group discussion data and other artefacts (science journals, pre- and post-IBSE drawings) I obtained. For the IBSE lesson learners were grouped into five groups of mostly five learners per group. They were seated in existing mathematics groups, and were thus used to working cooperatively in these groups. This activity was the learners’ first encounter with IBSE, implying the possibility of learners’ inquiry skills not being well-developed, and that they could perhaps have

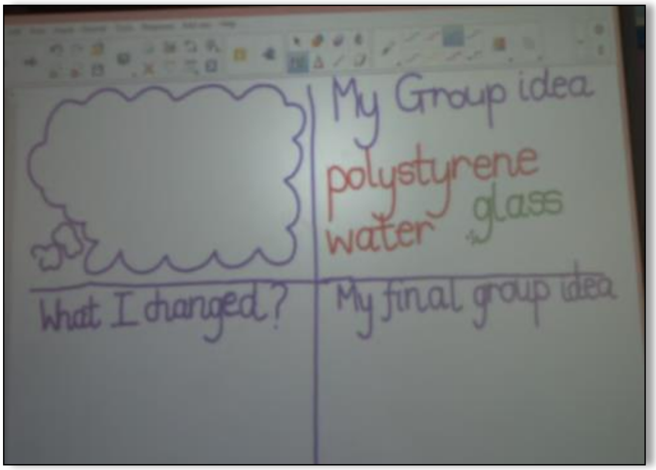
[28]The following codes are used henceforth: A/B/C = school; ST = student teacher; ST1 = Bronwyn (Grade 1); ST2 = Jean (Grade 2); ST3 = Monique (Grade 3); LP = lesson plan; LR = lesson reflection; R = reflection document (1-10); FG = focus group; p = page; L = Line.

relied on their naturally acquired inquiry competencies and skills to engage in the activity.

Bronwyn planned and presented the IBSE activity following the steps of IBSE. She introduced the *IBSE problem* verbally as a real life challenge that needed to be solved urgently. For this purpose, she presented the learners with pet fish in plastic bags, and explained that the fish needed to be transferred to better conditions within a few hours. Since there was no suitable fish tank in class, learners were challenged with the problem to build a fish tank with the materials she had found in and around the classroom in which the fish could be released.

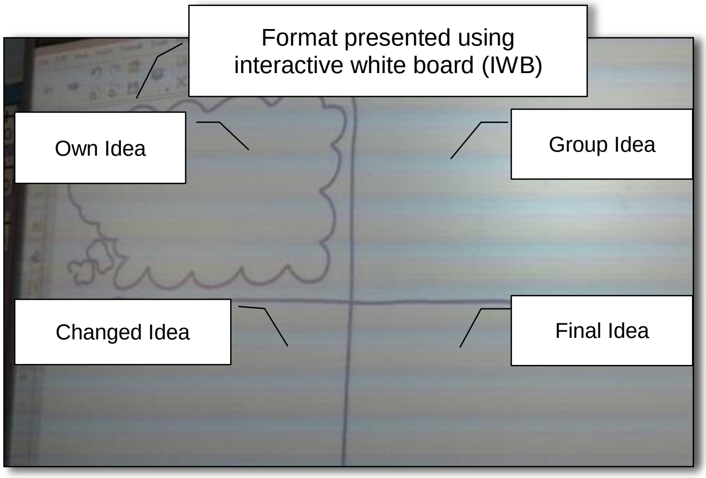
Even though not typically inquiry-based, Bronwyn facilitated the *engage phase* by presenting some information in order to address the science outcomes she had formulated for the lesson, and for learners to acquire some background knowledge about the requirements for pet fish before the investigation. She used the Internet, displayed information on an interactive whiteboard (IWB), and actively involved learners in searching for information about the specific fish. After allowing learners time to explore the available material, she requested them to *think on their own*, and to write or draw their own ideas, thus giving them the opportunity to explore and express their own available knowledge. Following the IBSE steps and approach, learners were next requested to *share their ideas in their groups*, to come up with the best solution, and to collect materials for the investigation. In this way, learners were given agency to use their inquiry skills to *investigate* and come up with their own solutions.

To *draw conclusions*, Bronwyn requested the different groups to explain their designs in terms of what they had built and used, why they thought they were a good option, what they had learned from changing their designs, and why and how they had built their specific tank. As this session continued for three hours, conclusions were not consolidated during the same session. To *communicate* their experiences, Bronwyn gathered learners on the carpet where groups verbally shared information with the rest of the class. By using technology, Bronwyn captured each group’s main thoughts (in the colours of their group) on the IWB, as depicted in Photograph 4.1.



Photograph 4.1: Recording learners' ideas on the IWB

Bronwyn also presented the format for recording their scientific ideas to the learners using the IWB. She displayed the format on the IWB, and asked learners to fold an A4 page in quarters and create a science notes page on which they could record their thinking in the four blocks (own idea – group idea – changed idea – final idea). The format of the science journal is captured in Photograph 4.2.



Photograph 4.2: Format of the science journal

4.2.2 Case 2: Implementation of IBSE in a Grade 2 classroom

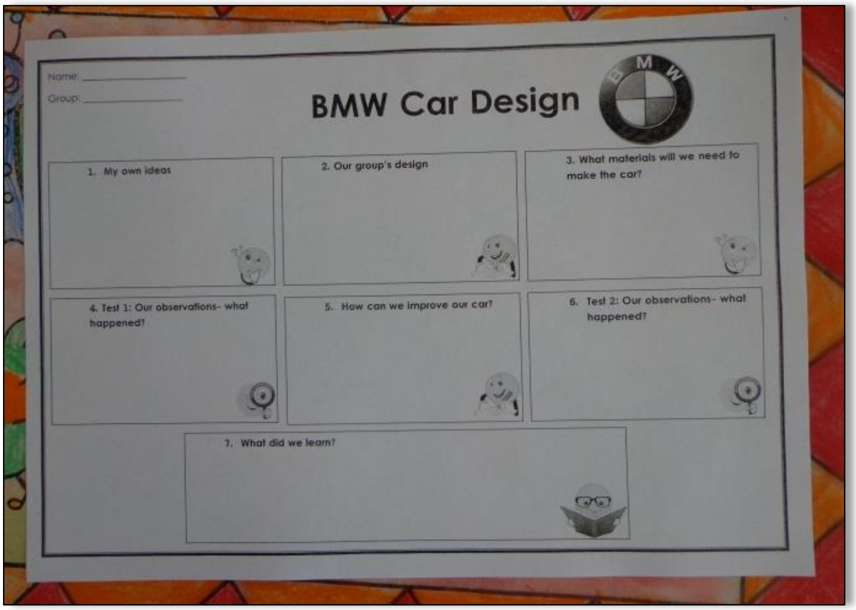
Jean, the student teacher placed in a Grade 2 classroom at School B, presented a car race activity on the theme "Transport". The car race activity was part of my original LAMAP training presented by French trainers in 2013, and I presented this activity as part of their IBSE training to the 2014 and 2015 PGCE students. As the activity suited the CAPS themes for Grade 2 for the third term, Jean decided to use this activity, relying on her own experience and the ideas she had gained as part of her teacher training in planning the IBSE lesson used in this study.

The Grade 2 class consisted of 30 learners (aged seven to eight years), and represented a diverse constitution. Learners were grouped into five groups of six learners each. All learners participated in the project, and contributed towards the data I obtained. Apart from the activities the student teacher presented during her teaching practice, the learners had not often been exposed to science, and had had no previous encounters with IBSE.

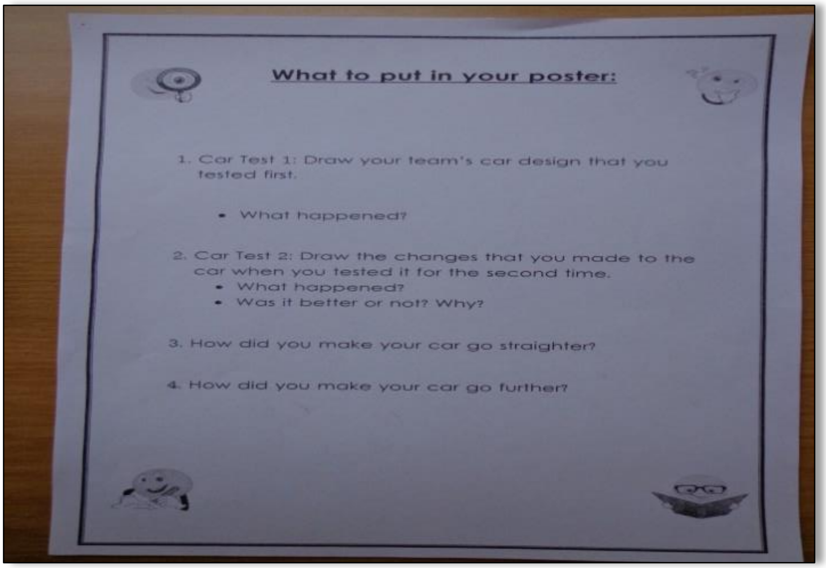
Jean presented the car race activity according to the steps and phases of IBSE. To introduce the *IBSE problem*, and to add (in her opinion) authenticity to the situation, she played a recording of a "BMW car designer" on her mobile telephone and requested learners' help in designing a model and building a car that could go as far and as straight as possible down an incline from recyclable material. To *engage* learners, Jean included a brief information sharing session during which she introduced parts of a car and provided vocabulary such as wheels and an axle. She then encouraged learners to *think on their own*, and to propose a possible solution to solve the problem. After allowing time for this, Jean requested the learners to *share their ideas with their group* members. She introduced and explained group roles (peace keeper, scribe, artist, gatherer, group manager), and then she offered a variety of materials and tools to the learners for them to design and build their prototypes as well as a ramp in the classroom (incline) to test their prototypes. She allowed ample time for the *investigation* and for testing and improving the car. She constantly reminded learners to stay focused on the problem, and to stay on task, saying, "Don't worry about decorating your car and making it pretty. Only remember it needs to roll straight and far".

Jean planned time for learners to *draw conclusions*, share findings and complete their group posters at the end of the session. Due to time constraints, conclusions were not consolidated during the same session. However, learners were given the opportunity to showcase their final product, letting it go down the ramp a final time, and then explaining their encounters with constructing the car. She planned for groups to present group posters at an informal discussion session and answer the following questions: *What did you learn from your investigation? Did your car improve after you tried and tested it the first time? Why did it improve? How did you make it go straighter? How did you make it go further? What is the most important thing you learnt from today?* Due to time constraints on the day of the IBSE activity, this phase was presented later in that week.

Jean also prepared journals for learners, guiding them to record their ideas in specified blocks on an A4 format page with the following headings: (1) own ideas; (2) group's design; (3) materials; (4) observations after first testing; (5) improvements; (6) observations after second testing, and (7) what was learned. She furthermore prepared a poster for the groups to use as guideline to communicate their findings to the class. In Photographs 4.3 and 4.4, copies of the instructions for recording their ideas as designed by Jean are presented.



Photograph 4.3: Example of instructions for the science journal



Photograph 4.4: Example of instructions for the group poster

4.2.3 Case 3: Implementation of IBSE in a Grade 3 classroom

Monique, the student teacher placed in a Grade 3 classroom at School C, presented the same car race activity as Jean. Although the car race activity did not fit the theme of the week, Monique decided on this activity for my research as she could reportedly not identify another IBSE activity to present. All fifteen Grade 3 learners participated in the activity. They were grouped into three groups of five learners each. Learners from this classroom were not used to working in groups, and were also inexperienced in terms of IBSE.

Monique presented the lesson following the steps of IBSE. She involved the deputy principal to introduce the IBSE *problem* as it would add (in her opinion) authenticity to the situation. The problem was introduced "on behalf of BMW", asking the Grade 3 learners to build a three dimensional model of a car that can go as straight and as far as possible. She engaged learners by requesting them *first to think on their own* and then design a car before *sharing their ideas* with group members.

Monique was clear in her instructions, and gave learners sufficient time to work individually and to record their own thinking in their science journals. She provided a large variety of recyclable materials and tools, and learners were given agency to explore the possibilities of the materials, *to design, build and test their models* in order to determine what worked and what not, and to modify the model according to the requirements. She planned the consolidation and *drawing conclusions* phase as a discussion on how learners modified their models to meet the requirements and perform the required functions. She also planned to introduce new terminology such as “axle” and “aerodynamics” to the learners. Due to time constraints, there was, however, no time for reflection and consolidation, and the consolidation session occurred a few days later. The activity concluded with a final test, and show-and-tell opportunity for learners to *communicate* their findings to the rest of the class.

Monique provided a prepared four-page science journal to each learner, containing the problem as well as nine blocks guiding learners to record the following: (1) own idea; (2) group’s joint idea; (3) materials required to build the model; (4) drawing of the first model; (5) description of observations after testing the model the first time in terms of what worked and what not; (6) required changes; (7) description of observations after testing the model a second time; (8) what was learned from observing the other groups’ models, and (9) what was learned from the own experiences. Throughout the investigation she constantly reminded learners to record all their steps in their journals. As the science journals involved extensive recordings, Monique did not plan a group poster for this activity.

4.3 OUTCOMES OF STUDENT TEACHERS’ EXPERIENCES (THEME 1)

Theme 1 concerns the experiences of the participating student teachers following their implementation of IBSE in Foundation Phase classrooms. I completed thematic inductive analysis of the transcripts, documents, onsite observational field notes, and my research diary, pertaining to the data generated by the student teachers or during my observation of them. In analysing the data, I assumed that the student teachers’ views and experiences, based on their authentic and reflective practice, might add coherence to my understanding of the implementation possibilities of IBSE from a teacher’s point of view.

I furthermore assumed that the contextualised views and experiences might shed light on the practicalities involved in science teaching in Foundation Phase classrooms, and possibly lead to insight into how teacher training may better prepare students to implement IBSE. As teachers play an instrumental role in curriculum implementation and reform, implementation of IBSE partially depends on teachers' views, orientations, attitudes, and the beliefs they hold about their competencies, and how these may shape their actions within specific contexts.

In discussing Theme 1, the related sub-themes and categories, I include verbatim quotations from the focus group discussion as well as excerpts from the variety of documents completed by the participants. In addition, I include excerpts from my field notes and reflexive journal to support my discussion. As an introduction, I provide an overview of the inclusion and exclusion criteria I relied on in identifying the various sub-themes and related categories in Table 4.1.

Table 4.1: Inclusion and exclusion criteria for Theme 1

THEME 1: STUDENT TEACHERS' EXPERIENCES OF IMPLEMENTING IBSE IN FOUNDATION PHASE CLASSROOMS		
Sub-themes	**Inclusion criteria**	**Exclusion criteria**
Sub-theme 1.1: **Being an IBSE facilitator**	This sub-theme includes data related to the teacher's role in planning and facilitating IBSE to support learners' science knowledge construction.	This sub-theme excludes data that refer to factors other than the teacher's role in planning and facilitating (implementing) an IBSE lesson.
Category 1: Being a thorough lesson planner	This category includes data related to the teacher's role in planning an IBSE activity.	This category excludes data that refer to the teacher's role in facilitating IBSE with learners,
Category 2: Encouraging learners to take the lead	This category includes data related to the student teachers' experiences of facilitating child-centred learning and supporting learners' own investigations.	This category excludes data that refer to student teacher participants' experiences of supporting learners' knowledge construction during IBSE phases other than the investigation phase.
Category 3: Guiding learners to make sound conclusions and reflect on their experiences	This category includes data related to the student teacher participants' experiences of their role in supporting learners to draw evidence-based conclusions and to communicate their findings.	This category excludes data that refer to student teacher participants' experiences of supporting learners' knowledge construction during IBSE phases other than the drawing conclusions phase.

Sub-theme 1.2: **Challenges experienced when implementing IBSE**	This category includes data related to factors that challenged the implementation of IBSE in Foundation Phase classrooms.	This category excludes data that refer to general systemic factors or challenges in schools.
Category 1: Science not being viewed as priority area	This category includes data related to the limited emphasis placed on science and science teaching in the Foundation Phase.	This category excludes data that refer to classroom-related challenges when implementing an IBSE lesson.
Category 2: Time required to implement an IBSE activity	This category includes data related to the timeframes implied by the implementation of an IBSE lesson.	This category excludes data that refer to factors other than time and associated constraints when implementing IBSE.
Category 3: Challenges related to classroom management	This category includes data related to demands placed on student teacher participants in terms of classroom management and discipline.	This category excludes data that refer to curriculum factors or time constraints when implementing IBSE.
Sub-theme 1.3: **Potential value of IBSE implementation in Foundation Phase classrooms**	This sub-theme includes data related to the potential benefits and suggestions for IBSE implementation.	This sub-theme excludes data that refer to challenges associated with the implementation of IBSE in the Foundation Phase context, or benefits of other teaching approaches.
Category 1: Supporting professional teacher identity development.	This category includes data related to the value of IBSE on shaping teachers' identities as teachers and reflective professionals.	This category excludes data that refer to the value of IBSE for parties other than the teacher, or the value of broad-level implementation.
Category 2: Ideas on broad-level implementation	This category includes data related to student teacher participants' suggestions for promoting the implementability of IBSE in Foundation Phase classrooms.	This category excludes data that refer to the value of IBSE for individual teachers and their development.

4.3.1 Sub-theme 1.1: Being an IBSE facilitator

This sub-theme concerns the student teachers' experiences of their roles as facilitators of active hands-on, minds-on and learner-centred activities. The following roles were foregrounded and subsequently emerged as categories: being a thorough lesson planner; encouraging learners to take the lead; guiding learners to make sound conclusions and reflect on their experiences.

4.3.1.1 Category 1: Being a thorough lesson planner

The student teacher participants regarded thorough planning as prerequisite for the successful implementation of IBSE. Reflecting on her role as IBSE lesson planner, Bronwyn, for example, noted: "*I plan well and get everything ready prior to the lesson to ensure it runs smoothly*" (A_ST1_R4). She acknowledged the value of proper planning by stating: *"… and plan it well so that you can ask the right questions, or give them the right encouragement"* (A_ST1_FG_p5L252-253).

For Monique, planning an IBSE lesson involved consideration of potentially unexpected events. She explained that she experienced this as challenging, saying:

> "*I think it's like preparing for the unexpected. Like, you're never fully prepared for what's gonna happen. Like I also was worried about how am I going to thingy [wangle] if they got this idea to use that box, and there is only one, … what am I going to do? … It's just like preparing for all the things you can't actually prepare for. I found that quite difficult*" (C_ST3_FG_p13L773-778).

Bronwyn confirmed this experience, stating, "*Yes, you have to plan it very well, and you have to think about what the children are gonna think of… so that you have the materials that they might want, … or need*" (A_ST1_FG_p11L613-615). Monique elaborated and emphasised the importance of timely planning. She said: "*… you also have to plan well in advance. You can't say, OK I'm going to do… building something tomorrow for a lesson when you don't have stuff…*" (C_ST3_FG_p11L646-648).

In addition to planning and preparing the materials and foreseeing possible unexpected events, Jean highlighted the importance of planning the sequence of events and the pace of these during the lesson. She explained her experience as follows: "*And think of the order you're doing things, and how long you can spend on each part. 'Cause I found that in some places I just felt like I spent way too much time, and then it was taking away from the time they would have to work … on their own*" (B_ST2_FG_p11L617-620).

My analysis of the data that was generated by the student teacher participants indicates that they generally had a good understanding of what needs to be considered when planning an IBSE lesson. Their insight and approach to planning appeared to be based on their knowledge of IBSE, their practical experience of implementing IBSE in the classroom, and continuous reflection on their experiences. However, in analysing their lesson plans, it became clear that the participants did not explicitly formulate inquiry-focused outcomes during their planning of the IBSE lessons. Even though all their planned lessons demonstrated the participants' understanding of appropriate theoretical frameworks for IBSE and how children learn (e.g. constructivism and social constructivism), the structure of a lesson and IBSE steps to follow, the underlying approach, principles and supporting framework, pedagogical considerations and strategies of IBSE, their lesson plans lacked clear inquiry-focused outcomes underlying the specific IBSE-problems. I furthermore noticed that the planned science outcomes did not always correlate with the formulated IBSE problems, as demonstrated in the excerpt of my analysis of the lesson plans (Table 4.2), and in summary of the lacunae I identified across the lessons plan.

Table 4.2: Excerpt taken from lesson plan analysis

ST	**Science outcome/s**	**Formulation of IBSE problem**	**Analysis**
A_ST1_LP	Concepts of life and living. Fish are living, and therefore certain requirements need to be met to sustain life. Knowledge of fish – body parts and habitat; knowledge of characteristics of living beings; how to look after pets; responsibility to care for and create sustainable habitat (p 2).	To build a fish tank with the available materials (p. 2).	**Outcomes**: Mostly relevant, but too broad and not inquiry-focused. **Limitations**: • Formulation is not IBSE-focused and investigable. • Disconnection between outcomes and problem.

B_ST2_LP	Learners should have a better knowledge of scientific concepts and vocabulary (p. 2).	To design a model of a car with recyclable material that can go as far and as straight as possible down an incline (p. 2).	**Outcomes**: Concepts not specified, not inquiry-focused. **Limitation:** Disconnection between outcomes and problem.
C_ST3_LP	The learners should be able to understand the different parts of a car in basic form, especially the aspects pertaining to the wheels (p. 2).	To design a car that can go as far and as straight as possible (p. 4).	**Outcomes**: Too vague, not inquiry-focused. **Limitation**: Disconnection between outcomes and problem.

From my lesson plan analysis, it thus seemed evident that the formulated science outcomes were not inquiry-focused, and did not inform the IBSE problems. Even though both Jean and Monique used the car race activity presented to them as part of the training they had received (that specified the procedure as well as the content knowledge relevant to the activity), their lesson planning did not reflect appropriate science outcomes for the activity. I explored this trend further by asking the participants to explain to me how they had selected outcomes for the activities. Bronwyn responded that: *"… the framework was in the curriculum, but it was very vague – I thought – but it's … you get it from there, and then I think I added my own outcomes. I like … filled it*" (A_ST1_FG_p5L269-271). Jean indicated that she searched elsewhere for relevant outcomes, saying, "*I looked at your [lecturer/researcher] slides as well. You had those science slides, and the values, and outcomes and something. So I got some from there. But also from just … I don't know … thinking, and going on Google*" (B_ST2_FG_p5L275-277). Therefore, even though the participants apparently were of the opinion that they had looked for suitable options in formulating the outcomes, their final products seemingly did not reflect sound formulations.

4.3.1.2 Category 2: Encouraging learners to take the lead

IBSE requires of facilitators to follow a child-centred approach to teaching, where learners are regarded as competent to contribute knowledge to the education situation. I observed all three student teachers as acknowledging learners' natural curiosity as well as their scientific potential. They furthermore appeared to be mindful of their own role in supporting learners' scientific awareness and development. In support of my observations, Bronwyn stated that *"[t]hey just have that … uhm …like* *inborn inquisitive sense of …*" (A_ST_FG_p13L746), with Monique adding: "… *natural curiosity*" (C_ST_FG_p13L748). In further support, Jean said:

> "*They're doing scientific things and they don't even know it. I mean … because we did a science lesson and I haven't even told them really about science, and then they did the science lesson, and then I asked them afterwards in a different lesson, you know, what is science? Then I made them think, and I was like – but you did all of that stuff on Monday, and then they like ohhhh … then the penny drops. So, I think they just do, and they don't know it's natural*" (B_ST_FG_p13L752-757).

Bronwyn indicated her understanding of the role of an IBSE facilitator in the following way: "*With the learners being in the centre of the lesson being a facilitator allows as much learner autonomy as possible with guidance*" (A_ST1_R4). Jean similarly noted that "*I also know that the learners need to be in control of their learning in this type of lesson and I must just guide*" (B_ST2_LRp2), and added:

> "*The investigation was very much learner-led. The learners initiated and planned the building of their prototype cars. I really feel like I encouraged the learners to think freely and promoted a culture of inquiry. I wanted the learners to ask questions and to find out the answers on their own. When I found some learners were struggling, I encouraged them to redesign or change something and not give up. When learners would ask me questions, I would answer with: I'm not sure, why don't you find out and tell me?*" (B_ST2_LRp3).

In further support, Bronwyn added: *"… the role of the teacher is merely to facilitate and guide, using leading questions in order for the learners to figure out the best solution and not told what to do*" (A_ST1_LRp7). As such, all three participants seemingly understood that they had the responsibility of supporting and allowing learners to take a leading role in the learning process.

Awareness of the effect of their role when encouraging learners to take the lead was furthermore displayed in several contributions by the student teachers. Focusing on their role in encouraging and guiding learners' investigations, Monique mentioned the following: "*I asked them questions … 'Is that gonna work? What's going to happen?' Ya, you know … things like that … Just to make them maybe think it through … a little more*" (C_ST3_FG_p6L367-369). Even though Bronwyn reportedly experienced some challenges, she too focused on supporting Grade 1 learners to investigate, as evident in the following extract: "*It was nice, but it was also frustrating, because … you can see that it is not gonna work, or you don't … you don't want to kill the vibe, but they have to kind of figure it out by themselves with your questions* *and stuff …, but it was easier though*” (A_ST1_FG_p10L553-556). More specifically, although Bronwyn thus preferred facilitation to direct teaching (previous excerpt), she experienced that “… *the constant facilitation to guide learners to get to a correct answer was tiring compared to just telling the learners the answer or what to do*” (A_ST1_LRp4). Monique shared Bronwyn’s experience, reporting that she also found it hard to see learners struggle, and refrain from intervening. She explained her experience as follows: “*It is hard sometimes to just be like, okay well, struggle along for an hour until you figure it out, and not say anything. That I found quite hard… when they’re building theirs – and you can see they’re doing it wrong, and then you just like, okay… well…*” (C_ST3_FG_p6-7L359-362). Despite these challenges, both Bronwyn and Monique’s expressions indicate their awareness of the importance of not merely providing answers to learners, and the efforts they put into supporting learners’ investigations.

In terms of the perceived effect on the learners, Bronwyn stated that “*I think it meant more to them. It was more important for them to do it properly, because it’s their own ideas … they’re doing it physically*” (A_ST_FG_p13L719-720). Monique added: “*And I think they also build confidence if you allow them to do something*” (C_ST_FG_p13L724). Monique furthermore noted that *“… if you just leave them to try, I think they …, they figure it out their own … even if it’s not realistic, they just … solve their own problems*” (C_ST_FG_p13L731-732). This idea was confirmed by Bronwyn’s reflection on IBSE’s effect on children where she recorded her observation in the following way: *“[IBSE makes kids feel] Important, ‘heard’, in charge, capable*” (A_ST_R1). Remarks such as these are indicative of the value that the participants apparently attached to IBSE, in terms of possible positive outcomes such as learners gaining self-confidence.

However, the participants also voiced some associated challenges they reportedly experienced, which is indicative of their view that such positive outcomes did not necessarily apply to all learners. In Jean’s opinion “… *some of them aren’t confident, or they don’t ...*”, with Monique adding, “*Yes, and they rely on other children, yes*”. Broadly speaking, the student teachers thus experienced some learners as not confident enough to take ownership of the learning process despite others taking the lead and gaining confidence. Jean provided the following explanation:

> "*I found that also with some of the activities I gave, the children didn't …, you know some of them didn't want to be too involved 'cause … but 'Am I drawing the right thing?', 'Am I doing the right thing?'. I was so tired of them … not wanting… (to think)*" (B_ST2_FG_p2L85-88), and later added: "*Like some of them aren't confident (to think on their own)*" (B_ST2_FG_p6L315).

Sharing Jean's experience, Monique shared her view that learners tended to rely on others in the group, stating the following:

> "*Uhm, I think it takes a little bit of encouragement sometimes, because they don't always want to think. A lot of children just drew an outline of a car for the sake of drawing something. But then they would quite happily take someone else's idea and say OK, that is better than mine, it is fine. Because they not always - well I found - some of them didn't want to… They were just like, ag, I'll use someone else's, because we are going to do group work*" (C_ST3_FG_p6L308-313).

This conversation was continued by Jean, who highlighted her experience of learners not wanting to be challenged. Jean's experiences are captured in the following extract from the focus group discussion:

> "*They don't like the challenge of having to think. It's like the child I reflected on a lot … He didn't like any sort of challenge, anything that challenged him, 'wo, I can't do this' - and he'd leave it blank. I promise you he wouldn't do anything. So there are just some that feel that way*" (B_ST2_FG_p6L319-322).

As such, participants seemingly held the view that selected learners who were uncertain about themselves would rely on others to take the lead, not benefitting from the potential outcome of increased self-confidence. However, other learners seemingly gained self-confidence as per the participants' reflections and reports. In terms of their own view of the learners, it seemed clear that the student teachers regarded learners as competent in contributing valid opinions, and encouraged them to explore and express their own ideas when solving a problem. Based on my onsite observation, as well as my analysis of the lesson planning documents and science journal formats provided to learners, it became evident that the student teachers allowed sufficient time and space for learners to think on their own and suggest possible explanations. Despite their experiences of the learners being hesitant to take the lead, all three student teacher participants acknowledged learners' possession of prior knowledge, and did not regard them as blank slates. In this regard Jean stated: "*So I think lots of them already have a prior knowledge in some way and they were definitely able to use it*" (B_ST2_FG_p6L301-303).

During my onsite observation, I noticed, however, that student teachers' facilitation was general rather than specific. In this regard, I reflected in my journal as follows:

> *"What I noticed in all classrooms (during observation and after watching the videos several times) is that, while student teachers provided learners with the opportunity to record their own thinking at the onset of the activity, their guidance throughout the activity was more general in terms of encouraging learners to think on their own … However … it is not sufficient merely to allow time and space for learners to explore and express their ideas. Learners need to experience physically and be aware of whether, why and how their initial ideas changed. I did not observe this kind of support from the student teachers, which may imply that they need clearer guidance in this regard"* (Research Journal, 1 March 2016).

Even though the student teachers were thus observed to acknowledge learners' possession of and ability to express ideas, and also their own role in encouraging learners to do so, I observed that learners seemingly required more individualised guidance. Learners could possibly also have benefitted from more opportunities to reflect on and review their initial ideas, and later compare these to final ideas.

Closely related and in support of my observations, Bronwyn, who viewed herself as a capable facilitator (A_ST1_R4), indicated that she needed more practical experience in facilitating an IBSE activity in a real classroom situation (A_ST1_R9). In her reflection, she wrote: "*I can prompt but need more practice in saying the correct thing/leading question*" (A_ST1_R4), requiring more knowledge and experience with "*guiding learners when they are designing an investigation*" (A_ST1_R9). In Jean's case, she voiced the view that she could perhaps have guided the learners' investigations more effectively, stating the following:

> "*I feel like I should have been more clear in my instructions. I should have spent more time discussing how the learners must work together and what rules they need to follow. I do feel like I was rushed for time and maybe neglected these aspects unintentionally*" (B_ST2_LRp3).

In cases where the participants got the idea that learners lacked the necessary skills to engage in an investigation, the student teachers reportedly supported the learners to develop the required inquiry skills. Jean, for example, explained her role in promoting the skill of observation in learners as follows:

> "… *because they hadn't done it. And they each got given a lavender plant, and I was like okay, I just need you to write down … Well, first we discussed observation, and they had to then realise that observation uses your senses to analyse and describe something, and so then they basically, each group had these big lavender plants, and they had to write down what sense they used, and what they see. And it was things like that that they never heard of before. They didn't know what observing was*" (B_ST2_FG_p7L408-414).

4.3.1.3 Category 3: Guiding learners to make sound conclusions and reflect on their experiences

An important role of an IBSE facilitator is to guide learners through analysis and reasoning for them to be able to explain their scientific ideas, and draw evidence-based conclusions. This requires an explicit and reflective approach, asking of teachers to guide learners during and at the conclusion of the IBSE activity to reflect on what they did and what they have found, and then make connections between their results and scientific facts. Based on my classroom observations, I noticed how the learners in all three classes were involved in "show-and-tell" activities where they verbally described what they had done and found. However, the phase of drawing conclusions, more specifically, reflecting and consolidating evidence-based conclusions, seemed limited. Confirming my observations, Bronwyn's noted, "*I couldn't check on that though, because my kids were too excited to … like actually then afterwards to sit down and draw conclusions*" (A_ST1_FG_p8L451-452). Similarly, Jean explained her experience: "*I know we ran out of time in my lesson. It was already going into break* …" (B_ST2_LRp9L501). Correspondingly, Monique commented: "*Ya, on that day I was like, that's not gonna happen*" (C_ST3_LRp8L454).

It therefore seems clear that time constraints as well as learners' excitement about the hands-on work they had been involved in, posed challenges to the student teachers in fulfilling their role of guiding learners to draw conclusions. Jean reflected as follows on her experience when learners compiled group posters on which they summarised their processes and conclusions to communicate these to the whole class:

> "*I found that I was scrabbling for time by this stage of the lesson. The groups had made posters but they were not very detailed as there was not much time for this … It was difficult to pull the learners out of the investigation stage and to ask them to compare their findings to their ideas, as some were incomplete*" (B_ST2_LRp3).

Jean's reflection highlighted her knowledge of the various roles of an IBSE facilitator, but also her perception that the learners' eagerness to engage in hands-on investigations was to the detriment of their engaging in minds-on activities (e.g. analysing and reasoning about the conclusions). In this regard, Monique reflected in the following manner: "*I needed to remind them of this (recording ideas) and also engage in a conclusion session to consolidate all the concepts*" (C_ST3_R2). As such, the data seemingly indicate that the student teacher participants valued their guidance to learners in order for the latter to draw conclusions, yet experienced this to be limited due to the said challenges they faced.

In the same way, the student teacher student teachers experienced their fulfilment of the role to guide learners in recording their thinking as challenging, despite their requests that learners reflect in scientific journals. Jean explained:

> "*A problem was the learners recording their steps scientifically. Many learners neglected to fill in their journals as they were absorbed by the idea of building the car and testing it! I then had the extra task of running around and making sure that the learners filled these in*" (B_ST2_LR_5).

Monique similarly noted: "*I reminded the learners constantly and felt as though I was nagging them to fill these in*" (C_ST3_R2). In this regard Jean described her role as one that involved constant reminders to herself and the learners, saying:

> "*I felt at times that I was nagging them to fill it in … because … some of them did it, some of them were just diligent, and you know when I told them, they ding-ding-ding – perfect, beautiful – and they filled it. But some got so excited, they were so intent on building that they wouldn't go back, and, you know, consolidate with the group ideas, or write what worked and what didn't. So often I felt that I was walking around, 'Don't forget to do this, don't forget to do this' … It was like just stop having fun and go back and fill this out*" (B_ST2_FG_p9L511-518).

As learners were apparently not used to recording their ideas, Bronwyn suggested the following during the focus group discussion:

> "*I think that might work better is if you have a science journal, like that is a normal thing that you do every week, or something … so that they know, after an activity, they write down what worked and what didn't work, because then … then they're reflecting on what just happened …. Because I think it's new to them, so they like … forget about the paperwork*" (A_ST1_LRp9L524-528).

This suggestion was positively accepted, and Jean commented: "*That's actually brilliant!*" (B_ST2_FG_p9L530). Jean's response points to the importance of learners reflecting on and sharing experiences with peers in order to improve their own practice. Bronwyn added: "*Make the science journal fun or exciting. Maybe make it digital or draw pictures. Or record it/watch video again and then discuss it in a group*" (A_ST1_R8).

4.3.2 Sub-theme 1.2: Challenges experienced when implementing IBSE

The student teacher participants identified certain challenges they experienced when implementing IBSE in the Foundation Phase context. The following categories capture these challenges: science not being viewed as a priority area; time required to implement an IBSE activity, and challenges related to classroom management.

4.3.2.1 Category 1: Science not being viewed as priority area

All three student teacher participants reported that science was not regarded as a priority subject in the schools where they were placed, and that the focus rather fell on other learning areas due to a lack of clear goals and outcomes in terms of science education. In Jean's opinion:

> "*Because the teacher does have to meet specific outcomes, and it's nowhere stipulated that you need to … you know … make sure the learners are equipped with these scientific skills. There is no priority placed on it, so to add that on to a typical average teacher who, perhaps isn't that interested wouldn't be beneficial, I don't think*" (B_ST2_FG_p15L864-868).

Along the same lines of thinking, Bronwyn noted:

> "*Ya, I think everyone is very conditioned …, and there's no time to, or … it's either too much effort or there's no time to branch out and actually spend time on the details of the little things, and … to spend time on something that is not really in the curriculum. But it is … it can be … I don't know*" (A_ST1_FG_p14L797-800).

Monique supported this idea by referring to the importance of completing the curriculum. She stated:

> "*And also the children. I mean if you did ... if their academic level …. Obviously if they're struggling, then you don't want to spend too much time on something that they do not need, but there is a curriculum to follow at the end of the day*" (C_ST3_FG_p2L64-66).

However, the student teacher participants reportedly struggled to obtain clear curriculum guidelines and outcomes for science in the CAPS. In one of her reflections, Bronwyn wrote: "*Guidelines aren't focused on science in Grade 0 – Grade 3. Not enough emphasis on it*" (A_ST1_R8). In referring to CAPS, she wrote: "CAPS – more the workload of what is expected, and there's hardly any science". In terms of IBSE specifically, Monique added: "*CAPS: don't really allocate anything for IBSE*" (C_ST3_R8). Bronwyn similarly indicated that there is "*not enough information on it*" (A_ST1_R8) and "*too little information on IBSE & Questioning techniques*" (A_ST1_R1).

Following their identification of limited curriculum guidelines as a challenge when implementing IBSE, Bronwyn suggested the following: "*Expand on the Curriculum. Even if it (CAPS) doesn't change, make it your own to add a holistic viewpoint to the classroom. Add scientific depth to NS [natural science]*" (A_ST1_R8). Along the same lines, Monique wrote: "*Use CAPS as a guideline, particularly themes and create own IBSE opportunities*" (C_ST3_R8). Both Bronwyn and Monique found *Pinterest* to be a helpful resource on IBSE (C_ST3_R10). Bronwyn explained: "*Pinterest gave great ideas because experiments/inquiry based lessons are difficult to find*" (A_ST1_R10). She added that more reference to IBSE websites (during teacher training courses) can be helpful (A_ST1_R10). These contributions indicate the participants' willingness to look elsewhere for resources and guidelines that are not provided in the current national school curriculum.

Pressure to cover the curriculum, yet without clear guidelines for science, and the perception that often exists that learners do not need to be taught science as it does not appear important in the curriculum, were thus foregrounded by the participants as challenges. In this regard, all three student teacher participants indicated that they had not witnessed any science lessons in their schools during the teaching practice period. Jean provided more detail, saying:

> "*I hadn't seen … anything, they just … Life Skills (subject) I think for them was integrated into everything … They have the little government things that they'd read together. So, transport is this; so, trains are transport; draw your own train. Just the governmental ones*" (B_ST2_FG_p3L126-129).

From Jean's comment, science seems often to be integrated and taught as part of the Life Skills subject, and then presented via approaches such as reading from a book instead of following an inquiry-based approach. Jean's negative experience of this is captured in the following extract taken from the data: "… *being a student teacher in someone else's class where you see that science isn't … there aren't any science lessons and … you know … they put pressure on you while you're doing your science lessons, was … disheartening*" (B_ST2_FG_p14L786-789).

The implementation of IBSE in the Foundation Phase science context was also apparently negatively affected by the tendency to focus on mathematics and languages as priority subjects, and by schools' preparation for the Annual National Assessments (ANA) (also focusing on mathematics and language). In Jean's words:

> "*There is so much pressure on the maths and the English … then they were doing the ANAs … It's just … the school and all of the staff, they were so focused on … they need to do this maths, and then you do this, and you need to write the ANAs*" (B_ST2_FG_p14L791-794).

Bronwyn elaborated as follows: "*There was no thinking more of learning in the broader sense of … you know, learning sciences, learning skills – it was just very … focused on those two*" (B_ST2_FG_p14L794-795).

Based on their experiences with the learners in the classroom context, the student teachers noticed a lacuna in learners' understanding of science and scientists. This view is evident in a statement made by Bronwyn, which was confirmed by both Jean and Monique. Bronwyn said: "*And it [science] is separated of them*" (A_ST_FG_p7L397), followed by Jean's comment indicating the following:

> "*Because, I don't think they have any knowledge of it really. I mean I had asked these Grade 2's, what is a scientist, and the one boy has tried, 'Despicable Me' and 'Minions'. Ya, so I think they have more of a fantasy kind of Hollywood idea of what a scientist is*" (B_ST_FG_p7L390-393).

Since learners were seemingly not exposed to science and independent learning opportunities on a regular basis, the student teacher participants perceived the learners to be lacking the necessary skills for thinking and behaving like scientists. In this regard Monique reflected as follows: "*Learners aren't used to this approach*" (C_ST3_R8). Similarly, Jean noted: "*I think that it's perhaps this idea … this approach is quite different to what they're expected to do in the classroom*" (B_ST2_FG_p2L92-93). In accordance, Bronwyn said: "*Yes, they're not used to ... Because they're told what to do; they're not …, they're not given the freedom to do like … just do it*" (A_ST1_FG_p2L95-96). Adding to this, Bronwyn remarked: "*I think they don't give them the opportunity … to practise being a scientist*" (A_ST1_FG_p15L839). As such, the student teacher participants seemingly viewed the Foundation Phase as ideal for developing learners' scientific competencies, yet often not encouraging this. In this regard Bronwyn suggested: "*And, it's also like a nice age group where they want to make things, and build things. Like they can do it, so they should do it at school*" (A_ST_FG_p8L422-423).

4.3.2.2 Category 2: Time required to implement an IBSE activity

Two of the three participants identified the time required to implement an IBSE activity as a challenge. For Jean, one of the main challenges she experienced was "*the time constraints*" (B_ST2_FG_p1L22). Regardless of curriculum flexibility in the Foundation Phase, she "… *still felt that I was so limited in the time that I had to prepare. Uhm, so that was definitely … definitely a challenge. That wasn't ideal*" (B_ST2_FG_p1L24-25). According to Jean, *"… if we had more time, it would've been excellent*" (B_ST2_FG_p1L32-33). Along similar lines, Bronwyn mentioned the time an IBSE activity takes as challenging, explaining her experience as follows:

> " … *you know, you have to get this done by the end of the week, you have to finish this … So, three hours of letting kids find it out for themselves … it's … almost takes in on other subjects' time, so uhm, ya, it's basically a time thing, I think*" (A_ST1_FG_p1L40-43).

In reflecting on the challenges associated with limited time frames, Jean noted:

> "*I really think that this lesson should have been done over a few days and not in one day. If I could do it over, I would do it over a few days, explain the instructions more clearly and facilitate more. I feel like due to time constraints, this lesson was rushed and perhaps not executed as best it could have been*" (B_ST2_LRp4).

As such, Jean associated the outcome and success of the lesson with the time available to her being too limited.

On the contrary Monique experienced the flexibility of her mentor-teacher and the school environment as supportive in allowing enough time for the IBSE lesson. She referred to the activity she presented for this study and explained herself as follows:

> "*Ya, I didn't find that with the time at all … there was no time constraint. I mean if I worked into break, and the kids were happy to stay, then it's fine. Because literally, that's all we did that day … was that lesson*" (C_ST3_FG_p1L48-51).

In her case, she felt that the school environment allowed flexibility for implementing approaches such as IBSE. She furthermore stated:

> "*But I think the school environment is like that as well. Although the planning is done for the week or whatever, but there's no like, if it's not finished by Friday – sorry! … So, it was quite nice in that aspect*" (C_ST3_FG_p1L56-59).

4.3.2.3 Category 3: Challenges related to classroom management

Implementing IBSE apparently placed high demands on student teacher participants, more specifically in terms of classroom management. For Jean, *"[t]he class was also difficult to manage as the learners were super excited and energetic*" (B_ST2_LRp3). Jean related the challenge of classroom management to learners' excitement and their immersion in the activity. She explained some of her experiences by saying:

> "*There were only a few things, like … uhm … when we … when I wanted them to start working on their posters … because they were so overwhelmed with testing the car and retesting it, and building and whatever, that when you know time was running out, and I was like OK they must make their posters now. I think I did … I maybe had to shout over them or do something*" (B_ST2_p12L686-691).

While all three student teachers accommodated the expected noise and higher activity levels of learners, they seemingly experienced this as challenging, and were frustrated when trying to get the attention of learners. Jean voiced her view in the following way: "*I don't mind them making a noise and doing their own thing. I just think if there was a nice method to regain their attention at once … it would be helpful*" (B_ST2_L691-693). Monique similarly explained her experiences by saying:

> "*I didn't mind it when they were doing that, like when they're busy doing that, I don't mind at all. Like they can carry on, I've got no problem. But it's obviously when you're trying to say something important, then they just needed to stop. In the beginning, they must just wait for everyone to just … focus*" (C_ST3_p11L671-673).

In this regard Bronwyn implemented an attention-focusing strategy (one-two-three, look-at-me) when aiming to get the learners' attention. By the end of the activity she, however, felt overpowered by the learners' energy, saying, "*I think I've kind of lost the plot towards like the end of the three hours. Like they were just too … they were like overwhelming me, and they were like… they were in charge. Not that I wasn't ever in charge, but …*" (A_ST1_FG_p12_L702-704). In her post-lesson reflection, Bronwyn once again pointed out the following aspects she wanted to improve on: "*Classroom management strategy to focus attention" and to be "Firmer*" (A_ST1_LRp5).

Managing groups apparently also posed challenges to the student teacher participants. However, this experience applied only to some learner-groups. Jean explained: "*I found that it can be difficult for learners to work together. This is not true for all learners though, as some groups worked really well together!*" (B_ST2_LRp4, 5). She added:

> "*With regard to the groups and group discussions, I found it difficult to facilitate in some groups and not in others. For example, the Yellow Group could not work together. They tried, and I tried to facilitate, but they were totally incompatible!"* (B_ST2_LRp4).

She furthermore wrote:

> "*I did walk between the groups to listen to their solutions, to ask questions and to stimulate further thinking; however, some groups were not working well together. I found that a lot of time was spent reiterating what the learners need to do in their groups*" (B_ST2_LRp3).

Jean's experiences were supported by the classroom teacher and resulted in Jean experiencing frustration. The teacher's perception is implied in the following excerpts:

- "*I felt that I was under so much pressure from the teacher and the classroom, because, she's like, it's too noisy, it's too this, it's too that – which was a bit perturbing*" (B_ST2_FG_p1L29-32).
- "*… some of the comments she (the mentor-teacher) gave me was that it was too noisy; I should have controlled the classroom, but those are exactly the things I didn't want to do. And I felt so stressed while I was doing it because she was like make me run around like, keep quiet, quiet, quiet, but I didn't want to be that way*" (B_ST2_FG_p2L81-84).

4.3.3 Sub-theme 1.3: Potential value of IBSE implementation in Foundation Phase classrooms

This sub-theme captures the student teacher participants' views on the potential benefits of IBSE implementation. The categories I identified are supporting professional teacher identity development, and ideas on broad-level implementation.

4.3.3.1 Category 1: Supporting professional teacher identity development

The data generated by the student teacher participants indicates their shift away from being teachers transferring knowledge, towards teachers being facilitators of learning. Based on their involvement, they conceptualised themselves as competent facilitators of IBSE, and displayed confidence in their facilitation qualities. Following their involvement in the study, Bronwyn mentioned that even though "*I do not come from a scientific background*" (A_ST1_R9), she regarded herself as a facilitator of learning-centred education (A_ST1_FG_p10L561), with facilitation being one of her strengths. In this regard, she stated: "… *this might be my best attribute*" (A_ST1_R9), and elaborated that "*it comes quite naturally for me as I am an introvert and I prefer being out of the spotlight and listening to others …It's easier for me to let learners think on their own*" (A_ST1_R4).

Monique similarly viewed herself as a facilitator of learning rather than a transmitter of information. She explained her view in the following way:

> "*I found that easier to do than to stand in front of a class and present a lesson and try and explain something to them, like a maths concept. Because you can only say something so many ways, and a lot of them will say 'but I still don't understand'. It is very difficult then to think … how am I going to do this, whereas there you can say OK, but what do yóú think? Now try and help yourself, instead of saying OK but this is how we do a minus sum where we carry and, …So I found it easier to facilitate learning that way … than to explain*" (C_ST3_FG_p5L284-290).

From Monique's remark, it is evident that she did not only apply an inquiry-based approach to science, but that she also followed the approach when facilitating other subjects (e.g. mathematics). Monique shared her reasons for preferring to be a facilitator of learning:

> "*Ya, and I think it is actually a better way for them to learn than always giving them … I think it is exhausting as well, if you think about it: "Ma'am, how do you spell this? Ma'am, how do I do this? Eventually I just want to say there is the dictionary do it yourself, just try, you know …*" (C_ST3_FG_p2L104-106).

Jean, who completed: *"… a year of BSc*" (B_ST2_FG_p14L811), reflected on her qualities and competencies in the following way:

> "*I love science. I always have been interested in science … I feel like I have the background and knowledge to be a successful teacher. By using the talents I already have, combined with what I am learning in the ECD course, I can understand my role as facilitator and not a teacher*" (B_ST2_LRp1-2).

For Jean, it was important to create space for and stimulate learners' thinking. She explained: "*So, ya, that's why I think I tried to push sciency things, quite a few of them, because I wanted them to … think*" (B_ST2_FG_p3L129-130). In her post-lesson reflection, she confirmed this tendency in the following way: "*I aim with all my lessons to let the learners do the thinking – the learners need to come up with solutions without me having to give them direct answers*" (B_ST2_LRp2).

Monique, like Bronwyn, did not come from a science background, yet viewed herself as "*creative and innovative, thus I am able to use creative ideas to implement IBSE*" (C_ST3_R1). She reflected on her qualities and competencies in the following way:

- "*I am patient and ask guiding questions*" (C_ST3_R9).
- "*I am able to stand back and let learners be involved and take learning into their own hands. I can guide with thinking questions and not get frustrated when trial and error takes very long*" (C_ST3_R4).
- "*Ability to encourage learners to keep trying*" (C_ST3_R4).

As such the data indicates that all three participants were able to identify their role of being facilitators, as well as the strengths they displayed in fulfilling this role. They furthermore seemed to view the facilitation of IBSE as a rewarding experience. Bronwyn described her experience as "*fulfilling as a facilitator*" (A_ST1_R1), and as: "*a very fun way of teaching … of doing things. I enjoyed it as much as the kids did as well*" (A_ST1_FG_p16L903-904). To her, the value of her own growth was reflected in the learners' achievement, as evident in the following explanation: "*Like you feel* *like you have accomplished something … by them accomplishing something on their own*" (A_ST1_FG_p16L908-910).

Monique similarly experienced IBSE as "*exciting and a new way of doing things*" (C_ST3_R1), and she felt "*rewarded for all the hard work and proud of the learners' abilities*" (C_ST3_R1). For her, another reward lay in the fact that "*IBSE teaches the facilitator as much as the children learn and allows one to be reflective and see things differently*" (C_ST3_R1). This reflection indicates the value that she attached to being an IBSE facilitator in terms of her own development as a reflective teacher.

Jean's post-lesson reflection similarly indicated the fulfilment she experienced in implementing IBSE as well as her ability to reflect on strengths and potential aspects for improvement. She wrote that she was "*satisfied with the outcome*" of the lesson (B_ST2_LRp1) and that she was "*proud of how I conducted myself* …" (B_ST2_LRp2). Based on the contributions by the participants it therefore seems that they valued the potential of IBSE in shaping their skills as facilitators, their personal qualities, and their professional identity as IBSE implementers. In further support of their own development, the student teacher participants highlighted the value of the training they had received prior to implementing IBSE, thereby indicating the value of learning inquiry through inquiry.

In this regard, two of the participants relied on the example of IBSE they had themselves experienced. Jean reflected as follows:

> "*This lesson idea excited me! I had such an amazing experience during our lectures when we did this as a group, engaging in many scientific skills myself as we worked to try create the best car. I really was so keen to do this lesson and put a lot of effort into finding the materials, planning the lesson and creating journal pages for all the learners*" (B_ST2_LRp1).

4.3.3.2 Category 2: Ideas on broad-level implementation

The participants shared several ideas about IBSE implementation on a broad level. According to them, IBSE implementation in all schools could benefit all learners. Based on her experiences in implementing IBSE Bronwyn reflected: "*IBSE should be implemented in all schools as it is a great way to improve the learners' cognitive and practical skills and it will be beneficial to the learners in all aspects*" (A_ST1_LRp7).

Similarly, Monique wrote in a reflection: "*IMPLEMENT IBSE. Definitely worth trying – so much to learn from the experience*" (C_ST3_R1). In Bronwyn's opinion, IBSE is implementable in the South African Foundation Phase context, and "*would definitely work. It just needs to be focused on*" (A_ST1_R1).

As background to such broad implementation, the participants indicated insight into the importance of raising awareness of IBSE as approach among relevant sectors and stakeholders. In this regard Bronwyn listed the following entities as possible audiences: "*Heads of Departments (HODs), School Governing Bodies (SGBs), teachers (in particular mentor-teachers) and parents*" (A_ST1_R1). Similarly, Monique identified and stated that "*parents, principals and HOD members should be included to create awareness, research and implementation of IBSE*" (C_ST3_R1). She furthermore added: "*Also government entities should include IBSE in the curriculum*" (C_ST3_R1).

To create this awareness, Monique suggested that the following message be conveyed to stakeholders: "*Bring IBSE into classrooms, make it regular practice and encourage learners to think for themselves*" (C_ST3_R1). Bronwyn's message reflects the same sentiment, with her stating: "*I'd tell anyone who is listening that this is the way forward in creating independent learners*" (A_ST1_R1). For Monique, an inquiry-based approach to learning is not restricted to science, but applicable to other subjects as well. She remarked: "*Any subject can implement inquiry based learning*" (C_ST3_R1).

Based on these contributions and views, the participants believed that it is important to challenge the views of teachers about science education and learners' competence to take the lead in their own learning. They further indicated the importance of certain qualities for teachers to be significantly prepared for this task. In terms of existing beliefs, Jean stated:

> "*Ya, there needs to be (awareness). Because I think even some of the teachers maybe … I don't know whether it's a thing between the different sectors, but maybe science or scientists are a bit of oooh untouchable … NASA, you know, whatever. So maybe the teachers feel a bit like it's not in their job description… if that makes sense*" (B_ST2_FG_p15L850-854).

When discussing required qualities, Monique emphasised the importance of thorough preparation. She said:

> "*I don't think anyone can do it. Like I don't think you can just go and be like OK! I think there is a certain amount of research … You do have to know what is going on. Like Bronwyn couldn't just go in there, and like hope and pray that they don't ask her a question about the fish. Like you do have to do a little bit of … prep and you know … you have to be prepared*" (C_ST3_FG_p14L817-821).

Jean added to this view by focusing on the importance of teachers being interested in teaching science and what they present in class. In her view, such interest could contribute to successful IBSE implementation. She explained this idea as follows:

> "*I think the teacher or facilitator has to be interested in what's going on, because I mean, everyone remembers teachers or people who were just so boring and bland. They came there and now I have to teach you this or that. So, I think if a teacher has … they should have a certain passion for it, or interest. Then it will help. Then it doesn't matter what science lesson you want to do*" (B_ST2_FG_p14L825-830).

4.4 SUMMARY

I commenced this chapter with a brief description of the three cases involved in this study. As background to my presentation of the results, I provided an overview of the four themes I identified, and then focused on Theme 1 in the current chapter. As such, this chapter reports on the experiences of the student teacher participants, following their implementation of IBSE in Foundation Phase classrooms.

In the following chapter I present the remaining three themes, focusing on learners' experiences following their participation in IBSE lessons. Throughout I illuminate the themes and sub-themes I discuss with excerpts from the data that was generated by the child participants.

Chapter 5

RESULTS: THE EXPERIENCES OF CHILD PARTICIPANTS

Community of Scientists

(Grade 1 learner's drawing of her groups' participation in the IBSE activity, School A, Pretoria, 2015)

5.1 INTRODUCTION

In Chapter 4, I presented the results of the study with regard to the experiences of the student teacher participants' on the implementability of IBSE in Foundation Phase classrooms (Theme 1). In this chapter, I focus on the learners' experiences. To this end, I present and discuss Themes 2 to 4. As in the previous chapter, I include excerpts from the data in support of my discussion. As an introduction I summarise the three themes I identified on the learners' experiences in Table 5.1.

Table 5.1: Overview of Themes 2, 3 and 4

THEME 2: LEARNERS' ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE	
Sub-theme 2.1	Understanding the problem and taking ownership of the learning process
Sub-theme 2.2	Identifying ways to investigate and solve the problem
Sub-theme 2.3	Engaging in the investigation as part of a team
Sub-theme 2.4	Gaining new insight and drawing conclusions
Sub-theme 2.5	Sharing and documenting experiences
THEME 3: LEARNERS' EXPERIENCES OF SOCIAL LEARNING	
Sub-theme 3.1	Perceived value of social learning
Sub-theme 3.2	Dealing with associated challenges
THEME 4: LEARNERS PERCEIVING IBSE AS AN EMPOWERING APPROACH	
Sub-theme 4.1	Value of owning the learning process
Sub-theme 4.2	Acquiring science-related knowledge, skills and dispositions
Sub-theme 4.3	Becoming aware of the broader application of science
Sub-theme 4.4	Being and becoming scientists

5.2 THEME 2: LEARNERS' ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE

Theme 2 presents learners' engagement in IBSE and reflects their experiences of doing science. It more specifically relates to their engagement in the inquiry-based learning process. The following sub-themes apply: understanding the problem and taking ownership of the learning process; identifying ways to investigate and solve the problem; engaging in the investigation as part of a team; gaining new insight and drawing conclusions; and sharing and documenting experiences. Table 5.2 captures the criteria I used in identifying the sub-themes for Theme 2.

Table 5.2: Inclusion and exclusion criteria for Theme 2

THEME 2: LEARNERS' ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE		
Sub-themes	**Inclusion criteria**	**Exclusion criteria**
Sub-theme 2.1: Understanding the problem and taking ownership of the learning process	This sub-theme includes data related to learners' engagement in the initial phase of IBSE. It includes all data related to learners' recall, articulation and understanding of the IBSE problem that serves as indication of taking ownership of the learning process.	This sub-theme excludes data that refers to learners' experiences of any IBSE phases other than the understanding and taking ownership of the problem phase.
Sub-theme 2.2: Identifying ways to investigate and solve the problem	This sub-theme includes data related to learners' own ideas as formulated during the think-on-your-own step of the IBSE process. It includes all data related to the plausibility of learners' initial suggestions to solve the stated problems, and their insight into the plausibility of their own ideas.	This sub-theme excludes data that refers to learners' experiences of any IBSE phases other than the think-on-your-own phase.
Sub-theme 2.3: Engaging in the investigation as part of a team	This sub-theme includes data related to learners' engagement in the investigation phase. It includes all data related to interaction among learners, their implementation of inquiry skills in theory formation and revision, and the roles they fulfilled as part of a community of scientists in finding solutions to the problems they encountered.	This sub-theme excludes data that refers to learners' experiences of any IBSE phases other than the investigation phase.
Sub-theme 2.4: Gaining new insight and drawing conclusions	This sub-theme includes data related to learners' engagement in the drawing conclusions phase. It includes all data that relate to the process of and factors that influenced gaining insight and drawing evidence-based conclusions.	This sub-theme excludes data that refers to learners' experiences of any IBSE phases other than the drawing conclusions phase.
Sub-theme 2.5: Sharing and documenting experiences	This sub-theme includes data related to learners' engagement in the communication phase. It includes all data related to learners' verbal and written communication of their experiences and understanding as a result of their participation in the IBSE activities.	This sub-theme excludes data that refers to learners' experiences of any IBSE phases other than the communication phase.

5.2.1 Sub-theme 2.1: Understanding the problem and taking ownership of the learning process

This sub-theme relates to how learners engaged in the initial phase of IBSE and therefore relies on data indicative of how the learners took ownership of the problem as first step of the IBSE process. A core idea of LAMAP IBSE is that learners need to understand what they are learning, thus own and understand the problem in order to acquire scientific knowledge through active participation. Keeping these guidelines in mind, the student teachers presented the problem verbally, and staged real-life challenges in an attempt to add authenticity to the situation.

Based on my exploration of the learners' articulation and recall of the problems during the whole class reflection sessions and focus group discussions, it seemed evident that the learners in all three cases understood the problems posed to them and were able to recall these, and in some cases relate them to their own experiences. More specifically, after explaining the urgency of transferring the pet fish in plastic pockets to better conditions within a certain time, Bronwyn introduced the problem to the Grade 1 class as follows: "*Quickly go to your desks, let us all design a fish tank quickly*" (A_ST1_LP_p7)[29]. Data obtained from the learners confirmed their understanding of the problem, as is evident in the following excerpts taken from the data set, capturing the learners' views of what the problem entailed:

- *"To build a tank for the fish"* (A_L_R_p1L3)
- *"Because it can't stay long in the plastic bag*" (A_L_FG_p1L46).

These learners' statements indicate an accurate recall and the learners' ability to express and explain the problem in their own words. Onsite observations confirmed their excitement on having living fish in the classroom, and their realisation of the urgency to find a solution to the real life problem.

[29]The following codes are used henceforth: A/B/C = school (A = Grade 1; B = Grade 2; C = Grade 3); L = learner; R = whole class reflection session (group interview); p = page; L = line; FG = focus group; BG = blue group; YG = yellow group; RG = red group; GG = green group; VD = video dialogue (observation onsite); SJ = science journal; Dr = drawing.

Similarly to the Grade 1 learners, the Grade 2 learners were able to accurately articulate the problem in their own words, after it had been presented to them. Jean used a phone message from a BMW car designer asking the learners' help in designing a model for BMW. She introduced the problem as follows: "*To design a model of a car with recyclable material that can go as far and as straight as possible down an incline*" (C_ST3_LP_p2). When asked how they understood the problem, learners stated:

- *"Uhm, because he* [BMW car designer] *… he doesn't know how to build an engine out of… He didn't know how to build an engine"* (B_L_R_p1L3-4)
- *"We had to make the car for him"* (B_L_R_p1L12)
- "*Well … he wanted the car to uhm … we made a model and then he wanted a car… he wanted the car to be uhm brilliant and nice for ... so that he could show his boss"* (B_L_R_p1L16-18)
- *"It had to have wheels, and it had to roll and it had to go far and straight*" (B_L_FG_p1L47).

In addition to the learners' understanding the problem and taking initial action to find a solution, they seemingly took ownership for the whole IBSE experience. The Grade 2 learners, for example, related the IBSE problem to the problems they later encountered while solving the IBSE problem, as indicated in the following contributions:

- *"We let it go down and then the whole thing [roof] just popped off"* (B_L_FG_p1L25)
- *"The problem was that we had to solve is: fix it"* (B_L_FG_p1L29)
- *"We had to fix it because the roof came off"* (B_L_FG_p1L31).

As in the case of the Grade 2 class, Monique requested learners to help in designing a BMW car model, introducing the problem as follows: "*To design a car that can go as far and as straight as possible down an incline*" (C_ST3_FG_p0). When articulating the problem in their own words, learners displayed a clear understanding and also related the problem to the problems they themselves encountered during the IBSE activity, stating:

- *"The activity was to build our own BMW car"* (C_L_R_p1L5)
- *"The problem was..uhm...we put the wheels too high"* (C_L_R_p1L7)
- *"It had to go far … it had to go as far as possible, and as straight as possible"* (C_L_R_p1L17).

5.2.2 Sub-theme 2.2: Identifying ways to investigate and solve the problem

Learners' engagement in conducting investigations depends on their ability to implement inquiry skills and cooperatively plan and conduct investigations while relying on existing theories and new ideas. My exploration of the learners' existing or working theories and how these effected the ideas they came up with indicates that learners were indeed able to come up with ideas to solve the problems they had to solve. Learners seemingly relied on their working theories to interpret the information in light of their current understandings and experiences (i.e. prior knowledge) and then make suggestions to solve the IBSE problems.

To this end, Grade 1 learners' engagement in the exploration of their own thinking (think-on-your-own) was evident in expressions such as the following:

- *"I kind of had an idea"* (A_L_R_p1L28)
- *"We all did"* (A_L_FG_p3L126)
- *"We had to think"* (A_L_R_p1L30)
- *"I wanted to make it with a big box, and tape the cellotape around, with water inside"* (A_L_FG_p3L128).

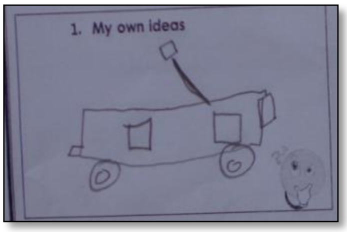
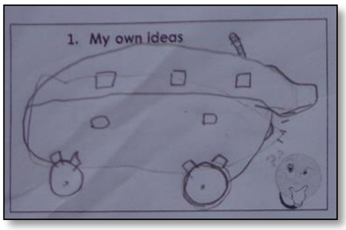
Grade 2 learners similarly explained their possession and the origin of their ideas as follows: "'*Cause it was your own, um … design that you wanted to make yourself*" (B_L_FG_p1L54). Learners agreed that they all had ideas (B_L_R_p2L58), and "[i]t came from your brain" (B_L_R_p2L70; 74). In the same way, the Grade 3 learners seemed confident that they had their own ideas "*to figure it out yourself*" (C_L_FG_p2L41), and that the origins of their ideas came from "*Our brains*!" (C_L_R_p2L57) or "*From up here*" (pointing to the head) (C_L_FG_p2L72).

In response to my question of how the ideas got "up there", learners responded:

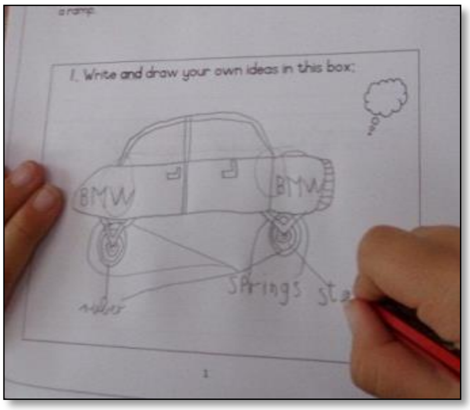
- "*You think of cars*" (C_L_FG_p2L81)
- *"Because..uhm…you thought and you could think of a car like you've seen a car before … you can draw it. So it was kind of easy to draw it and think of it"* (C_L_FG_p2L54-56)
- *"I've seen cars previously, so I decided to draw some cars from there"* (C_L_FG_p2L83-87)
- *"Actually my idea … I never actually got everything from up here. I got it from the picture on the top (pointing to the picture of the car on the science journal). It was the only plan I could think of"* (C_L_FG_p2L83-85).

These contributions indicate confidence in the own ideas, which reportedly originated in learners' thinking (A_L_R_p1L30). In this manner, available theories apparently enabled problem-focused predictions. In terms of the quality of their predictions and the plausibility of the learners' ideas as possible solutions to problems, in other words, the predictive power of their suggestions, the data I obtained indicate that learners' ideas were often not sufficiently problem-focused and clear enough to address the problems they attempted to solve. Even though the Grade 2 learners were able to explain their ideas, these were not necessarily sufficient to solve the problem. Two examples, taken from the six learners of the focus group discussion during onsite interactive observation and captured in Table 5.3, serve as supportive evidence.

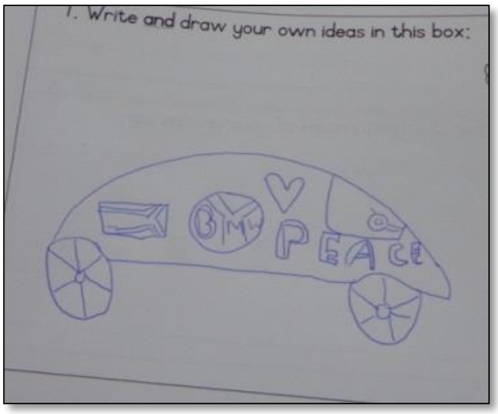
Table 5.3: Grade 2 learners explaining their own ideas as represented in their science journals

Example of own idea represented in science journal	**Dialogue during interactive observation**
 Rudi's representation of his own idea in his science journal	Rudi: "*Uh, my car is like a very fast car … it's a BMW kind of car. I put like milk jugs on it and those squares are the tinfoil thingies. And there's a (pointing to the wire) … that's a wire over there. And the top thing is a lid. And the two things at the bottom is cellotape. And the thing over there is also a lid – for the exhaust*". Researcher: "*The wire? What is the wire for*?" Rudi: "*Uh …, the radio*". Researcher: "*OK, one should have a radio in a car, hey? And will the radio make the car go far and straight*?" Rudi: "*Yes*". Researcher: "*How*?" Rudi: "*Uh …, the radio will do that …, uh… I don't know*" (B_L_VD_FG_p1L3-24).
 Lyn's representation of her own idea in her science journal	Lyn: "*This is the bottle for the car's top thing. There's the windows with those little sticky things. There's a bit of pipe cleaners stuck to the door for the door handles. That's sticky tape to stick the wheels on it. And the wheels are made out of the round thing on the table. And the pipe cleaner is for the radio just for decoration. This is half a bottle lid and this is the tin thing that you can put like food in, but it's the bit of the car that you like … open the door*" (B_L_VD_FG_p1L30-36).

These examples indicate that, although learners were able to explain their ideas, some of these ideas were not problem-focused and contained quite a number of imaginative aspects. As such, their predictions would not necessarily allow them to solve the IBSE problem at hand. Similarly, the ideas of the Grade 3 learners were seemingly not focused on the inquiry problem, and did not involve practical suggestions to solve the IBSE problem (i.e. making predictions for a car to go far and straight down an incline). Photographs 5.1 to 5.2 provide two examples that I observed onsite of learners' own ideas documented in their science journals (being representative of the class of 15 learners). These examples indicate that learners added unnecessary detail and impractical elements to their designs.



Photograph 5.1:
Grade 3 learner busy drawing his own idea



Photograph 5.2:
Grade 3 learner's drawing of his own idea

Grade 3 learners reportedly realised that, when they had to share their ideas in their groups in order to select the best option for the investigation, their own "complicated" suggestions were not practical to implement. During the focus group discussion, Robert explained: "*My decision was too complicated to work, so I just start with hers 'cause mine look so realistic but …*" (C_L_FG_p2L108-109).

Upon realising that their "fancy" ideas were impractical, learners allegedly adopted a more realistic problem-focused approach, as explained by Keshni: "*We decided on the easiest model of a car and then we decided like uhm … Jacob's wheels, Robert's windows, Luca's…*" (C_L_FG_p2L125-126). In contrast to the Grade 2 and Grade 3 learners' initial ideas having limited predictive power, Grade 1 learners (see sub-theme 2.5) found it difficult to determine the predictive power of individual ideas.

5.2.3 Sub-theme 2.3: Engaging in the investigation as part of a team

Based on my onsite observations and analysis of the interaction between learners during the investigation, I noted that in all classrooms, contributions and communication within the group context seemingly came naturally, instinctively and spontaneously for the learners. Learners appeared to be driven by the problem and eager to fulfil a role in the cooperative investigation. As the learners' experiences of social learning are captured in Theme 3, this sub-theme merely focuses on cooperative interaction and the roles learners fulfilled during the investigation phase as part of a team.

In the Grade 1 class, the group cooperatively decided to use the plastic construction blocks they found in a polystyrene container to build their fish tank. During onsite observation, I captured the following dialogue that demonstrates how the learners spontaneously started collaborating. If a suggestion from a team member made sense, it was simply adopted and tried. Hesitation by a team member was in this way easily overturned by alternative suggestions from others. The following excerpts provide examples:

- *"This will be extremely hard … to make a fish tank"* (A_VD_FG_p1L3)
- *"No, we just put blocks on the bottom and then we click it together and then we put it up and then it's done"* (A_L_VD_FG_p1L5-6).

When I prompted this group to take an inquiry-focused stance, asking them: "Do you think the blocks will hold water?", learners responded (A_VD_FG_p1L12-16):

- *"We're saying we'll use blocks and then put cellotape around"*
- *"I think we should put duck tape all around so that it doesn't fall apart"*
- *"I also think we should tape it so that the water doesn't fall out".*

This excerpt demonstrates how learners functioned as a community of scientists, and fulfilled different roles in justifying the group's decisions ("*We're saying*"), contributing to ("I *think*") and expanding ideas ("*so that it doesn't fall apart*"), confirming suggestions ("*I also think*") and further expanding ideas ("*so that the water doesn't fall out*"). When forced to reflect on their decisions ("*Will it hold water?*") learners individually and cooperatively provided reasoned justifications for their group's decisions.

Similarly to the Grade 1 learners, Grade 2 learners were able to contribute and communicate their ideas in a group context without effort. Learners worked together in planning, testing and carrying out their investigations. Despite some challenging personal interactions in some of the groups, learners generally managed to work together cooperatively in sharing ideas, debating, reasoning and agreeing on a plan.

During my interactive observation with one of the groups onsite, a learner explained the group's plan, while group members continued with constructing the car according to the groups' suggestion. The following excerpt and Photographs 5.3 to 5.5 provide evidence of the group members collaboratively working towards one goal, yet each with his/her specific role or task to complete. Lyn (explaining on behalf of the group):

> *"We are putting the wheels and attaching the pipe cleaners so that it can roll like this, and then this thing will be where the people sit. And that (pointing to the milk carton) will be the top. Then we're gonna stick little sticky things here for the windows, and … here are the four wheels".*

With all the wheels attached, Tiger tested the wheels by gently pushing the car. He said: *"It won't roll".* Rudi responded by saying*: "We told you it won't roll"* (B_VD_FG_p1L48-50).

Photograph 5.3:
Lyn explaining the group's decision to use pipe cleaners to attach the wheels

Photograph 5.4:
Lyn explaining the purpose of the milk carton

Photograph 5.5:
Tiger testing the wheels

This excerpt demonstrates how learners agreed and disagreed on plans in a group, followed a plan as suggested by the majority of the team, intuitively tested their theories (i.e. to use pipe cleaners to attach the wheels), verbalised evidence ("*It won't roll*"), and instinctively contributed opinions. Rudi's remark (*"We told you it won't roll"*) captures how an individual's idea can serve as stimulus for the group to question the plausibility of suggestions, and consequently rethink their plans.

Like learners in Grade 1 and 2, the Grade 3 learners participated spontaneously in sharing suggestions, making decisions and working in their groups. As individuals, learners provided and questioned suggestions, listened to others and acted accordingly. They verbalised findings, seemingly handled disappointment and acted as motivators. They worked as a team to implement their plans and to make adjustments based on individual suggestions. The following vignette provides evidence of the cooperative effort of the Grade 3 learners.

Realising that the wheels of their first construction would not roll, Robert suggested: *"Guys, I think I have an idea so that the wheels can roll. We can stick like a pin or something in there, then we can attach them to the wheels so they can roll".* When Robert's suggestion didn't solve the problem, Keshni remarked*: "They're not staying on. Every time we roll them, they come off".* Based on the evidence, group members spontaneously started making adjustments, taking off the wheels and taking out the sticks (axles). Not understanding her teams' actions, Keshni remarked: *"It just doesn't make sense. 'Cause you're taking stuff out, then you're putting them back in"*. In the meantime, Luca, attached and tested the wheels, and responded "*Oh, it actually rolls. Ah, it works!"* The evidence together with Luca's remark seemingly inspired new confidence, and Keshni continued to motivate her team: *"Guys now we go on to phase two. We have to put this on top"* (picking up a tinfoil container). While Luca, Sharon and Jacob were working on the wheels (attaching cellotape), Keshni explained: *"We're putting the wheels on so when it's moving, the wheels don't come off".* During the investigation, Jacob mostly observed closely and silently, withholding suggestions until he was sure of the plausibility of his suggestion (C_L_VD_p1L1-44).

The way in which the learners across the three cases cooperatively designed and conducted their investigation by means of experimentation, trial and error, designing models, or observations, provides evidence of the learners' ability to use inquiry skills naturally and instinctively in a flexible way for theory formation and revision. The Grade 1 learners, for example, constantly questioned their assumptions, and revisited and revised their plans. The way in which they relied on inquiry skills is captured in the following excerpt:

> *"I don't think this is gonna work"* (A_VD_FG_p1L22)
> *"It is. We first anyway gonna test it"* (A_VD_FG_p1L24)
> *"And if it doesn't work we need to start all over again"* (A_VD_FG_p1L26)
> *"And also if the water goes out we can use this*" (picking up the tape) (A_VD_FG_p1L28).

Grade 1 learners seemed to rely intuitively on inquiry skills and strategies in solving the problem. They namely made reasoned predictions (to use blocks); constructed plans; tested the plausibility of their plans ("testing" the constructed block columns by pulling them apart and observing the evidence); used the evidence to revisit their plans, and proposed new plans (use tape to attach the columns) as captured in Photograph sequence 5.6 to 5.8. Learners therefore seemingly constantly reviewed and revised their theories based on their active hands-on, minds-on involvement, using a variety of inquiry skills and strategies.

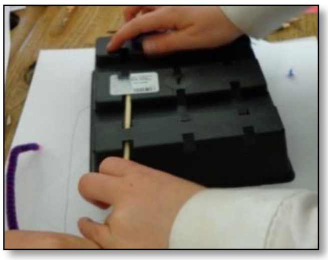
Photograph 5.6: Initial idea/problem-focused prediction (use blocks to construct the fish tank)

Photograph 5.7: Use inquiry skills intuitively to test plausibility of plan (test by pulling columns apart and observing the result)

Photograph 5.8: Implement revised plan (use tape to attach block columns)

Grade 2 learners similarly demonstrated their use of a range of inquiry skills, e.g. testing the wheels (i.e. trial and error – pushing the car), observing the evidence ("*it won't roll*"), questioning their plans (revisiting their theory), considering which variables to change and which to keep the same (e.g. the wheels, axle or body of the car), implementing revised plans, testing revised theory, observing evidence, constructing a new theory (that is more effective in solving the problem) and verbalising findings ("*Ah! It's gonna roll*!") (B_L_VD_FG_p2L54-62) as depicted in Photographs 5.9 to 5.11. The skills learners used in theory revision were apparently applied intuitively as learners did not receive any instruction or guidance in this regard.

Photograph 5.9: Testing, observing and questioning theory



Photograph 5.10: Implementing revised plans

Photograph 5.11: Testing modification, observing evidence and articulating findings

Grade 3 learners seemingly encountered quite a number of challenges in designing their cars, specifically pertaining to the wheels. After testing their car on the ramp, learners from the selected group discovered that the car was merely sliding off the ramp instead of the wheels rolling. They responded by saying that it was an "epic fail" – indicating that their theory was inadequate to solve the problem. Although I observed learners being disappointed, it also seemed to motivate them to revisit their plans. The following excerpt demonstrates learners' use of inquiry-focused skills during the theory revision process:

> Jacob: *"I understand why the car is not working, because the front here is too low, so then it can't roll off."*
> Team members shouting excitedly: *"Aah, Yay!"*
> Researcher: "*Jacob, you figured out the problem. Can you explain it to me?"*
> Jacob: *"Because if the front is too low, the car won't go off things, and it won't be able to go off the ramp."*
> Researcher: *"So will you be able to fix that now?"*
> Jacob: *"I'm not sure … But we'll try"* (C_L_VD_FG_p2L47-61).

In "*trying to fix it*", by implication revising theory, learners were seemingly again driven by inquiry skills. In this regard Robert explained: "*We took it back to the repair station … which was our desk*". Keshni added: "*Because what's the point of giving up … when they're out, you should do something … 'cause you're just kids, you don't know how to do stuff properly yet, and so you can try and try until you get it right*" (C_L_FG_p4L187-197).

5.2.4 Sub-theme 2.4: Gaining new insight and drawing conclusions

In all three cases, learners seemingly gained new insight in a sudden and unexpected manner after several encounters of trial and error, reviewing, revising, implementing and reflecting on their theories. While the group of Grade 1 learners continued to build and tape block columns together in order to construct their fish tank, they unexpectedly overturned their idea and came up with a new idea. The following vignette, captured in Photographs 5.12 to 5.14, presents evidence of the focus group learners' "eureka"-encounter:

> Ben unexpectedly suggested*: "Let's take it [the blocks] out!",* and Anna started pouring out the blocks from the polystyrene container. Josh, not understanding Anna's actions, protested: *"Oh nooo, stop it! What are you doing?"* Realising the plausibility of the suggestion, he looked up at me and said: *"Teacher, we'd taken all the blocks out"* (A_L_VD_FG_p1L32-42).

Photograph 5.12:
Sudden insight (pouring out the blocks from the container)

Photograph 5.13:
Reconceptualising theory and implementing new plans

Photograph 5.14:
New theory (using the box instead)

As captured in the account of events, the idea to use the container instead, came suddenly. Anna emptied the block container, disregarding the protest of a group member. Hesitation by this member was, however, apparently revised when he realised the plausibility of the suggestion. In response to my question of how they came up with the new idea, learners referred to the group combining their brain power: "We put our brains together" (A_L_FG_p4L215), and realising the potential of what they had available: "*We were lucky we had that* [the container]" (A_L_FG_p5L246), also using common sense based on their active participation. Their initial idea (to use blocks and tape) was thus disregarded based on deductions they made about the workability of their plan (experienced first-hand), as well as the presumed suitability of the available material (logical reasoning). They justified their actions as follows:

- *"Because it would take too long"* (A_L_FG_p3L175)
- *"And it would fall apart …"* (A_L_FG_p4L177)
- *"And it couldn't stand up"* (A_L_FG_p4L179)
- *"And there wasn't enough blocks on the sides to make it stand"* (A_L_FG_p4L181)
- *"Because it would leak easily"* (A_L_FG_p4L219)
- *"The cellotape is like a piece of paper, so if the fish like accidently bumps in it, it might tear"* (A_L_FG_p4L221)
- "*And it* [the tape] *could stick onto him* [the fish]" (A_L_FG_p4L224).

Similar to Grade 1, the Grade 2 learners' insight apparently came unexpectedly. As Rudi explained: "*Because when we realised that the pipe cleaners did not make the thing roll, that was the first part when the whole thing broke into millions of pieces*". Tiger added: "*That's when we sort of decided to make this and put a …*" He was interrupted by Rudi who said: "*No that's where your silly idea never even worked. We had to put that stick in … that's the thing I chose to do and it worked*" (B_FG_p4-5L198-221). As in the Grade 1 class, one can deduce that this idea came as an unexpected insight, with Rudi saying, "*I just did it*" (B_L_FG_VD_p2L60) and Lyn adding: "*We just decided it*" (B_L_FG_VD_p2L60).

The same applies to the Grade 3 class, where insight apparently came all of a sudden, as an 'aha' experience. When modifications made to the car (cutting the box to make the bottom lower) did not deliver the intended result, team members cooperatively considered more variables to change in their attempt to solve the problem. While the team suggested cutting off more of the box, Luca picked up the car, inspected the wheels, and suddenly discovered the problem. The insight he came to is captured in the following excerpt: "*Wo-wo-wo-wo! I found it! Look here*!" (pointing to the wheel), saying, "*This wheel won't work if we don't do something about it*" (C_L_ FG_VD_p2L86-87).

Luca's insight seemingly inspired new motivation within the group with learners immediately formulating new suggestions such as:

- Keshni: *"Guys the wheels are too low."*
- Luca: *"Look, it's not even working."*
- Robert: *"We have to cut this"* (pointing to the bottom of the box).
- Keshni: *"We have to make the wheels higher."*
- Team members correcting her: *"Lower!"*
- Researcher: *"So how will you make them lower?"*
- Keshni: *"By moving the sticks"* (C_L_ FG_VD_ p2, 3L89-101).

Following the insight they gained, learners across all three cases were able to draw conclusions based on their experience and involvement in the investigation process. They therefore acquired science knowledge based on the context of their activity. In the case of the Grade 1 learners, however, the knowledge they acquired seemed to have been derived via knowledge transmission (during the introduction session), or was based on their own prior knowledge – and not reached as a result of the evidence they found based on the investigation. In contrast, Grade 2 and 3 learners apparently drew conclusions based on their investigations as well as their observations of other groups in the class. With regard to the Grade 2 class, some conclusions appeared to be based on scientific grounding, yet with little relation to the actual activity, and being "flavoured" by learners' imagination. Supportive evidence for each of these trends in drawing conclusions is presented in Table 5.4.

Table 5.4: Basis of learners' conclusions

Class	Basis of conclusions	Supportive evidence
Grade 1	Knowledge transmission during the information sharing session	• "*We learned that they (the fish) need food and a big place to swim*" (A_L_FG_p1L32) • "*They (the containers) must be empty, and you fill it up with water*" (A_L_R_p4L202)
Grade 1	Learners' prior understanding of materials and their properties	• "*I think it would have looked nicer if you could use glass - then you could see through … But glass, glass can break easily*" (A_L_FG_p5L281-282, 288)

Grade 2	Evidence as a result of participation in the car race activity	• "*Uhm, we learnt that sometimes the wheels uhm also need to be a little out than close, 'cause if the wheels are too close to the car, the wheels won't roll because the wheels are too stuck to the car because the car can make the…the parts of the car can make the wheels stop because the wheels don't have any space to…uhm…roll*" (B_L_R_p4L227-231) • "*We realised that the wire at the bottom made the car slow down, but we thought that it would work because the wire actually didn't touch the ground. Then we just took the wire off and then we realised that the car was perfect*" (B_L_R_p5L241-246) • [You need a stick/axel]*: "So that the thing could roll properly and could go straight and far*" (B_L_FG_p6L318)
Grade 2	Learners' imagination	• Researcher: "*Why did your car need a roof*?" Lyn: "*So the thing wouldn't get sopping wet and all the gears would break and … and when your cell phone is sitting there it wouldn't smash into millions of pieces". Researcher: "But did it make the car go far or straight?" Lyn: "It made the car go far, because more of the air holes made the steam go through*" (B_FG_p4L198-221)
Grade 3	Evidence as a result of participation in the car race activity	• "*You must make the car lighter. Because the more weight you add to your car it's gonna make your car slower, 'cause if something is heavy, then it can't move that much*" (C_L_R_p6L310, 314-315) • "*I learnt that the wheels have to be loose for the car to roll, otherwise it won't go really far, it will just stop in the middle of nowhere*" (C_L_R_p6L329-330) • "*We learned that the wheels mustn't be like too, they mustn't be like too high and they must be at the bottom of the car*" (C_L_R_p6L334-335)
Grade 3	From observing other groups' models	• "*The Blue Group mustn't put too much stuff on their car or it would become too slow and too heavy for the car, and then it would just flip over and nothing would happen*" (C_L_R_p6325-327) • "*…that the wheels must be low*" (C_L_BG_SJ4) • "*There wheels were too tight and the bottom was hanging down*" (C_L_RG_SJ1)[30]

In all cases, learners' conclusions related to science concepts; for instance, the relationship between weight and speed, requirements for wheels to be able to roll (mobility, positioning), and the relationship between the stability of wheels and the distance a car can go. Although not expressed in scientific terms, learners across the cases thus seemingly acquired an understanding of basic science concepts (i.e.

[30]The exact spelling of the learners as recorded in the science journals.

contextualised knowledge). Even though the learners were able to draw conclusions and acquired science concepts, my analysis of the data indicated a mismatch between what learners learned and the science outcomes planned for the specific activity.

In the case of the Grade 1 activity, for example, the problem was formulated in general terms rather than in IBSE format, with the science outcomes underlying the problem (A_ST1_LP_p1) not being inquiry-focused, but rather general and dependent on knowledge transmission. The IBSE problem was formulated as: "*To build a fish tank for living fish with the available materials*" (A_ST1_LP_p7), and to challenge children to "*Quickly go to your desks, let us all design a fish tank quickly*" (A_ST1_LP_p7). Learners were, however, still able to draw conclusions, as evident in the following excerpt from my research journal:

> *Regardless of the fact that the problem was not IBSE-focused, and that important science concepts were not consolidated by the student teacher, children drew conclusions based on the evidence presented to them by the problem solving activity and their hands-on, minds-on effort to solve it (October 2015).*

Lesson outcomes for the Grade 2 class stated that learners should have a better knowledge of scientific concepts and vocabulary and that they should be able to build a miniature car from recyclable materials and to follow rules (i.e. the car needs to roll in a straight line and roll a certain distance) (B_ST2_LP_p2). While Grade 2 learners unknowingly drew important conclusions based on the evidence they found, these also did not match the planned outcomes. The same trend could be observed in the case of the Grade 3 class.

5.2.5 Sub-theme 2.5: Sharing and documenting experiences

In all three cases learners communicated their understanding to others (groups and the whole class) by verbally explaining their insight or by using other means (such as the science journals). Learners seemed excited to share what they had learned with others, and used their everyday language to explain their experiences in simple terms. As such, learners' reports focused on their own encounters, which were not represented in scientific terms.

Grade 1 learners, for example, participated in a show-and-tell activity towards the end of the lesson during which they shared information with the rest of the class about the processes they had followed to make their fish tanks, and their fish's names. My observation that these learners communicated in a natural, relaxed manner was confirmed by Bronwyn, who reflected as follows: "*They … ya, they want to tell what they have learned, and … show people, and be excited about it*" (ST_FG_p8L481-482).

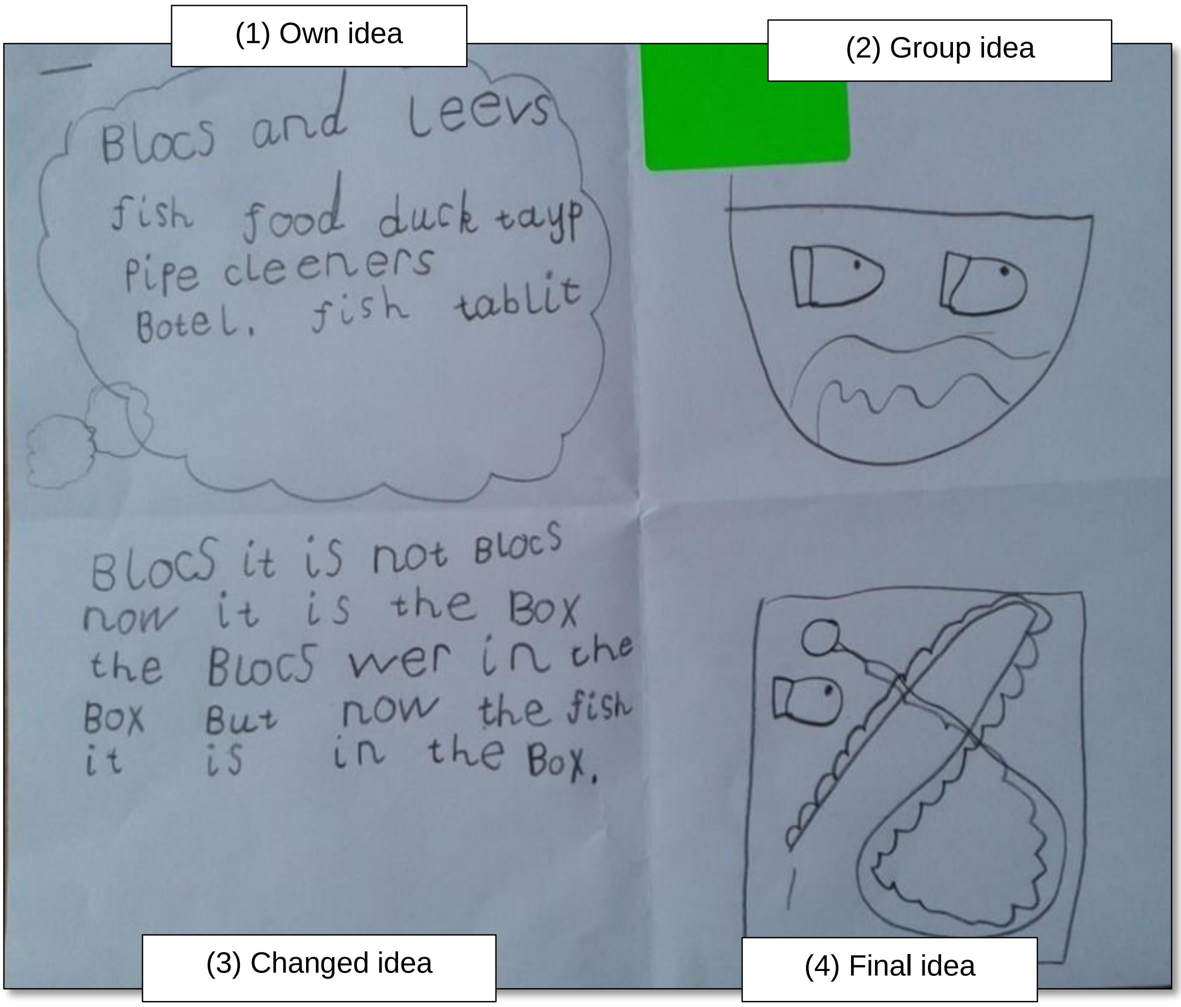
Like the Grade 1s, the Grade 2 learners were able to show and share their encounters with the rest of the class. They eagerly explained their encounters as captured in the following excerpts from the data:

- Rian: *"The wheels were too close, then we moved them a bit."*
- Rudi: *"And the first time we tried, the whole thing [roof] just popped off."*
- Rian*: "And we made a decoration like a star*" (B_L_FG_VD_p2L69-73).

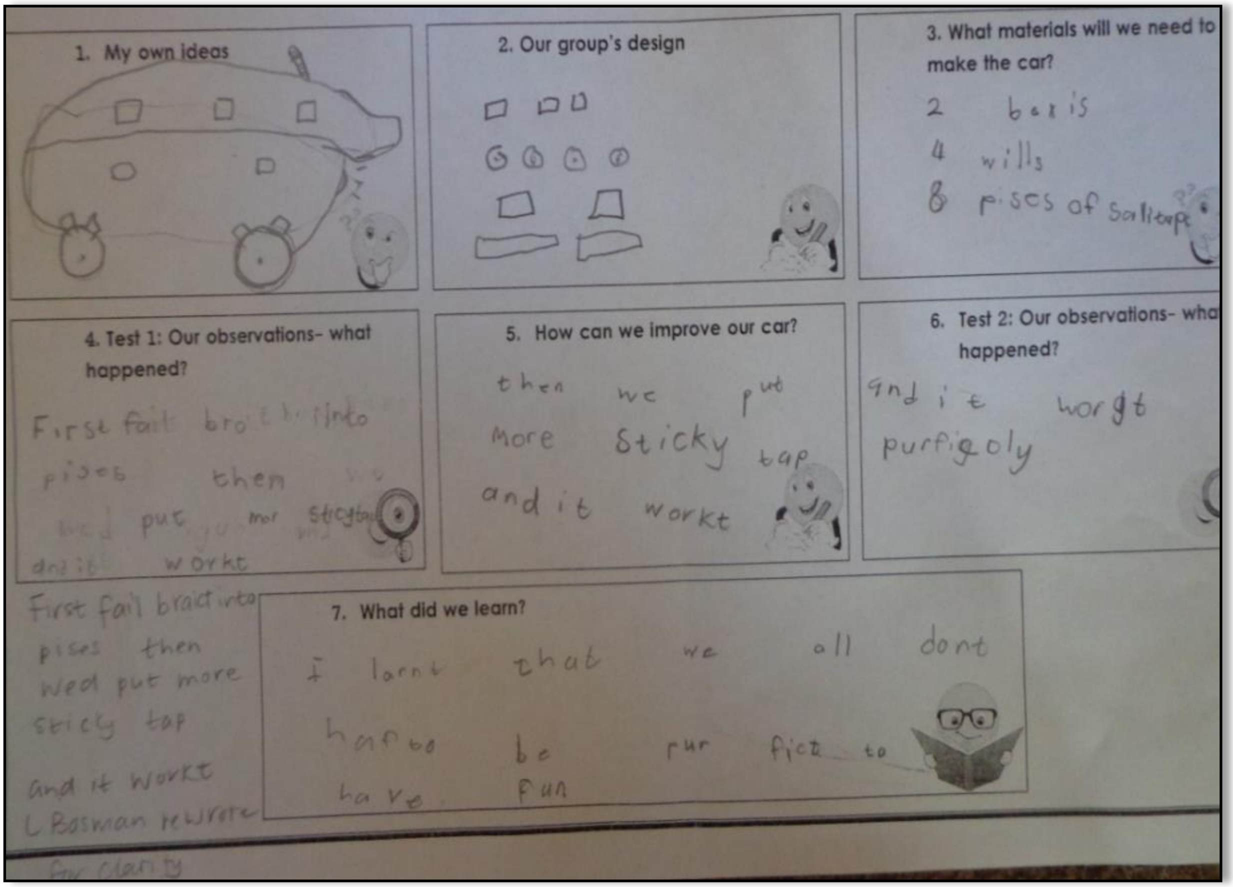
After the show-and-tell activity, most groups seemed interested in making improvements to their cars. In addition to many of the explanations focusing on personal encounters rather than the inquiry problem, Grade 2 learners tended to describe their cars in terms of performance rather than the variables they had considered for making the cars perform in such ways. In both the Grade 1 and 2 classes, learners' conclusions were not consolidated in scientific terms after discussions had been concluded. The same pattern could be observed in the Grade 3 class.

In both the Grade 1 and Grade 2 classes learners struggled to contain their excitement and energy, resulting in everyone wanting to share and contribute at the same time, and not really paying attention to other groups' explanations. On the contrary, in the smaller class of only 15 Grade 3 learners, the communication of findings seemed more fluent. Monique ensured that all learners paid attention to other groups' explanations.

In addition to disseminating their conclusions verbally, learners were expected to record all the scientific steps of their investigations in a specific format. While collecting data, I thus searched for evidence on how learners represented their initial ideas, revisions and science conclusions. In all classrooms I noticed that most learners were able to record their science stories according to the given format and instructions. In support of this observation, Photographs 5.15 to 5.17 demonstrate the various grades of learners' ability to record their ideas in a required way. Grade 1 learners (Photograph 5.15), for example, recorded their ideas in four blocks whereas the majority of Grade 2 learners (Photograph 5.16) were able to record their ideas in seven blocks as requested by the student teacher. Some learners, however, completed only sections of the required page.

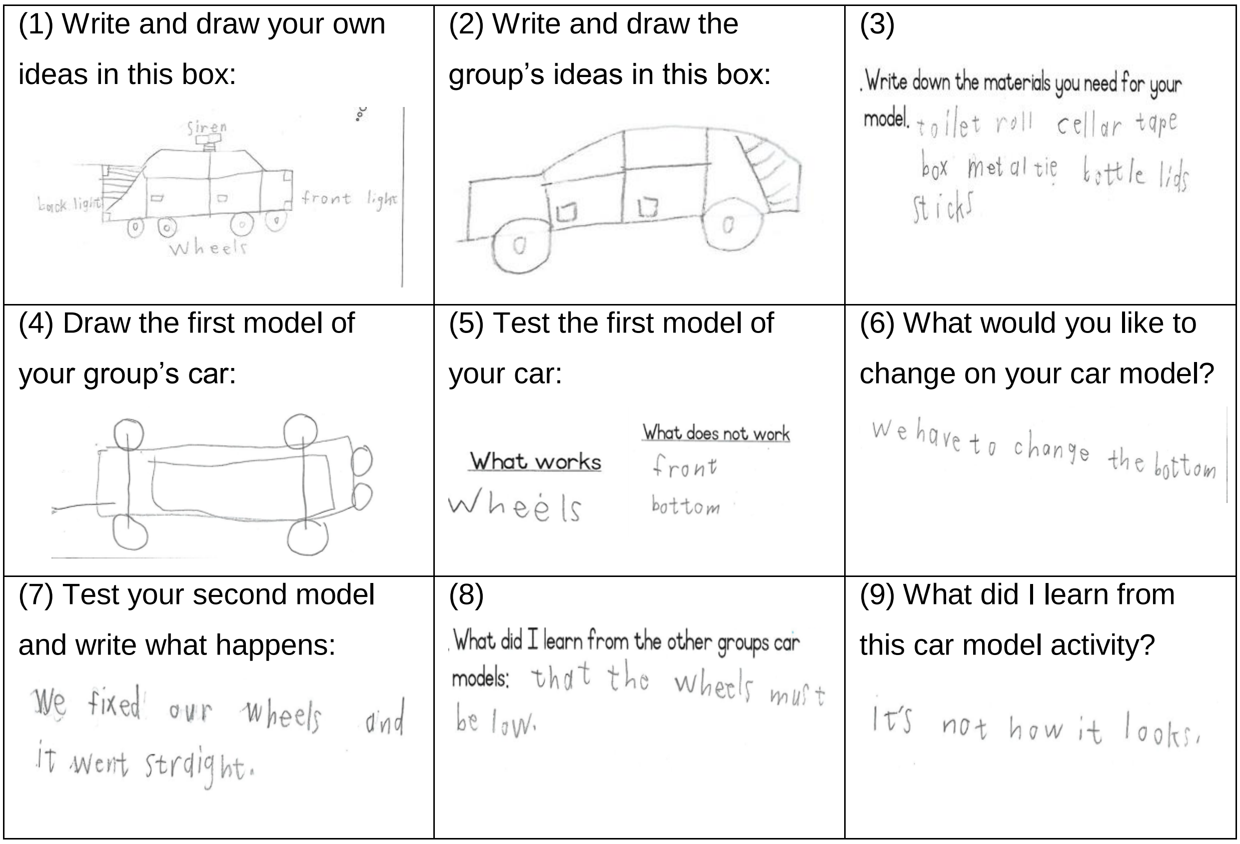


Photograph 5.15: Example of a Grade 1 learner's science notes page



Photograph 5.16: Example of a Grade 2 learner's science journal

The format for Grade 3 learners seemed age-appropriate, providing sufficient guidance to inexperienced learners. Here the IBSE problem appeared on the first page, and learners were requested to record their steps across numbered blocks with simple instructions guiding them through the IBSE process. Monique remained focused on these recordings, and constantly reminded learners to complete this task. She provided sufficient time for recordings, and the majority of the class managed to complete their four-page journals. An example of a recording by a Grade 3 learner is captured in Photograph 5.17.

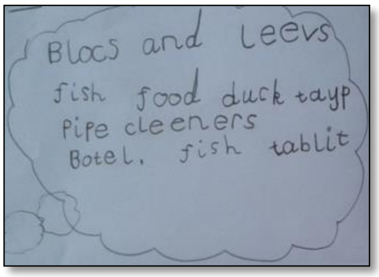


(1) Write and draw your own ideas in this box: Siren; back light; front light; wheels	(2) Write and draw the group's ideas in this box:	(3) Write down the materials you need for your model. toilet roll cellar tape box metal tie bottle lids sticks
(4) Draw the first model of your group's car:	(5) Test the first model of your car: What works: wheels. What does not work: front, bottom	(6) What would you like to change on your car model? We have to change the bottom
(7) Test your second model and write what happens: We fixed our wheels and it went straight.	(8) What did I learn from the other groups car models: that the wheels must be low.	(9) What did I learn from this car model activity? It's not how it looks.

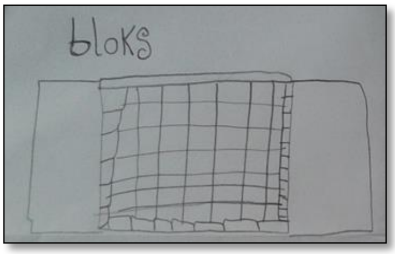
Photograph 5.17: Example of a Grade 3 learner's science journal

As such, the Grade 3 learners exhibited advanced competence to record their ideas when compared to the other two classes, and although their first experience, they used signs, symbols and text to record their thinking. These learners seemingly built on the Grade 1 and 2 learners' focus on recording ideas in a symbolic format.

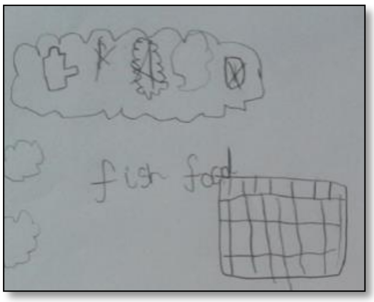
Learners were furthermore requested to record their initial thinking, working theories and changed theories throughout the IBSE process in their science journals. Grade 1 learners recorded their ideas in different ways, using text, drawings or a combination thereof. A few examples are presented in Photographs 5.18 to 5.20.



Photograph 5.18: Grade 1 learner using a speech bubble to record her own idea in writing



Photograph 5.19: Grade 1 learner recording his own idea by means of a drawing and text



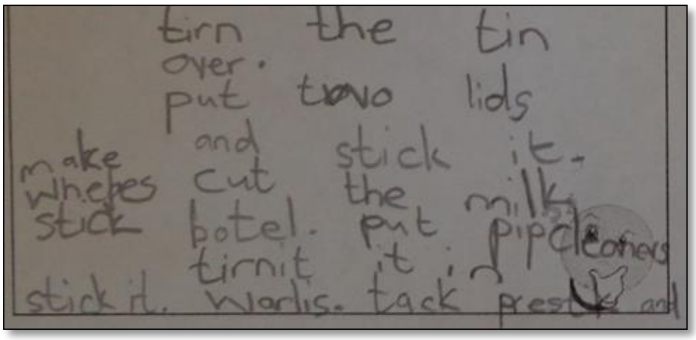
Photograph 5.20: Grade 1 learner using a speech bubble, writing and drawings to record his own idea

Even though most learners in the Grade 1 group were observed to hold similar "own" ideas, group members represented these in different ways. However, it appeared as if cooperation between group members might have influenced the individual recordings of own ideas, as evident from the following focus group discussion excerpt:

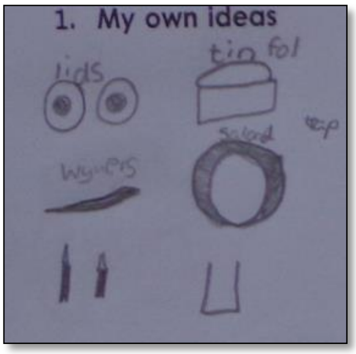
> Researcher: "*Who had the idea of using blocks?"*
> Anna: "*It was mine. And Ben's."*
> Researcher: *"Why did you all have the same own idea? How did that happen?"*
> Joey: *"We spoke to one another and we all decided on the idea"*
> Researcher*: "So you spoke to one another and decided on that idea?"*
> Ben: *"Yes and then we swopped it"* (Implying that the idea was revised again at a later stage) (A_L_FG_p3L140-155).

Although influenced by the group, learners' recordings of their own ideas seemed problem-focused, and relevant to the inquiry question. Learners evidently also captured their available knowledge (fish food, oxygen tablet) and included resources (blocks, leaves, tape, pipe cleaners, bottle) that were available when recording their proposals for a possible solution.

Similarly, Grade 2 learners recorded their own ideas in a variety of ways, but with more focus on drawings or a combination of text and drawings. A selection of the Grade 2 learners' representations of their own ideas is captured in Photographs 5.21 to 5.23.



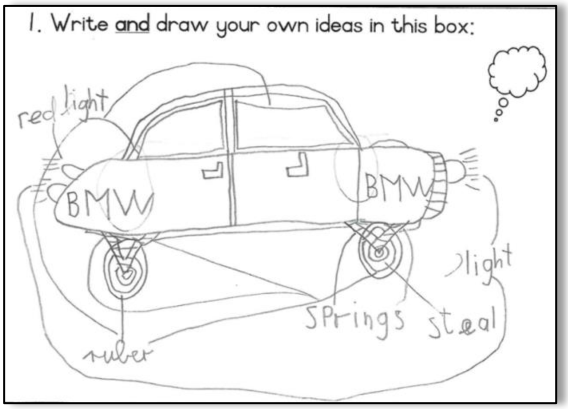
Photograph 5.21: A Grade 2 learner representing his own idea by means of text



Photograph 5.22: A Grade 2 learner representing her own idea by means of text and drawings

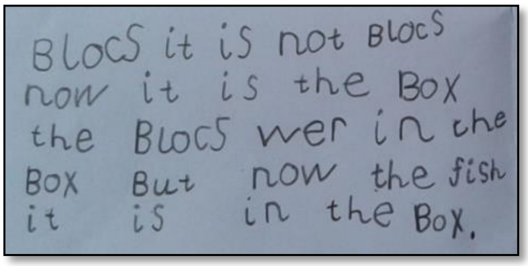
Photograph 5.23: A Grade 2 learner representing his own idea by means of a detailed drawing

An analysis of the Grade 2 learners' drawings indicates that the majority of their drawings were not problem-focused, containing too much detail and/or too many impractical elements. This trend was also observed in the case of the Grade 3 class where representations of their own ideas often seemed impractical to serve as plausible suggestions. An example of such a suggestion is included in Photograph 5.24.

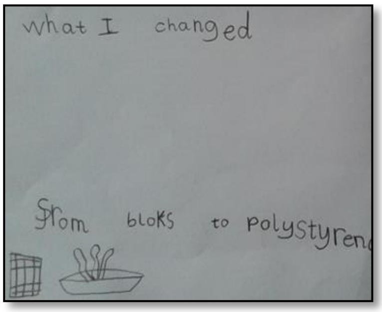


Photograph 5.24: A Grade 3 learner's recording of his own idea by means of a detailed drawing and labels

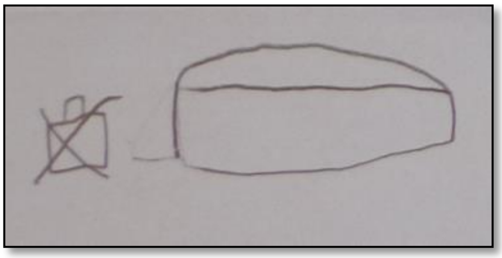
In recording their modifications and revisions while the IBSE activity progressed, learners (specifically in Grades 2 and 3) tended to rely more strongly on written recordings and the terminology and vocabulary they possessed and had acquired. Even though Grade 1 learners still relied on a combination of text and drawings, they seemingly used text more effectively to describe what their group had changed (as illustrated by Photograph 5.25), and also included symbols (e.g. arrows and a cross-out) when representing simple drawings to explain their ideas. Learners therefore displayed the ability to capture the changes they had made by using signs, symbols, drawings and text as depicted in Photographs 5.25 to 5.28.



Photograph 5.25: A Grade 1 learner using text to record revisions



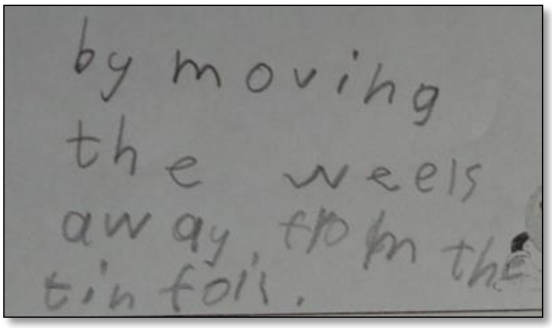
Photograph 5.26: A Grade 1 learner using text and drawings to record revisions



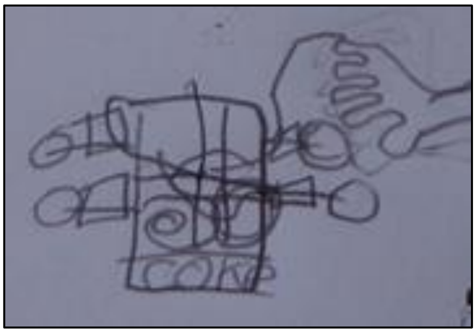
Photograph 5.27: A Grade 1 learner using drawings and symbols (cross-out) to record revisions

Photograph 5.28: A Grade 1 learner using drawings and symbols (arrow) to record revisions

In the case of the Grade 2 learners, revisions were most often described by means of text, with a smaller focus on drawings. Photographs 5.29 to 5.30 are representative of the majority of learners recording their revisions by using text, with a small number of learners (two in 30) using drawings such as the one included in Photograph 5.30.



Photograph 5.29: A Grade 2 learner using text to describe revisions



Photograph 5.30: A Grade 2 learner describing revisions by means of a drawing

My analysis of the text that the learners relied on when recording their modifications indicates that the Grade 2 learners tended to use everyday language to describe observations, the modifications they made and the results of these modifications. Some examples are included in Table 5.5.

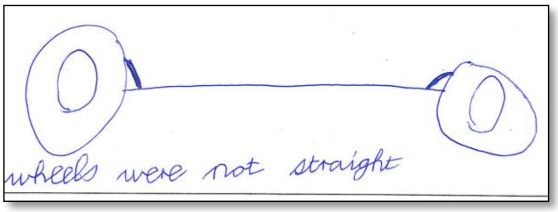
Table 5.5: Grade 2 learners' use of vocabulary to describe observations, modifications, and results of the modifications[31]

	Observations	Modifications	Results	Child-participants
Vocabulary used	"*ouwr car smasht wehl was out*"	"*we can mayk owe car strog* [strong]"	"*Ow car was cool*"	B_L_OG_SJ4
	"*It did not work out the first time because the wheles where to close*"	"*move the wheels awaye*"	"*we put some selow tape because it looked like it will brake*"	B_L_YG_SJ4
	"*It didint work at all*"	"*we jest fix the wils*"	"*It went well*"	B_L_BG_SJ1
	"*Fale*"	"*make weels lowor*"	"*Suckses*"	B_L_GG_SJ4
	"*it did not go far*"	"*by moving the weels away from the tin foil*"	"*it went much more far*"	B_L_RG_SJ2
	"*what happene was we failed the first time*"	"*If we fail we can just work again together*"	"*we won*"	B_L_ RG_SJ6

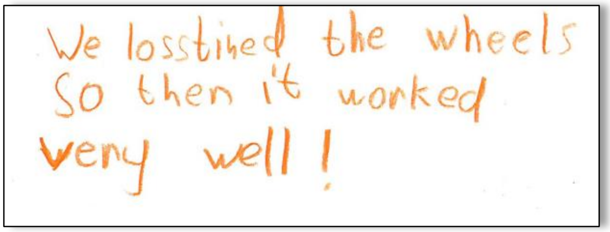
In the Grade 3 class, the learners similarly tended to rely on text when recording their revisions, with only three learners relying on drawings. Photograph 5.31

[31]The exact words and spelling of the learners are given in Tables 5.5 and 5.6, not correcting any spelling or grammar.

provides an example of the use of a drawing by a Grade 3 learner, and Photograph 5.32 an example of the use of descriptive text.



Photograph 5.31: A Grade 3 learner's use of drawing and text to record revisions



Photograph 5.32: A Grade 3 learner's use of descriptive text to record revisions

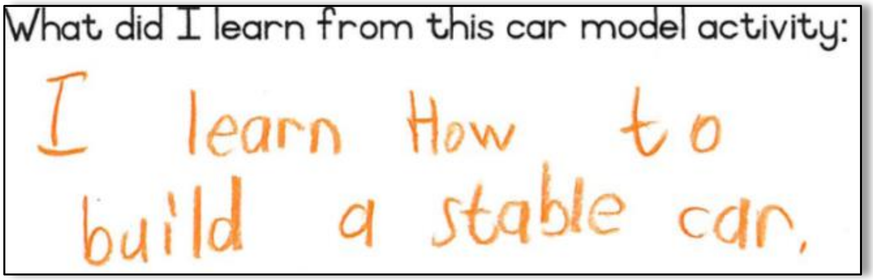
The excerpts included in Table 5.6 demonstrate the Grade 3 learners' ability describe their observations to more accurately than the Grade 2 learners, and to document the changes they proposed during the IBSE activity. However, scientific language use still seemed limited.

Table 5.6: Grade 3 learners' use of vocabulary to describe observations, modifications, and results of the modifications

	Observations	**Modifications**	**Results**	**Child-participant**
Vocabulary used	*"the bottom is to low so when it went on the carpet it stopped moving"*	*"we would like to change the bottom"*	*"we tested and I was perfect it went straight and far"*	C_L_BG_SJ5
	"front bottom"	*"we have to change the bottom"*	*"we fixed our wheels and it went straight"*	C_L_BG_SJ3
	"the exhast pipe fell off and the tires are scew"	*[Drawing and text] "wheels were not straight"*	*"we loosend the wheels"*	C_L_RG_SJ2
	"wheels are scue and the egsase [exhaust] pipe"	*"the pipes wheels are not stable propley"*	*"we loosend the wheels so it works at last"*	C_L_RG_SJ4
	"1 wheel"	*"the wheels and the top"*	*"the wheels got stuck"*	C_L_YG_SJ1

Even though the recording of conclusions that were drawn based on the investigation forms part of any IBSE activity with the aim of guiding learners to reflect on their initial ideas and to compare these with the evidence they find, while confirming, rejecting or revising their prior theory, such reflections did not optimally occur in the three cases of this study. Despite the fact that time was a limiting factor, student teacher participants attempted to obtain final conclusions from the learners in some way or other, resulting in limited reports on what had been experienced, but without the necessary depth and reference to science content knowledge or science terms.

More specifically, Grade 1 learners were able to draw the completed product (fish tank), yet their recordings did not shed light on the science content knowledge they had acquired. Similarly, Grade 2 learners apparently acquired a wealth of important competencies associated with IBSE, yet no science concepts were recorded in any of their journals. As such, no indication of evidence-based conclusions underlying the IBSE problem could be found in the data captured for Grade 1 and 2 learners. The recordings of the Grade 3 learners on what they had learned from the activity as well as from other groups' models confirm this trend, as these learners mostly recorded non-scientific skills in the block where they had to record what they had learned, with the exception of one learner who recorded science-related knowledge (see Photograph 5.33).



Photograph 5.33: Grade 3 learner's conclusion recorded in his science journal

In the block where learners had to record what they had learned from other groups, more science-related concepts were recorded. The following excerpts from the data provide examples:

- *"I learnt that the wheels have to be loose*" (C_L_BG_SJ1)
- *"that the wheels must be low"* (C_L_BG_SJ4).

As such, learners across the grades seemed able to record the final outcomes of the IBSE activity without reflecting on the knowledge and skills they had acquired in the process. Grade 3 learners, to a certain extent, appeared able to incorporate some scientific references, more so when thinking of what they had learned by observing and listening to others.

When asked about their experiences in recording their ideas in science journals, learners responded positively. Learners across all classrooms reported that they liked recording their ideas. For example, Grade 1 learners said: "*It felt good*" (A_L_R_p4L210); "*I also like writing*" (A_L_FGp6L314); and "*I like drawing, but I don't like writing*" (A_L_FGp6L321). Grade 2 learners similarly commented: "*I wrote ánd I drew some pictures. It was very fun*" (B_L_R_p5L288). In support, Grade 3 learners reported positive experiences in ways such as the following: "*I loved it because I like to write stories"* (C_L_FG_p5L218), and: "*It was quite fun because we got to draw a car, share our ideas, and draw what we had to use so that we won't forget what we had to do*" (C_L_R_p6L341-342).

Even though the learners generally expressed positive feelings about them recording their notes, some of them experienced the recording process as challenging. A Grade 1 learner, for instance, explained: "*It was a little hard … Cause you had to design still and you had to do a lot of working*" (A_L_R_p4L212, 214). Similarly, a Grade 2 learner experienced the recording as "*Horrible*". When asked to elaborate (and referring to his incomplete journal), the learner responded: "*Because I just don't like writing. Yip, that's why. I don't like writing*"; "*Yip, that's why mine is empty*" (B_L_FG_p7L336, 340, 345). The negative experiences reported in this regard, however, do not indicate the origin of the experiences, which may perhaps be based on reasons other than that of recording classroom experiences.

Learners were able to identify a number of benefits when recording information. For many learners their recording of ideas initiated thinking, and assisted them in formulating their thoughts. As a Grade 1 learner explained, recording helped "… *to think of it*" (A_L_R_p4L231). For another learner, drawing a design was helpful: "… *because then, then you can actually see what you're wanting to make. Then you know what you're wanting to make*" (A_L_FG_p6L329-330). Another learner added:

"*Because then when you write down everything, it makes an idea, and then you can put that idea together with your friend's idea*" (B_L_R_p5L270-271). A Grade 3 learner similarly reported, "*It was important because you can't start something without an idea of what you're gonna do*" (C_L_R_p6L348-349).

Learners also highlighted the long-term significance of recording in assisting people to remember what they had experienced and apply newly gained knowledge during future problem-solving activities. If not recorded, a Grade 2 learner stated, "*Then you'll forget it*" (B_L_R_p5L277). Similarly Grade 3 learners noted: "*So that you don't forget your ideas* …" (C_L_FG_p5L223); "… *to remember what you did*" (C_L_R_p6L353), and "*It was important because we don't have to rethink everything*" (C_L_R_p6L346). Along the same lines, another learner added: "*Every time you want to make something else, you can just copy what you did* …" (C_L_FG_p5L227-228).

Finally, learners indicated that recording is an important way of conveying information to other people. A Grade 2 learner explained: "… *what we learned about writing is that it's a lot, but you actually explain instead of us talking to the person, you'll actually write down what you are trying to say to the person, so they can understand more*" (B_L_R_p5L282-284). Grade 3 learners similarly viewed recording as a means of transferring information to the benefit of other people. In this regard a learner stated: "*It felt nice because you could explain what you did and at some place someone else can read it and do the same*" (C_L_FG_p5L215-216). Another learner added: "*People can learn from you*" (C_L_FG_p5L230).

5.3 THEME 3: LEARNERS' EXPERIENCES OF SOCIAL LEARNING

Theme 3 captures learners' experiences of being part of a small community of scientists, more specifically focusing on social and cooperative learning in a scientific context. The following sub-themes apply: perceived value of social learning, and dealing with associated challenges. Table 5.7 summarises the inclusion and exclusion criteria I applied.

Table 5.7: Inclusion and exclusion criteria for Theme 3

THEME 3: LEARNERS' EXPERIENCES OF SOCIAL LEARNING		
Sub-themes	**Inclusion criteria**	**Exclusion criteria**
Sub-theme 3.1: Perceived value of social learning	This sub-theme includes data related to the benefits learners experienced as a result of engaging in social learning as members of a community of scientists.	This sub-theme excludes data that relates to challenges that learners experienced or how they dealt with these.
Sub-theme 3.2: Dealing with associated challenges	This sub-theme includes data related to challenges that learners experienced while engaging in the IBSE activities.	This sub-theme excludes data that refers to the benefits of social learning as experienced by the learners.

5.3.1 Sub-theme 3.1: Perceived value of social learning

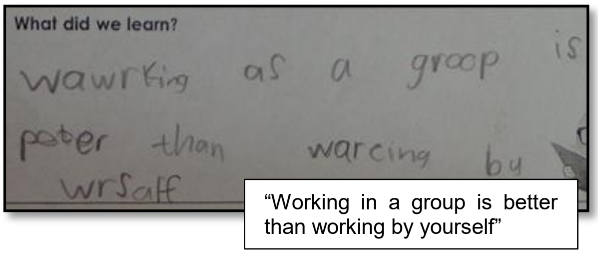
Learners seemingly perceived social learning to be an enriching experience. The categories I identified relate to the benefits of working as a team; and the value of reciprocal interaction.

5.3.1.1 Category 1: Benefits of working as a team

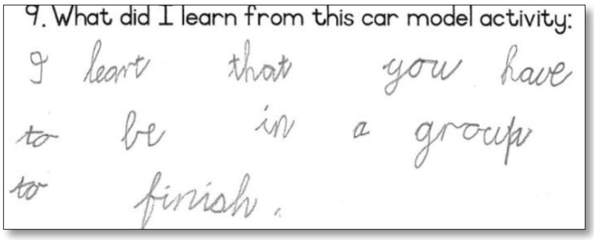
In all classrooms the learners expressed positive experiences of the cooperative nature of IBSE. They remarked: "*It was fun and it was nice*" (C_L_Rp3L119); It felt "Good" and "Fine" (B_L_R_p2L90) and "*Good … Because we were working together*" (A_R_p1-2L54, 58). Friendship and working with friends in a team was foregrounded as valuable, as captured in the following explanation by Grade 2 learners: "*Because all of us are friends and …", handing the "microphone"* over to her friend, who completed the sentence: "*We love working together and we like deciding everything together, because we all best friends*" (B_L_R_p3L137-139).

The value of working in a team was similarly indicated by a Grade 3 learner who highlighted how team work can promote the successful completion of tasks. She remarked, "*I say it was nice because uhm … you can't do anything without your* *teammates*" (C_L_FG_p3L158-159). In support of this indication of team members depending on one another, a Grade 1 learner stated: "*Because then life will go easy … easier … more not difficult anymore*" (A_L_R_p2L62). Another Grade 1 learner added: "*Because then like, then you don't have to do it all by yourself, and it becomes boring*" (A_L_R_p2L66-67).

A Grade 2 learner similarly referred to the value of a team coming together as opposed to an individual having only one person's ideas, skills and knowledge, by saying: "*Well, the last one of ours, yes … uhm… it's better to work in a group than work just by yourself, 'cause if you work in a group you have more people to help you, but if you work by yourself, you just have you*" (B_L_R_p4L175-177). In support learners recorded the perceived benefits of social learning in their science journals. Examples of such recordings are depicted in Photographs 5.34 and 5.35.



Photograph 5.34: A Grade 2 learner recording the benefit of group work



Photograph 5.35: A Grade 3 learner recording insight regarding group work

Learners' positive experiences of working in groups were furthermore evident in their post-IBSE drawings where they had to highlight aspects of the activities they deemed important. A Grade 1 learner (see Photograph 5.36), for example, asked the student teacher to write "*I liked working in groups*" and "*Other group's fish tanks*" on his drawing. This drawing thus demonstrates the learner's understanding of the social nature of the activity, and his developing understanding of being part of a small community.

Photograph 5.36: A Grade 1 learner's drawing highlighting the value of social learning

5.3.1.2 Category 2: Value of reciprocal interaction

Learners in all three classrooms apparently experienced the value of working together when sharing and joining ideas to generate solutions. They highlighted the value of being both able to share their ideas with others and at the same time to learn from them. A Grade 3 learner explained: "*I also liked it because we heard someone else's ideas and then another person's and another person's and then we added it all together, and then we had a plan*" (C_L_R_p4L209-211). In sharing ideas, learners were reportedly able to make joint decisions and find solutions. In this regard another Grade 3 learner mentioned: "*We all worked as a group, and we finally* *made something that actually works"* (C_L_R_p9L532). In accordance, another learner explained: "*It helped because none of us would've gotten the idea of bettering… of making the wheels roll*" (C_L_FG_p3L137-138). Likewise, a Grade 2 learner said:

> "*Yes, uhm we worked as a group. We tested it, but it didn't work, but … but we worked together, so ours uhm could go faster and not skew all the time. So we … it was helpful to work as a group*" (B_L_R_p3L128-129,133).

Several learners highlighted the value of reciprocal interaction. The following extracts from the data serve as examples:

- "*It was very good …, because people … we were actually sharing our ideas …, we had a chance, uhm … to tell everyone about our ideas, and then they see if it is good or bad"* (C_L_R_p4L187, 191, 195-196).
- *"It is nice to share our ideas, because if you share your ideas, then they can uhm see your ideas and then they can experience what you like to do, and things like that"* (C_L_R_p4L200-202).
- *"It was creative, and we uhm told everyone our ideas, because they could know how we did it and added to the cars and things like that"* (C_L_R_p4L204-205).

As stated earlier, in addition to the reported value of being able to share their own ideas with others, learners apparently valued the opportunity to listen to the idea of their team mates. The value of and ability to negotiate and seek agreed solutions in relation to the process and outcome of the activity is captured in the following expression: "*I think it was fine because you could also listen to their ideas, uhm … and change your car and make it into one car from all five of them*" (C_L_FG_p2L103-104). Linking their interaction to scientists, a Grade 2 learner stated: "I think we did kind of work like scientists today, because there was lots of things for us to learn and tell people our answers and all those type of things" (B_L_R_p8L416-417). As such, learners supported one another's learning, by sharing and also learning from others.

5.3.2 Sub-theme 3.2: Dealing with associated challenges

Despite their general positive experiences of working cooperatively, learners reported some challenges they had to deal with. I grouped these in the following categories: sharing and compromising ideas; and dealing with challenges related to group roles and dynamics.

5.3.2.1 Category 1: Sharing and compromising ideas

As part of the IBSE activity, learners had to share their individual ideas with their team and then select the best option for investigation. Making such a choice was apparently experienced as challenging by some learners. A Grade 1 learner explained his experience by saying: "*Everyone thought of different ideas, and it was hard to choose one of them*" (A_L_R_p2L80). A Grade 2 learner similarly stated, "*It was hard, because we didn't know what we should do, and we didn't want to do the same thing as the other one that wanted to do the other thing*" (B_L_R_p2L92, 101-102).

Some learners specifically found it hard when they perceived their ideas not to be heard or considered by the group members. A Grade 1 learner voiced her experiences in the following way: "*I couldn't really understand why no-one took any one of my ideas*" (A_L_R_p2L94). Similarly, a Grade 3 learner posited: "*When I tried to, uhm … when I tried to say ... tell them a plan …, no-one let me say anything*" (C_L_Rp4L215-216). In support another learner shared his negative experience, saying, "*Sometimes it feels bad because they don't use your idea and then you feel really really really mad, then you can't be like really mad, because it's actually mean to be mad*" (A_L_BG_p1L28-30).

Contrary to some learners' personal experiences of not being heard or their ideas not being used, this was not the perception of all group members. When a Grade 3 learner for instance complained: "*I felt like uhm people would not choose my idea*" (C_L_Rp3L146), her team members responded by saying, "*But we did! We used your inflatable tires. We used your spoiler. We used your …*" (C_L_R_p3L148-150). As such, the data analysis points to learners' need to be heard when working in a group, as captured in the words of a Grade 3 learner: "*I do like people doing the work, but most of all I wanted them to listen to my ideas*" (C_L_Rp3L165-166).

Only a few learners indicated that they preferred not to share their ideas with others. A Grade 3 learner, for example, seemed unfamiliar with such a process, stating, "*I don't think it was a good idea … Because it feels weird to share ideas … 'Cause, I don't like sharing my ideas with other people*" (C_L_R_p3L123, 129, 133). In reflecting on this during the focus group discussion with the student teacher participants, they confirmed that the process of sharing ideas was generally experienced positively, with the exception of selected individuals.

After sharing their ideas and listening to others, learners in all three cases displayed the ability to merge ideas and/or select a suitable strategy. A Grade 1 learner explained how their group made a decision: "*We made up one (an idea). We made a whole new one that the whole group decided*" (A_R_p2L86, 90). Similarly, Grade 2 learners suggested the merge of ideas as a way of addressing the challenges related to letting go of the own ideas. The learners suggested: "*And you should … include other people's ideas*" (B_L_R_p3L160) and "*You could also make your own idea and you could make all of the ideas into one idea*" (B_L_R_p3L164-165). Grade 3 learners apparently adopted the same strategy, as captured in the following contribution: "*Uhm, how we made our decision was we said we gonna use from everybody's … so we used one of the person's wheels, the body, and things like that*" (C_L_R_p3L171-172).

Even though the learners reportedly found it hard to let go of initial ideas, they showed insight into the value of using shared ideas. A Grade 2 learner remarked: "*It was hard, but we also got used to it and then we realised that both of our ideas were good, so we mixed all of our ideas together*" (B_L_R_p2L107-108). This expression indicates learners' move away from egocentric thinking towards collaboration and an appreciation of the underlying component of social learning.

Learners therefore seemingly relied on social skills (do's and don'ts) to overcome difficulties and move forward. The following suggestions by learners attest to this:

- *"We must all listen to everyone's ideas"* (A_L_R_p2L100).
- *"And you also mustn't throw a tantrum if they ... if they also … if they take your idea … and they come up with a new idea, you mustn't throw a tantrum"* (A_L_R_p3L136-137).
- *"We should work together and work properly, and not shouting at other children"* (B_L_R_p3L155-156).
- *"And we should also be kind to one another and always respect one another"* (B_L_R_p3L171).

In support of such suggestions, in photograph 5.37 a Grade 2 learner drew herself in her school clothes in the classroom (school desks and chairs), with evidence of the car her group constructed on the table. For her, it was important to get the group to work together ("*Guys, let's work together*").

Photograph 5.37: A Grade 2 learner's drawing, requesting the group to work together

The suggestions learners came up with are indicative of their willingness to act and learn cooperatively. They display their willingness to listen and pay attention to others, and some understanding of socially acceptable behaviour within a group context.

5.3.2.2 Category 2: Dealing with challenges related to group roles and dynamics

Working in a group seemingly also evoked some negative emotions and feelings of frustration and annoyance. These negative experiences could often be related to relationship-related challenges, group roles as well as dynamics within the groups.

Learners fulfilled different roles during the IBSE activity. Even though the three student teacher participants employed classroom management approaches that are favourable to IBSE, and relied on strategies that can promote child-centred learning and freedom of thinking and acting within boundaries, some learners seemingly experienced difficulty in sorting out the roles they were expected to fulfil. While the allocation of group roles was mostly effective, onsite observation in the Grade 2 class indicated a degree of difficulty. In this class, Jean introduced the group roles at the onset of the investigation phase. Even though other groups (almost ignoring the assigning of roles) immediately and eagerly started sharing and negotiating ideas, one of the groups started quarrelling about the assigning of roles. This eventually resulted in learners tossing a rubber with a Yes/No indication on it in order to determine their roles. During the focus group discussion, I showed the group a video of this incident, and asked them to reflect on their actions. They responded in the following way:

> Lyn: *"Because everybody was arguing: I want to be the manager. No, I don't want to be the manager. No, you can't be the manager, I'm the manager."*
> Researcher: "A*nd the rubber-tossing?"*
> Lyn: *"The flicking rubber was who would vote on to: Would I be the manager, would I be the artist…?"*
> Rian: *"I was the first one that flicked, and then I said, 'Could I be the manager?' Then it just went yes."*
> Rudi: *"You* (talking to Rian) *wanted everybody to do what you wanted them to do."*
> Rian: "*Because I am the manager, and that's what managers do. Managers tell everybody what to do."*
> Researcher: *"You spent minutes and minutes arguing about the group roles. Why was this so important to you?"*
> Lyn: *"Because we don't like people arguing, and we just wanted to get the arguing done so that we could start with the real fun stuff"* (B_L_FG_p3L149-166).

Despite the conflict they experienced, these learners were able to find a solution before commencing with the IBSE activity. They seemingly required a clear indication of who would do what, thereby creating a non-threatening environment (*We don't like people arguing*), by resolving conflict in a non-violent way (flicking the rubber to determine roles). It seems as if the group roles in this instance (e.g. being the manager) were rather prescriptive and restrictive in the sharing of and listening to different ideas. Based on my own observations in all three classrooms, I reflected in my research journal in the following way:

> *"While this group resourcefully attempted to sort out the group roles at the beginning, valuable time was wasted on argumentation and quarrelling about the group roles, and this remained a challenge throughout the investigation phase … Moreover, what I noticed in all classrooms, is that learners did not necessarily stick to their assigned group roles"* (October 2015).

In all three classrooms a few individuals experienced challenges to get along with others, and evidently found it hard to work together. In the Grade 2 classroom, for instance, learners participating in the focus group discussion experienced particular difficulty to work together. During the discussion I used emoticons as prompts for stimulating responses to the following question: "*How did you feel about working together?*". After considering what these emoticons represented, a learner from the Grade 2 group used laden words to describe her frustrations: "*I felt irritated, happy, sad, angry, sweating, and very angry*" (B_L_FG_p8L402). In response to her team mates commenting on one emoticon she had missed, the same learner rephrased by saying, "*I felt disgusted, angry, annoyed and kind of happy, and mostly angry*".

This learner, however, added at a later stage: "*But in the second time, I disco-danced on the carpet*" (B_L_FG_p8L410, 420). After prompting her to elaborate on her response, she explained this expression as one of joy when the group eventually decided to work together and cooperatively find a solution to the problem. As such, the negative experience associated with group work seemed limited and of temporary nature.

5.4 THEME 4: LEARNERS PERCEIVING IBSE AS AN EMPOWERING APPROACH

IBSE provides a space for learners to do science like scientists and acquire scientific knowledge, skills, dispositions and growth in the process. In this theme I discuss the child participants' experiences of IBSE in terms of the following sub-themes: value of owning the learning process; acquiring science-related knowledge, skills and dispositions; becoming aware of broader application of science, and being and becoming scientists. Table 5.8 summarises the inclusion and exclusion criteria I applied for Theme 4.

Table 5.8: Inclusion and exclusion criteria for Theme 4

THEME 4: LEARNERS PERCEIVING IBSE AS AN EMPOWERING APPROACH		
Sub-themes	**Inclusion criteria**	**Exclusion criteria**
Sub-theme 4.1: Value of owning the learning process	This sub-theme includes data related to learners' experiences of a sense of agency in the learning and knowledge-construction process and their confidence in their ability to learn by doing.	This sub-theme excludes data that refers to specific knowledge, skills and dispositions learners acquired or to their view of themselves as scientists.
Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions	This sub-theme includes data related to learners' acquisition of science-related knowledge, skills and dispositions as a result of participating in the IBSE activities.	This sub-theme excludes data that refers to the feelings learners attributed to learning by doing (working scientifically), or to the value they attached to the process of IBSE learning.
Sub-theme 4.3: Becoming aware of the broader application of science	This sub-theme includes data related to learners' awareness of the correlation between their experiences in the classrooms and science in real life.	This sub-theme excludes data that refers to learners' disposition towards science as a subject, or to the specific knowledge and skills they acquired.
Sub-theme 4.4: Being and becoming scientists	This sub-theme includes data related to learners' developing identity as young scientists (being, doing, becoming) as a result of participating in the IBSE activities.	This sub-theme excludes data that refers to specific knowledge and skills learners acquired, or to the value they attached to the IBSE process.

5.4.1 Sub-theme 4.1: Value of owning the learning process

Learners' contributions affirmed their confidence in the ability to engage independently in IBSE and learn science by doing science. A Grade 2 learner explained: "*For me it felt exciting and I felt that I was uhm very clever and smart, and I did my own thing that I wanted to do*" (B_L_R_p6L303-304). Along the same lines, a Grade 3 learner described her feelings of ownership of the learning process in the following way: "*It felt realistic like… uhm … it felt nice because you were actually doing something on your own*" (C_L_FG_p1L25-26). Voicing her opinion on learning through IBSE, another learner stated: "*I feel like it's better because you can actually do something and it's more creative than just writing on a piece of paper. I'll rather do than say*" (C_L_FG_p5L268-267).

Contributions such as these seemingly relate to the learners' feeling "*clever and smart*" (B_L_R_p6L303-304) through autonomous involvement (agency). Throughout the cases, learners highlighted positive experiences in terms of their ability to "be", to "do" and to play an active role in the learning and knowledge-construction process.

For Grade 3 learners, such learning by doing (i.e. the IBSE process) apparently also involved learning from making mistakes. Grade 3 learners explained: "*We learned to learn from our mistakes and uhm don't give up and keep on trying*" (C_L_R_p5L281-282); and: "*Learning from our mistakes, and doing it over and over again*" (C_L_R_p7L394). In further support another Grade 3 learner said:

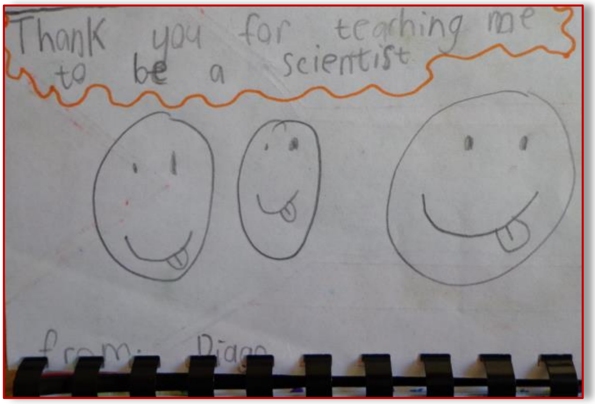
> "*… because you must never give up … when you do things. You must keep on trying and trying until … until you get it correct. And, … and we always have to learn from our mistakes, because it's …, because it teaches us uhm, what … what did you do wrong, and you must fix … and you must do it again*" (C_L_R_p7-8L414-418).

These contributions represent learners' experiences of learning by doing, and its potential to propagate cognitive engagement and persistence to solve problems. In their reflections the student teacher participants confirmed this idea, based on their observations of learners taking ownership of the learning process and persevering until they had found a solution.

As such, participation in the IBSE activities apparently helped to shape learners' appreciation of and motivation to master science as a subject. All three student teacher participants experienced the joy, excitement and enthusiasm of learners when participating in IBSE. Bronwyn and Jean claimed: "*And they enjoy it*" (A_ST1_FG_p1L33; B_ST2_FG_p7L420), and were "... *super excited and energetic*" (B_ST2_LRp3). In confirmation of these views, a learner stated: "*We feeled ... fun!"* (B_L_R_p6L299). Another Grade 2 learner added: "*I felt that I wanted to do more of it because it was so fun*" (B_L_R_p6L308) while a Grade 3 learner remarked: "... *it felt nice because you were actually doing something on your own*" (C_L_FG_p1L25-26).

Across the cases, learners thus indicated the positive effect of IBSE activities on their beliefs about their own competence and abilities. Examples of their contributions attesting to this are included in a booklet compiled by the Grade 2 learners at the end of Jean's teaching practice period, showing evidence of the positive effect of IBSE on the motivation and views of learners on science. Photographs 5.39 to 5.40 are examples.

Photograph 5.38: A Grade 2 girl's drawing and note to the student teacher



Photograph 5.39: A Grade 2 boy's drawing and note to the student teacher

5.4.2 Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions

IBSE has the potential to equip learners with knowledge, skills, dispositions and competencies across different literacies and subjects. Child participants indicated several competencies they had allegedly acquired during the IBSE activities, which was also confirmed by the student teacher participants in their reflections. When asked: "What did you learn from this activity?", learners indicated that they acquired knowledge, skills, dispositions and attitudes related to science, as well as social learning skills. As these competencies are also discussed as part of other themes and sub-themes, I do not include a detailed discussion here. Readers are referred to the related themes and sub-themes for more detail, as captured in Table 5.9.

Table 5.9: Summary of the competencies learners acquired as a result of their participation in IBSE

Competencies	Discussed in theme/sub-theme
Science knowledge	• Sub-theme 2.4: Gaining new insight and drawing conclusions • Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions
Inquiry skills and dispositions	• Sub-theme 2.2: Identifying ways to investigate and solve the problem • Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions
Practical skills	• Sub-theme 4.3: Becoming aware of the broader application of science
Social skills	• Sub-theme 2.3: Engaging as part of a team • Sub-theme 3.1: Perceived value of social learning

As evident from the table, learners not only acquired science knowledge, but also skills and competencies relevant to other Foundation Phase subjects and general functioning in life. Apart from the competencies that the learners themselves expressed, student teacher participants noted the potential of IBSE in terms of the possibility of learners acquiring subject-related knowledge and skills. They furthermore emphasised their observations that learners were subsequently able to integrate and apply newly gained knowledge and skills to other subjects and in their lives.

An analysis of the participants' contributions indicates that IBSE provided the learners with a deep learning experience. Evident in all classrooms was learners' ability – after some time lapse – to recall the IBSE problem they had to solve accurately, but more specifically, to recall the concepts they had acquired based on the hands-on approach they followed. During the focus group discussion approximately one week after the IBSE activity, I, for example, asked the Grade 2 learners if they could remember the activity they had participated in. A learner responded: "*We'd never forgot about it*" (B_L_FG_p1L21), and continued listing the problems their group encountered with their car (refer to B_L_FG_p1L25-35). Similarly, during the whole class reflection session and focus group discussion with the Grade 3 class, learners were able to recall their IBSE lesson.

As further confirmation, Monique shared her experience of learners reportedly applying newly acquired knowledge and skills during a follow-up lesson (see C_ST3_FG_p8L437-445). Jean had a similar experience, which she reported as follows:

> *"… it was just before I was leaving, you know, one of my last lessons where we did almost like, not a consolidation, but where they had to draw their experience of the race car activity. So it was quite a gap away. But they hadn't forgotten a thing, which was amazing! They had … you know they were able to draw and recall their favourite parts. Like some of them drew the ramp, and … what not, but I think what was … what I did was I linked those scientific things the whole way along. So it wasn't just like OK here is science …, two weeks later another science thing ... So ya, by the end of it they really had a good concept"* (B_ST2_FG_p8L460-470).

In relation to these results, learners seemingly developed and used a variety of skills concerned with gathering information about the surrounding world, such as observing, hypothesising, questioning, exploring, investigating and checking hypotheses. Based on her observation of the Grade 1 learners' participation in the IBSE activity, Bronwyn reflected on the value of IBSE for skills acquisition. Along the same lines, Jean's experience of the Grade 2 learners was captured as follows: "Some of the benefits I could see for learners would be that IBSE encourages critical, creative and independent thinking. Further to this, it makes learners want to ask questions" (B_ST2_LR_p2).

Learners furthermore seemingly developed and relied on some dispositions, attitudes and virtues involved in science as a human activity. For example, Grade 1 learners acquired the virtue of responsibly looking after pets, and creating a sustainable environment for them, as evident in the following expressions:

- *“To save God’s creatures”* (A_L_FG_p6L344)
- *“To look after animals”* (A_L_FG_p6L346)
- *“To put them back in their home”* (A_L_FG_p6L348).

Similarly, Grade 2 learners allegedly acquired dispositions related to doing one’s best, being content with one’s efforts, and enjoying learning experiences. Following their practical experiences with the car-race activity, Grade 2 learners stated: “*You don’t have to be perfect. You can… you mus’ just try your hardest*” (B_L_R_p4L217), and, “*We learnt about the car that it doesn’t matter if your car is not the best … it might still win, and that not everything has to be uhm perfect and stuff*” (B_L_R_p5L256-257). Along the same lines of thinking, another learner added: “*It doesn’t matter if you win, it just matters how you have fun*” (B_L_R_p5L259). The same qualities were recorded in learners’ science journals, including remarks such as: “*We don’t have to be perfect*” (B_BG_L_SJ5), and “*Never give up*” (C_BG_L_SJ4).

5.4.3 Sub-theme 4.3: Becoming aware of the broader application of science

Based on their participation in the IBSE activities, learners seemingly realised that science can be practised in their own classrooms using everyday materials, yet also in the everyday life world (i.e. how science is carried out in real life). Following their participation in the car race activity, a Grade 3 learner, for example, stated: “*We learned how to make … anything out of boxes and junk and stuff*” (C_L_FG_p5L43-44). Learners seemed able to draw correlations between their own experiences and real life, thereby realising the value and challenges implied by science practice. In this regard, a Grade 2 learner, for example, realised, “*It is hard making an engine to go in a car*” (B_YG_L_SJ4). Similarly, a Grade 3 learner noted,“*… it must be frustrating to build a real car”* (C_L_C_R_p5L286). Another learner added: “*Another thing is that it’s not really easy to build a car. Especially with metal*”

(C_L_FG_p5L249, 253). In confirmation yet another learner added: "*It was kind of hard to build a car. Now imagine you had to build a real car with an engine and lots of wires…"* (C_L_FG_p5L255-256).

In addition to voicing possibilities, learners realised restrictions and limitations, as captured in Grade 1 learners' contributions; they said: "*It is not that easy to make* … (a fish tank)" (A_L_Rp4L198); and that some materials are "difficult to use" (A_L_FG_p6L362). Furthermore, as there were limited materials for learners to choose from, a learner learned that "*you had to use different materials, and not everything has to be the same*" (A_L_FG_p6L357). Dealing with the disappointment of not getting the material they wanted, a learner noted: "*And that you didn't have to use the material that you wanted to use*" (A_L_FG_p6L364).

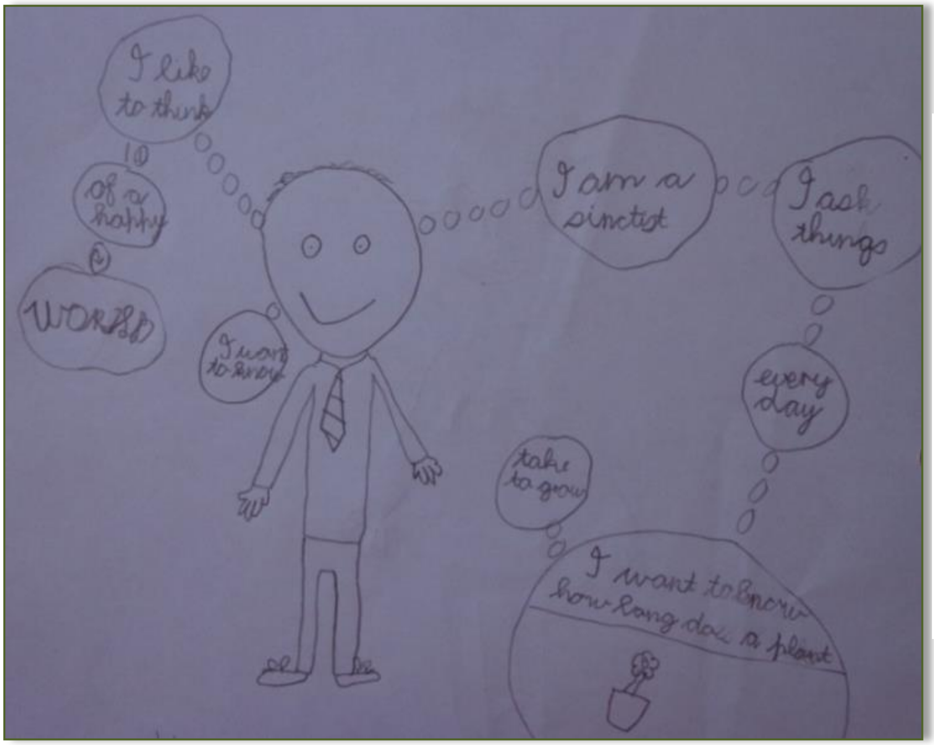
Making a car from waste materials was similarly not experienced as so simple, and learners reportedly had to put considerable effort into the planning and execution of their plans. A Grade 3 learner shared his experience:

> *"And we learned that it's not easy to make a car, and it's not … well … if you want to make a car you must first get designs and then you can make the car, but you have to see first what the problems could be with the car"* (C_L_R_p6L296-298).

5.4.4 Sub-theme 4.4: Being and becoming scientists

This sub-theme reflects child participants' views on "being" and "becoming" scientists. In all three cases, learners viewed themselves as being scientists, and seemed confident about their scientific abilities. It appeared as if learners viewed science as a human activity, using scientific qualities, skills and dispositions to describe their actions, interactions and behaviour in the IBSE context. In a Grade 2 learner's opinion, "*We did work like scientists today*" (B_L_R_p7L389), which was supported by the following views of Grade 3 learners: "*Because we are scientists*" (C_L_R_p9L502), and "*It felt like we were very good engineers*" (C_L_FG_p1L20). Although expressed in simpler terms, the Grade 1 class mutually agreed, and connected the qualities (as scientists) they displayed during the IBSE activity to illuminate this view. They mentioned cognitive qualities such as, "*Because we're* *clever*" (A_L_R_p1L10) and "*We thinked!*" (A_L_R_p1L28) as evidence of being young scientists.

Reflecting on a broader level, a Grade 3 learner (girl) claimed: "*Because every kid can think like a scientist. We ask questions every day, we grow plants, ya…*" (C_L_FG_p1L22-23). Her claim that "every kid can think like a scientist" seemingly reflects the idea of "being" a scientist, but also the inherent potential of "becoming" a scientist. Confirming this view, a post-session drawing (Photograph 5.42) completed by a Grade 3 learner is representative of the learners' acquired perceptions of science and of being scientists.



Remarks in drawing:

"I am a scientist …
I ask things …
every day
I want to learn how long does a plant… take to grow
I want to know
I like to think of a happy … world"
(C_L_Dr2).

Photograph 5.40: A Grade 3 learner's representation of himself as a scientist

In both the girl's quote and the boy's drawing, learners' awareness of their questioning nature (qualities), their curiosity about the natural and material world, and their natural scientific abilities are evident (*I/we ask questions every day, want to learn, want to know*). These reflect a view of science in society (creating a happy world), as well as learners' awareness of science as a human activity and their potential role in it. Data furthermore indicates that the learners regarded themselves as scientists (*I am/We are/We did work like scientists*) and that they displayed confidence in their scientific nature and abilities as being scientists. It furthermore points to learners' acknowledgement of their potential of becoming scientists.

For learners, working scientifically involved actions (i.e. hands-on work), relying on their skills of "doing" something practically. For instance, a Grade 3 learner claimed: "*We proved that we could be scientists … by building a car*" (C_L_FG_p1L8,12). Another Grade 3 learner confirmed this idea by stating, "*Because we made stuff*" (C_L_FG_p1L6). Similarly, another learner in the class added, "*Because, uhm we can learn how to build things, and …, and create new things*" (C_L_R_p9L518-519). These expressions indicate the learners' understanding of science as a human activity, but also their belief in their ability to do science and use scientific methods like scientists.

Learners' view of science being a human activity involving new encounters, and new discoveries or inventions is furthermore evident in a Grade 2 learner's expression; the learner stated, "*I think we worked like scientists, because normally scientists are the ones who invent things and who discover the things that haven't been discovered before*" (B_L_R_p8L421-422). In explaining why they may be regarded as scientists, another Grade 2 learner compared their actions to scientists in the following way: "*Because we improve, or we used to … because I don't think any of us tried this before, but this time we did, and it doesn't matter if it went far or not far, but at least we tried*" (B_L_R_p7L406-408). These expressions point to learners' perspectives on being scientists and their agency in creating, improving, inventing, or discovering new things (see sub-heading 4.1).

Grade 3 learners similarly displayed an awareness of the value and place of science and technology in society, and their potential role and contribution as young scientists (citizens). A learner explained:

> *"'Cause also scientists can also do inventions, and … which is good 'cause you need to also learn so you can also do good. Also as our ideas grow up you're also gonna tell us that we also need to do a project whe' we invent something that people will need… in the world"* (C_L_R_p10L540-543).

This expression is indicative of learners' awareness of being, but also of becoming scientists, and the potential value of their contributions to invent something that could eventually benefit others.

Learners' representations of themselves at the end of the teaching practice period confirm this view of children being scientists. Photograph 5.41 captures an example of such a presentation, prepared by a Grade 3 learner, who presented herself as scientist in the classroom context.

Photograph 5.41: A Grade 3 learner's representation of herself as scientist engaged in an IBSE activity in class

In further support and confirmation of this view, a narrative reflection in Monique's portfolio captures her experiences following the draw-a-scientist activity she presented to Grade 3 learners. She reflected as follows:

> "*What I enjoyed was to see the excitement on their faces, especially the first child who said it, when she said: "I am a scientist", with a big smile on her face. There was a sense of pride and accomplishment … learners perceptions had changed … it was not a lesson that lasted only while the lesson was happening … the effects and change could be seen after the lesson … it had a lasting impact on the learners"* (Reflection, 03 August 2015).

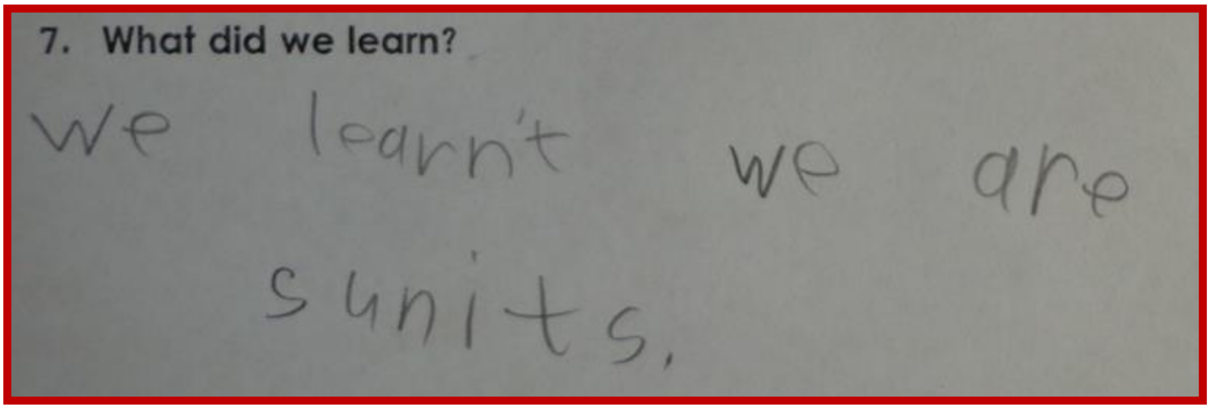
5.5 SUMMARY

In this chapter I reported on child participants' experiences of the IBSE activity they participated in. The three themes that apply relate to learners' engagement in IBSE, reflecting their experiences of doing science; learners' experiences of social learning, and learners' perception of IBSE as empowering approach. As I regarded the learners as experts in their experiences of the IBSE activities, I consulted them as primary informants and presented their voices by including excerpts from their contributions throughout my discussions.

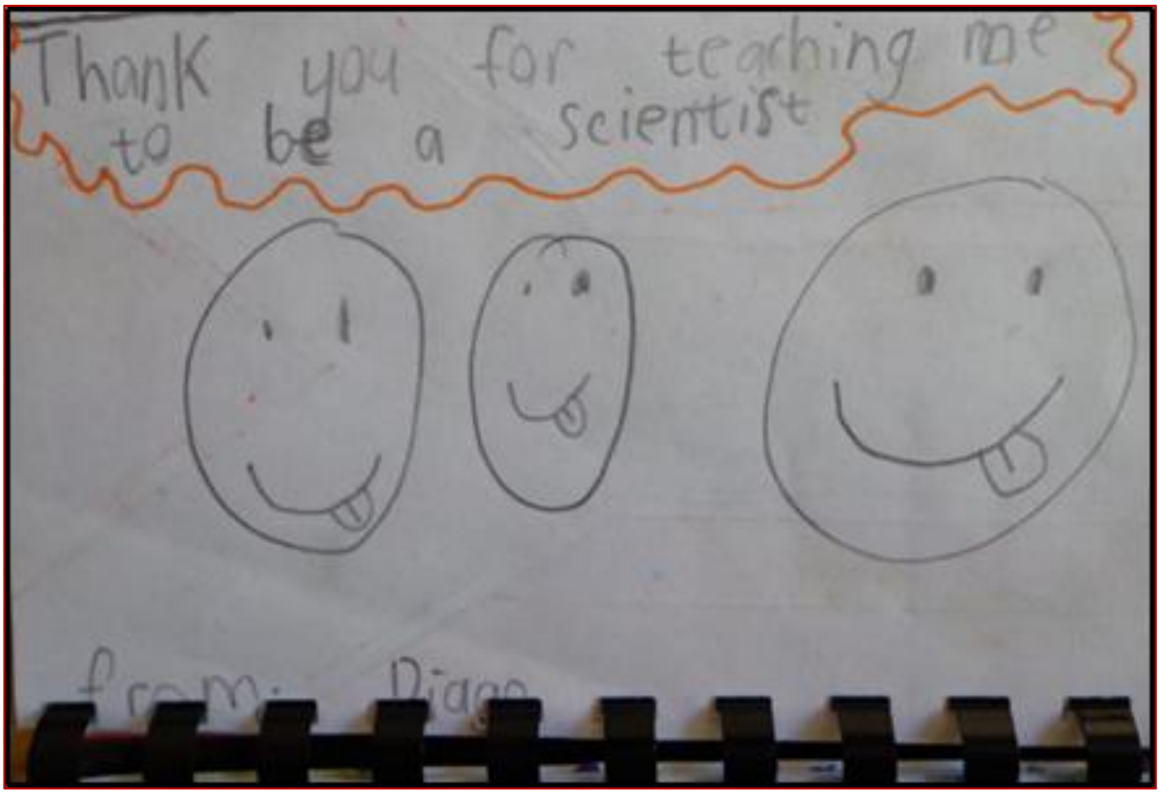
In the next chapter I present the findings of the study by relating the results I presented in Chapters 4 and 5 to existing literature and the conceptual framework that guided the study. In my discussion, I highlight correlations and contradictions, as well as silences in the data. I also indicate new knowledge that emerged as a result of this investigation.

Chapter 6

DISCUSSION OF FINDINGS



(Grade 2 learner recording what he had learned by participating in IBSE, School B, Pretoria, 2015)



(Grade 2 learner’s note to the student teacher, School B, Pretoria, 2015)

6.1 INTRODUCTION

In Chapters 4 and 5 I presented the results of my study, reporting on the participants' perceptions of the implementability of IBSE in Foundation Phase classrooms. The themes and sub-themes I discussed represent the student teachers' voices on implementation (teaching), as well as the learners' voices on engaging in IBSE (learning).

In this chapter I interpret the results of the study against the background of the literature I consulted. I discuss correlations, contradictions as well as silences when comparing the findings of the study with existing literature. I conclude the chapter by discussing new insights that emerged from the study.

6.2 FINDINGS IN SUPPORT OF EXISTING LITERATURE

In this section I highlight correlations between the studies I cited in Chapter 2, and the participants' perceptions uncovered in this study. As an introduction I provide an overview of these correlations in Table 6.1. In the paragraphs following the table, I elaborate on the points of congruency in terms of the main findings of the study.

Table 6.1: Findings that support existing literature

Author and Year	**Existing knowledge**	**Interpretive discussion on how the results of this study support existing knowledge**
THEME 1: STUDENT TEACHERS' EXPERIENCES OF IMPLEMENTING IBSE IN FOUNDATION PHASE CLASSROOMS		
Sub-theme 1.1: Being an IBSE facilitator		
• Gillies and Nichols (2015) • Koch (2013) • Martin (2012) • Ødegaard et al. (2014) • Qablan and DeBaz (2015) • Tan and Wong (2012) • Worth et al. (2009)	IBSE implementation depends on teachers' ability to adopt complex and sophisticated roles in planning for and facilitating inquiry-based learning.	Student teacher participants revealed awareness and the ability to use the roles associated with planning and facilitating IBSE. They also reported on the complexity involved in planning IBSE activities, as well as supporting learners' thinking throughout the IBSE phases.

• Adair (2014) • Dunlop et al. (2015) • Schweisfurth (2015)	Implementing IBSE requires teachers to act from a child-centred stance and to guide learners to take a central role in the learning process.	Student teacher participants displayed an understanding of and the necessary skills to promote and facilitate child-centred inquiry-based learning.
Sub-theme 1.2: Challenges experienced when implementing IBSE		
• Fraser-Abder (2011) • Hand et al. (2016) • Kershner et al. (2014) • Krämer et al. (2015) • Seung et al. (2014) • Ødegaard (2014) • Tenaw (2014) • Tao et al. (2013) • Siry et al. (2012) • Zogza and Ergazaki (2013)	Many challenges have been associated with the implementation of IBSE (e.g. the curriculum, time and classroom management). This can place high demands on teachers who implement IBSE.	Student teacher participants experienced a number of challenges that impacted on their implementation of IBSE in the various classrooms, e.g. factors relating to CAPS, time and classroom management.
• Krogh and Morehouse (2014) • Patrick and Mantzicopoulus (2015) • Trundle et al. (2011)	Perceived unimportance or non-appearance of science in the curriculum may negatively influence learners' development in science.	Student teacher participants highlighted the impact of limited opportunities to engage in meaningful science on learners' development of inquiry and independent learning skills, as complication to IBSE implementation.
Sub-theme 1.3: Potential value of IBSE implementation in Foundation Phase classrooms		
• Avraamidou (2014) • Flores (2015) • Forbes (2011) • Harshbarger (2014) • Lewis et al. (2015) • Smolleck and Nordgren (2014)	Shaping a beginner teacher's identity for science should reflect a reform-mindedness and orientation towards inquiry teaching. Teachers' awareness of the value of IBSE for young children and their attitudes will determine their capacity to engage learners in scientific inquiry. As such, teachers' self-efficacy beliefs and views of themselves as transformational science teachers may positively impact IBSE implementation.	Student teacher participants – as teachers-in-training – displayed a developing professional identity and qualities favourable to IBSE implementation, as well as an awareness of the importance of science at Foundation Phase level. They regarded the facilitation of IBSE as rewarding and experienced fulfilment based on the enabling role they fulfilled in learners' accomplishments during the learning process.

• Delclaux et al. (2012) • Krämer et al. (2015) • Kazempour and Amirshokoohi (2013) • Smolleck and Nordgren (2014)	Effective IBSE implementation depends on various broad-level factors. These include a network of support, provision of and easy access to training resources (science content, teaching units, learning sequences), and specialised training for novices (including first-hand positive experiences in learning science as inquiry, in order to build confidence to implement inquiry-based approaches in practice).	Based on their personal and practical experiences, student teacher participants suggested the following in support of implementation in school contexts: a support network (e.g. like-minded teachers, mentor-teachers and other relevant stakeholders); cultivation of specific qualities and specialised education as preparation for teachers to teach science following an inquiry approach; and experiencing inquiry first-hand during teacher training to shape self-efficacy beliefs and competencies to implement IBSE.
• Cofré et al. (2015) • Dickson and Kadbey (2014) • Forbes (2011) • Qablan and DeBaz (2015)	The beliefs that elementary school teachers hold about science education are often inconsistent with reform initiatives, and should consequently be challenged.	Student teacher participants experienced teachers in practice as holding certain beliefs in terms of science education that may inhibit IBSE implementation. For this reason, they proposed that teachers' perceptions of science education and learners' competence in this regard need to be challenged.
THEME 2: LEARNERS' ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE		
Sub-theme 2.1: Understanding the problem and taking ownership of the learning process		
• NRC (2000) • Minner et al. (2010) • Levy et al. (2011) • Tan and Wong (2012) • Metz (2011) • Trundle (2015) • Martin (2012) • Patrick and Mantzicopoulus (2015) • Gopnik et al. (1999) • Jirout and Zimmerman (2015)	Children are seen as naturally curious and motivated to explore and understand the natural world. The introduction of a problem may therefore create uncertainty within learners' minds, which can motivate them towards active exploration and using scientific skills in an attempt to find solutions.	In all cases, the child participants were able to recall and articulate accurately the stated problems as introduced by the student teachers. They also related these problems to problems they themselves encountered – in this way displaying ownership of the learning process.

Sub-theme 2.2: Identifying ways to investigate and solve the problem		
• Delclaux and Saltiel (2013) • Harlen (2012) • Gopnik and Wellman (2013) • Goswami (2015) • Vosniadou and Ioannides (1998) • Gooding and Metz (2011) • Hedges (2014)	IBSE assumes that all children possess theories that they use as basis to interpret new information and make reasoned predictions. The power of theories depends on their usefulness to solve the problem at hand.	Learners displayed confidence in having ideas (theories) as well as an awareness of the origin of their ideas (from within, brain, environmental stimuli, others). Learners' initial suggestions to solve IBSE problems were, however, generally impractical and imaginative and thus not sufficiently powerful to solve problems.
Sub-theme 2.3: Engaging in the investigation as part of a team		
• Bell and St.Clair (2015) • Hedges (2014) • Gopnik et al. (1999) • Vosniadou (2001) • James and Prout (1997) • Siry and Kremer (2011) • Smidt (2013) • Kirch and Amoroso (2016)	Young children are cognitively able to use inquiry skills naturally and flexibly, like real scientists, in order to make sense of their world. The human and social nature of science implies that sense-making processes rely on individual, but also socio-cultural influences. Learning science in a social context may consequently impact theory formation and revision – so that theories may become richer, and more differentiated as a result of social input.	In all classrooms, child participants used inquiry skills intuitively and flexibly during the learning process. In this regard they continually revised their theories, based on the evidence presented to them through their direct engagement in the investigation. Working collaboratively as part of a small team, as well as the roles individuals fulfilled during their engagement in the activities, furthermore influenced knowledge construction and enriched the learning experience.
Sub-theme 2.4: Gaining new insight and drawing conclusions		
• Harlen (2013a) • Levy et al. (2011) • Minner et al. (2010) • Worth et al. (2009) • Tan and Wong (2012)	Direct experience is key to science concept acquisition in the inquiry-based approach to science education.	Child participants were able to draw contextualised conclusions, based on their direct experiences and active involvement in the investigation. Their conclusions were, however, also influenced by factors such as their prior knowledge and experience, as well as knowledge transmission.
• Ødegaard et al. (2014)	The hands-on phases of IBSE seem to be over-emphasised to the detriment of the minds-on phases of the inquiry	The investigation phase overpowered the reflection and conclusion phases in this study. This resulted in learners drawing their own conclusions rather than

	process (e.g. reflection and consolidation).	basing their conclusions on science concepts underlying the problem, consolidated by the student teacher.
Sub-theme 2.5: Sharing and documenting experiences		
• Smidt (2013) • Lansdown (2003) • Clark and Moss (2001) • Worth et al. (2009)	Researchers conceptualise contemporary children as instinctive, skilful communicators who are able to work with others when making and sharing meaning.	Child participants in all classrooms were able to communicate their self-constructed understandings competently and confidently to audiences – using verbal, visual and written means.
• Harlen (2012)	IBSE requires children to listen to and learn from others. This skill depends on age, level of maturity and experience.	Some child participants seemingly lacked maturity and experience to listen attentively and consider others' viewpoints. Other learners were, however, able to listen and learn from peers.
• Worth et al. (2009) • Hand et al. (2016)	Writing is a critical form of communication, especially in argument-based approaches to science education. As such, learners are required to record their thinking processes in written format when implementing IBSE.	Regardless of their lack of experience, child participants in all classrooms were able to use signs, symbols and text skilfully when recording their ideas scientifically.
THEME 3: LEARNERS' EXPERIENCES OF SOCIAL LEARNING		
Sub-theme 3.1: Perceived value of social learning		
• Gillies and Nichols (2015) • Goswami (2015) • Worth et al. (2009) • Vosniadou (2001) • Dunlop et al. (2015) • Hand et al. (2016) • Levy et al. (2011) • Harcourt and Hägglund (2013) • Smidt (2013) • Lansdown (2005)	Science learning (as human activity) is socially and culturally mediated, and thus supports socio-cultural constructivist theory. As social actors, learning within cultural contexts may enhance children's emotional, social and academic development.	During interaction in small cooperative groups, while working like scientists, the child participants perceived working as part of a team and the reciprocal interaction between team members as beneficial to their learning experience. In this regard they experienced the effect of their own contributions on others, but also the contribution of others on them. Cooperative learning may thus have positively impacted their development.

Sub-theme 3.2: Dealing with associated challenges		
• Harlen (2012) • Gillies and Nichols (2015) • Kershner et al. (2014)	Human interaction poses challenges in terms of self- and social regulation during collaborative group work, and requires culturally appropriate ways to manage behaviour.	The child participants in this study reported some adverse feelings as a result of cooperative participation (e.g. the challenge of compromising ideas, handling interaction and managing group roles).
• Dunlop et al. (2015) • Smidt (2013)	Children generally prefer to work in a non-threatening environment.	The child participants in this study resourcefully devised strategies to ensure a peaceful learning atmosphere based on their authentic experiences.
THEME 4: LEARNERS PERCEIVING IBSE AS AN EMPOWERING APPROACH		
Sub-theme 4.1: Value of owning the learning process		
• Kellet (2011) • Furtak et al. (2012) • Harlen (2013a) • Koch (2013) • Martin (2012) • Morrow (2011) • Pedaste et al. (2015)	IBSE engages learners in learning science by doing science, thereby constructing knowledge through action. Children's agency (the capacity to act) implies that learners are capable of playing an active and central role in the learning and knowledge-construction process.	In this study, learners took agency and displayed confidence to independently engage in activities and to learn by doing (even by making mistakes).
Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions		
• Gillies (2013) • Harlen (2013b) • Kovalik and Olsen (2010) • Krogh and Morehouse (2014) • Roehrig et al. (2012) • Sousa (2013) • Vosniadou (2001) • Zull (2011)	IBSE promotes knowledge and understanding, and enables learning transfer across different literacies and subjects – which can in turn make learning more meaningful and long-lasting.	Learners acquired knowledge, skills and competencies across a range of subjects. They reported on the lasting impression the IBSE activities had on them. This was confirmed by the student teacher participants.
• Adair (2014) • Patrick and Mantzicopoulus (2015) • Schweisfurth (2015) • Suduc et al. 2015) • Vosniadou (2001) • Trundle (2015)	IBSE may shape motivation, learner-autonomy, self-efficacy, and a sense of agency. Context plays an instrumental role in developing children's motivational attitudes.	The IBSE experience as well as the student teachers' roles impacted on learners' motivational attitudes and their sense of agency as scientists.

Sub-theme 4.3: Becoming aware of the broader application of science		
• Ashbrook, 2014 • Abd-El-Khalick et al. (2004) • Gillies and Nichols (2014) • Haug and Ødegaard (2014) • Janulaw (2014) • Krogh and Morehouse (2014) • Lederman (2014) • Minner et al. (2010) • NRC (2000) • Smolleck and Nordgren (2014) • Tenaw (2014)	IBSE focuses on learning science by doing science, employing a range of inquiry skills. Working like scientists in their classrooms may enable children to connect what they do to the work of scientists. In this way they can start understanding what science is, what scientists do, and how science is carried out in the real world.	The learners in this study displayed competence in applying inquiry skills and dispositions like scientists, but also an awareness of working like scientists in the classroom. They were able to relate what they were doing to real-world science.
Sub-theme 4.4: Being and becoming scientists		
• Jirout and Zimmerman (2015) • Martin (2012) • Metz (2011) • Patrick and Mantzicopoulus (2015) • Trundle (2015)	Researchers regard children as natural scientists, displaying the qualities and dispositions of real scientists.	In this study the learners' natural competence and dispositions were observed by the researcher, confirmed by the student teachers, and expressed by the child participants themselves.
• Akerson et al. (2011) • Hedges (2014) • Kirch and Amoroso (2016) • Kumpulainen et al. (2014) • Zhai et al. (2014)	Researchers often highlight the complexity of children's scientific thinking.	The complexity of the learners' understanding of what science is and entails was reflected in their expressions, reflecting various viewpoints on the nature of science concepts.
• Dahlberg et al. (2013) • Dockett et al. (2011) • Hammersley (2015) • Kellet (2011) • Kirch and Amoroso (2016) • Morrow (2011)	Contemporary researchers portray children as agentic beings, and active participants in social and cultural settings.	Children's agency as scientists was evident in the way in which their identities and sense of agency developed through active participation in IBSE, and their projections of their capabilities as scientists.

6.2.1 Teacher views and related factors influencing the implementation of IBSE in Foundation Phase classrooms

Effective application of IBSE depends on the teacher's ability to implement the curriculum, and to strategically guide learners through the entire inquiry cycle (Gilles & Nichols, 2015). In this regard teachers are viewed as facilitators of learning who intentionally guide learners' thought processes throughout the inquiry phases in order to support their knowledge construction (Dunlop et al., 2015; Gilles & Nichols, 2015; Howe et al., 2012; Levy et al., 2011; Wilson & Kittleson, 2012; Zhai et al., 2014). Effective IBSE implementation furthermore depends on teachers displaying reform-mindedness, as well as an orientation favourable to implementing innovative teaching approaches (Avraamidou, 2014; Hanuscin, 2013; Lewis et al., 2014).

Congruent with existing literature, student teacher participants were aware of and articulated the different roles proposed by the LAMAP IBSE. They supported a child-centred approach to teaching and highlighted their roles as planners and facilitators of child-centred learning, encouraging learners to take the lead in the learning process while supporting learners' knowledge construction. The finding aligns with the work of several authors who support child-centred and inquiry-based approaches to science education (for example Adair, 2014; Dunlop et al., 2015; Koch, 2013; Martin, 2012; Schweisfurth, 2015; Worth et al., 2009).

In further support of existing literature, the student teachers realised the complexity involved in planning and facilitating inquiry and child-centred learning. They highlighted tasks such as finding science outcomes in CAPS, planning for the unexpected, encouraging learners to think for themselves and to take ownership of their learning; and were frustrated by factors associated with constant facilitation (as opposed to simply conveying solutions), and limited skills when guiding learners' thinking throughout the investigation process. This finding correlates with several authors, for example, Qablan and DeBaz (2015), Gillies and Nichols (2015), Ødegaard et al. (2014) as well as Tan and Wong (2012) who underscore the complexity involved in the role of the teacher as planner and facilitator.

Researchers such as Hand et al. (2016), Krämer et al. (2015), Seung et al. (2014), and Ødegaard (2014) point to curriculum-related factors and classroom management as potential challenges of IBSE implementation. In this regard my findings support existing literature in that the student teachers indicated challenges relating to insufficient curriculum guidelines, marginalisation of science as subject in the Foundation Phase, learners' underdeveloped inquiry skills, as well as time and classroom management. I found that curriculum limitations negatively impacted student teachers' planning, while the consequences of insufficient emphasis on science as subject in the Foundation Phase curriculum and programme had a detrimental effect on their implementation of inquiry-based activities. Moreover, the low emphasis on science in CAPS seemingly places constraints on the time available for scientific investigations in the Foundation Phase programme, as also indicated by Tao et al. (2013), Siry et al. (2012), Zogza and Ergazaki (2013), Tenaw (2014) and Fraser-Abder (2011).

The student teacher participants furthermore indicated that the learners' lack of quality science experiences and opportunities to work independently negatively affected their development of science competencies, and as such, that learners needed more structured guidance. This finding relates to the work of Krogh and Morehouse (2014), Patrick and Mantzicopoulus (2015), as well as Trundle et al. (2011) who state that insufficient emphasis on science as subject may negatively affect learners' science development. While student teachers apparently followed classroom management approaches in support of IBSE, they also did, as widely reported in literature (Kershner et al., 2014; Tenaw, 2014), experience classroom management challenges, more specifically with regard to attention-focusing strategies, and managing effective group work.

As contended by several authors such as Avraamidou (2014), Lewis et al. (2014), Riegle-Crumb (2015) as well as Smolleck and Nordgren (2014), shaping reform-minded inquiry-oriented professional teacher identities requires a close and purposeful link between theoretical components of teacher training and the practical realities of a classroom (e.g. translating theory into authentic teaching practice). This requirement, coupled with critical reflective practices (Flores, 2015; Forbes, 2011) may enhance student teachers' professional practice as well as their self-efficacy beliefs and the views of themselves as transformational science teachers. In line with these arguments, I found that student teacher participants in this study conceptualised themselves as competent IBSE facilitators, with qualities, orientation and competencies favourable to implementing innovative and child-centred approaches.

The recommendations that the student teacher participants made for implementing IBSE furthermore correlate with the guidelines for IBSE implementation generally proposed in existing literature, for example Delclaux et al. (2012), Krämer et al. (2015), Kazempour and Amirshokoohi (2013), as well as Smolleck and Nordgren (2014). To illustrate, while the student teacher participants were positive about the possibilities of IBSE implementation in their classrooms and schools, they identified a support network, for instance like-minded teachers, mentor-teachers, and other relevant stakeholders (e.g. parents, the HOD, principal, education department) as structures that would support the implementability of the approach. Additionally, student teachers recommended specialised skills development and training to prepare teachers for the complexity of IBSE implementation, including teacher training practices that can shape competencies through first-hand positive experiences, thereby learning inquiry through inquiry.

Finally, in confirmation of existing literature on teachers' disregard for science education and children's scientific potential (see Cofré et al., 2015; Dickson & Kadbey, 2014; Forbes, 2011; Qablan & DeBaz, 2015), the student teacher participants regarded practising teachers' beliefs and practices that are inconsistent with reform initiatives as inhibitors of IBSE implementation, and suggested that these should be addressed. In support of Hanuscin's (2013) observation that novice teachers often find themselves immersed in a classroom culture that does not support implementation of reform-based practices, the student teachers in this study experienced their mentor-teachers' ignorance of IBSE as a constraint to translating their views on science education to their classrooms. As such, their recommendation to create awareness of and address ignorance among practising Foundation Phase teachers is in line with the findings of related studies in literature (for example, Riegle-Crumb et al., 2015; Smolleck & Nordgren, 2014).

6.2.2 Child participants' active engagement in the IBSE phases

In this study learners engaged in IBSE, doing science like scientists in the context of a Foundation Phase classroom. IBSE generally introduces an authentic question or problem, which drives the learning experience (NRC, 2000; Minner et al., 2010; Levy et al., 2011; Tan & Wong, 2012). As such, Phase 1 of the inquiry process starts with an exploratory phase where learners get the opportunity to become familiar with the phenomenon they will study. In order to become cognitively invested, the importance of learners understanding the IBSE problem is highlighted by Worth et al. (2009). In line with this appeal I found that child participants in this study displayed ownership of, and seemed driven by the IBSE problem introduced to them in their classrooms by the student teachers. They furthermore articulated the problem in terms of the problems they themselves encountered, and as such, learners could experience the problem as relevant and meaningful to their personal lives, which serves as motivation to become and stay engaged in the learning process. Additionally, in agreement with researchers suggesting that learners' natural curiosity and desire to explore, interact, understand and master new things serve as driving force for engagement (for example, Vosniadou, 2001; Metz, 2011; Trundle, 2015; Jirout & Zimmerman, 2015; Fleer, 2015), I found that the introduction of the IBSE problem ignited learners' curiosity, sparked their excitement, and propagated their active engagement in the activities planned for their classrooms.

IBSE typically uses learners' intuitive ideas as starting point for investigations, so that teachers can facilitate their conceptual development in science by building on their prior knowledge (Siry & Kremer, 2011). With regard to the availability of learners' scientific ideas, the notion of children's theories is well supported in literature (Gopnik & Wellman, 2013; Gooding & Metz, 2011; Goswami, 2015; Vosniadou & Ioannides, 1998). As such IBSE proceeds from the assumption that such available theories will enable learners to make sense of the experience under investigation, but also to make reasoned predictions with regard to solving IBSE problems during the think-on-your-own phase (Delclaux & Saltiel, 2013; Harlen, 2012). In support of existing literature, I found that learners themselves displayed confidence in having ideas, as well as in sharing their theories when proposing possible solutions to the problems. In terms of the plausibility of learners' theories, the findings of this study also correspond to existing studies (for example, Gopnik & Wellman, 2013; Gooding & Metz, 2011; Goswami, 2015; Hedges, 2014; Vosniadou & Ioannides, 1998) as I too found learners' theories to be naïve, incomplete and sometimes incorrect.

While I did not detect misconceptions *per se*, the ideas the learners proposed during the think-on-your-own phase in specifically the Grade 2 and 3 classrooms generally contained imaginative and impractical elements. This finding relates to the work of Goswami (2015) and Vosniadou (2001), indicating that this in turn can prevent learning in that such misconceptions are not always problem-focused, and may be less useful in solving a problem at hand. While I found the learners' ideas to be less useful in terms of solving the problem, their scientific nature, adaptability, and cognitive flexibility enabled them to realise the impracticality of their predictions, and subsequently to propose more practical suggestions. This finding supports numerous studies (for example, Bell & St.Clair, 2015; Eshach, 2011; Gopnik et al., 1999; Gopnik, 2012; Hedges, 2014; Trundle, 2015) that highlight the sophistication of children's scientific thinking and their ability to revise and revisit theories as required.

In terms of engagement during the investigation phase (Phase 2), IBSE relies on children's ability to do science like scientists, and to use inquiry skills to plan and conduct investigations cooperatively. To this end, general consensus exists among researchers (for example, Bell & St.Clair, 2015; Cremin et al., 2015; Eshach, 2011; Gopnik & Meltzoff 1997; Gopnik, 2012; Patrick & Mantzicopulos, 2015; Trundle, 2015) about young children's cognitive capacity and possession of mechanisms that enable them to engage in scientific investigation. These views are supported by the findings of the current study where child participants used cognitive strategies similar to those of scientists to move flexibly between the different parts of the investigation phase. Moreover, as suggested by Hedges (2014), Gopnik and Wellman (1992), Gopnik and Meltzoff (1997) as well as Trundle (2015), I also found that the child participants were able to use inquiry skills naturally, instinctively and flexibly during theory formation and revisions in modifying and restructuring their working theories as they accumulated more evidence. It was also evident that the learners revised their theories based on their active experiences. Their fearlessness in experimentation (also referred to by Trundle, 2015) could be seen in the way in which the learners almost instinctively used what they had learned, revised their thinking, asked new questions, and steered their investigations in new directions.

Additionally, with regard to social influences on the learning process, I found that participation and interaction in the socio-cultural context of IBSE resulted in the co-construction of understanding, based on both personal as well as shared meaning making processes. As such I found evidence in all classrooms of the powerful influence of collaboration and contributions of knowledgeable others (e.g. peers) that stimulated, challenged and supported theory formation and revision while learners participated in the IBSE activities. These findings align with existing studies and the work of Cremin et al. (2015), Gillies and Nichols (2015), Gopnik et al. (1999), Hedges (2014), Vosniadou (2001) as well as Siry and Kremer (2011).

Concerning the drawing of conclusions (Phase 3), IBSE relies on direct experience as key to conceptual understanding (Harlen 2013a; Levy et al., 2011; Minner et al., 2010; Tan & Wong, 2012; Worth, Duque & Saltiel, 2009). This implies that learners draw conclusions based on their first-hand experiences. In support of this notion I found that the learners who participated drew conclusions from their active participation in the respective IBSE activities, and their efforts to solve problems collaboratively. This finding confirms the views of Koch (2013), Martin (2012) as well as Siry and Kremer (2011), according to whom knowledge is viewed as contextually embedded and socio-culturally constructed.

During the communication phase (Phase 4), learners communicated their understanding to others using different formats, namely verbal, visual and written modes. In support of researchers viewing contemporary children as instinctive, skilful communicators, able to work with others to make and share meaning (Smidt, 2013; Lansdown, 2005; Clark & Moss, 2001; Malaguzzi, 1993), I found that the learners in this study could expertly and confidently express themselves in a variety of ways using their everyday language. In line with Harlen's (2012) opinion, I also found that younger participants (in particular Grade 1 and 2 learners) may still continue to develop the necessary self-discipline and affective maturity in order to gain optimally when learning with and through others. Concerning the recording of their ideas, I found that, regardless of being inexperienced, the child participants were able to use signs, symbols and text skilfully when documenting their scientific thinking according to the written format provided by the student teachers. This finding confirms the work of Smidt (2013), Lansdown (2005), Clark and Moss (2001), as well as Malaguzzi (1993), indicating that contemporary children can participate and make their meaning known by employing a range of languages.

Finally, several studies on IBSE have revealed that the emphasis placed on the hands-on phases of the process often results in less emphasis on the minds-on phases of the inquiry. Minner et al. (2010), as well as Ødegaard et al. (2014) serve as examples. In line with existing literature, I found that the learners' immersion in and preference for the hands-on phases of the inquiry process (i.e. doing) generally overpowered their willingness to engage in the minds-on (thinking) phases. In this regard, the reflection, drawing conclusions and communication phases were neglected, partially due to time constraints, but also due to learners' deep immersion in the investigation, and their reluctance to steer away from doing and moving to thinking, reflecting and writing. While the student teachers' facilitation was not the focus of my observation, in agreement with Ødegaard et al. (2014), I noted that the student teachers tended to focus more strongly on tasks, activities, procedures and guiding learners' thinking in general, than on supporting the learners' conceptual structure formation and scientific reasoning.

6.2.3 Child participants' experiences of social learning in the IBSE context

Contemporary researchers (Gopnik et al., 1999; Hinton & Fischer, 2010; Zull, 2011) confirm the human brain's preference for social learning and, subsequently, the importance of structuring community-oriented learning environments that can allow for social engagement and interaction, in order to enhance learning. Rooted in socio-cultural constructivist theory (Piaget and Vygotsky), the IBSE learning environment mirrors science in a real-life context in which knowledge-building practices are social and cooperative in nature (Gillies & Nichols, 2015; Worth et al., 2009). Researchers in both science education (Dunlop et.al., 2015, Gillies & Nichols, 2015; Hand et al., 2016; Levy et al., 2011) and childhood development (Goswami, 2015; Lansdown, 2005; Smidt, 2013) support the notion of learning as a social and cultural act, indicating that cooperative learning will promote learners' engagement in the learning process. The child participants in this study participated in a community of scientists while cooperatively engaging in IBSE. In this regard the child participants' experiences of being part of a learning community as voiced in this study, elicit both the educational gains and the challenges they experienced as well as the areas in need of expansion to ensure meaningful participation in formal social learning contexts.

In support of Smidt's (2013) and Goswami's (2015) view of children as competent sense makers and navigators of the social world, I found that the learners participating in this study generally enjoyed working together with their friends, displayed team spirit, and experienced participation in this small community as emotionally supporting and comforting, often alleviating the challenging demands placed on them. In addition, correlating with Smidt (2013) and Goswami's (2015) views on the importance of active participation on children's understanding of the feelings, intentions, needs and ambitions of others, the learners in this study perceived the process of working in groups as challenging yet as an important learning experience. More specifically, learners (although voiced in children's terms) regarded the dialogic discussions, reciprocal interaction, knowledge-exchange and co-construction of meaning in their groups as enriching learning experiences. This finding aligns with a study by Dunlop et al. (2015), where it was found that social learning can positively impact learners' academic development when engaging in IBSE.

Corresponding to existing literature on the challenges typically associated with cooperative learning (e.g. Harlen, 2012; Gillies & Nichols, 2015; Kershner et al., 2014), child participants in this study experienced the regulation and negotiation of their own and their team members' participation as challenging. In this regard, their interactions and attempts to navigate the complexity of interactions in their groups contributed to feelings of not being heard and acknowledged, but also to feelings of irritation, frustration, anger and discomfort. As such, the formal learning context placed demands on them to avoid negative interactions, regulate their emotions, and devise accepted ways of managing their feelings of frustration and annoyance. In support of Harlen's (2012) observation that young children's developmental maturity may negatively impact their ability to work productively in groups, a small number of learners from all classrooms seemingly struggled with compromising their ideas, and with incorporating the ideas of others into their conceptual structures. In some instances the children displayed a preference to work individually, partially due to their reported inexperience of functioning as a member of small cooperative learning groups in the classroom.

Due to some complexity generally implied by human interaction, the IBSE classroom relies on both teachers' and learners' ability for self- and social regulation to ensure conducive social learning. In this regard the student teacher participants in this study introduced guidelines and measures to regulate learners' behaviour (e.g. group roles and guidelines for participation), yet the learners themselves also proposed measures to regulate behaviour within their groups. In line with Kershner and colleagues' (2015) finding that children will collectively devise their own ways of handling uncomfortable experiences based on their actual experiences in cooperative learning contexts, the child participants in the current study proposed strategies based on their personal encounters. In other words, regardless of their possessing knowledge of classroom principles and the ground rules for participation, the learners did not merely apply their knowledge of social learning principles, but devised their own strategies, based on real-life experiences. Furthermore, in agreement with Hand et al. (2016), indicating that meaningful cooperative learning depends on learners' ability to work productively in a safe space, the child participants in this study displayed a preference for working in a non-threatening environment, and as such, ensuring serenity in the group and maintain the behaviour of group members. I thus found that the learners displayed the necessary competence to devise strategies that could regulate behaviour in acceptable ways in order to ensure meaningful and productive participation.

6.2.4 Child participants' experiences of IBSE as an empowering approach

The potential educational benefits associated with IBSE as approach are well documented by Boaventura and Faria (2015), Gillies and Nichols (2014), Krämer et al. (2015), the NRC (1996), Suduc et al. (2015), Tenaw (2014), Ergazaki and Zogza (2013), Harlen and Léna (2013), Harlen (2013a), Gillies and Nichols (2014), Ireland et al. (2012), Levy et al. (2011) and Tenaw (2014). To this end, several researchers argue that IBSE is an empowering approach, and that the act of engaging in science like scientists, may potentially yield educational benefits such as motivation and competency-beliefs, knowledge construction, the development of inquiry skills and dispositions, and the development of competencies required in a 21st century society (including e.g. scientific thinking habits and scientific literacy). The findings of this study confirm these educational benefits reported on in existing literature, more specifically those related to children's agency and motivation, but also the acquisition of science-related knowledge, skills, dispositions and identity as scientists.

IBSE's potential to enhance children's interest in and enthusiasm for science as a subject (as noted by Cremin et al., 2015; Krämer et al., 2015; Minner et al., 2010; Patrick & Mantzicopoulus, 2015; Suduc et al., 2015) could also be observed in this study, as the child participants generally displayed pleasure, satisfaction and an eagerness to gain more and continued experiences with IBSE. Their experiences of excitement often related to the satisfaction they seemingly experienced through autonomous involvement (agency) and confidence in their ability to fulfil an active role in the learning process.

Additionally, in support of existing literature emphasising the inevitable impact of teachers' attitudes, behaviours and practices on children's self-efficacy beliefs and motivations (for example, Avraamidou, 2014; Boaventura & Faria, 2015; Patrick & Mantzicopoulus, 2015; and Tenaw, 2014), the child participants' responses, reactions and behaviours indicated the influential role of the IBSE experience, but also of the student teachers in shaping their motivation, efficacy, and love for science. Thus, this study highlights the potential of IBSE as motivation-shaper and its power to instil in learners a positive disposition towards science, and consequently a motivation to learn science.

Researchers (Gillies, 2013; Harlen 2013b; Roehrig et al., 2012) indicate the potential of IBSE in equipping learners with knowledge and skills across different subjects and literacies, and with competencies that can be applied to real-world contexts. This study supports these findings from both learner and teacher perspectives. Based on the child participants' experiences, the IBSE activities offered them an opportunity to apply their knowledge and skills when solving science problems like professional scientists would do in real-life, and, in doing this, employ skills and tools from different subject areas (e.g. mathematics; listening, speaking, reading, writing; creative arts, and technology).

Apart from the integrated learning experiences articulated by the learners, student teachers indicated that cross-curricular learning was made possible through IBSE. This finding confirms the work of Kovalik and Olsen (2010) as well as Sousa (2013), pointing to the potential of science information to be stored in multiple places in the brain to enable horizontal connectedness between subjects and literacies. Additionally, the active nature of IBSE – and learners' concept acquisition based on their authentic experiences – seemingly contributed to their deep understanding, and meaningful, long-lasting learning. In support of my observations of the learners' memory, the student teachers commented on the learners' recall of activities as well as the concepts they acquired. This finding furthermore provides evidence that competencies can be transferred to other subjects and other contexts, as proposed by Kovalik and Olsen (2010), Krogh and Morehouse (2014), and Sousa (2013). Consequently this study confirms the potential of IBSE to empower learners through meaningful and long-lasting learning.

With regard to working scientifically, IBSE focuses on the learning of science by doing science. Consequently, according to Gillies and Nichols (2014), Tenaw (2014), Abd-El-Khalick et al. (2004), Haug and Ødegaard (2014), Minner et al. (2010), the NRC (2000), and Smolleck and Nordgren (2014), when children work like scientists, they may connect what they do in their own classrooms to the work of scientists. This may consequently contribute to their understanding of what science is, what scientists do, and how science is carried out in the real world. I similarly found that the child participants in this study described their way of doing science and working like scientists as reflecting many of the skills and dispositions employed by real scientists. They, for example, referred to skills related to inquiry (e.g. gathering information about the surrounding world, questioning, exploring, investigating, etc.), but also to skills related to critical thinking, problem solving and decision making. This finding confirms the work of Boaventura and Faria (2015), and Harlen (2013) who also foreground these skills as generally implemented by learners when doing science like scientists. The emotions and dispositions involved in science as human endeavour, indicated by Cremin et al. (2015), Gopnik (2012), Patrick and Mantzicopoulus (2015), and Worth et al. (2009) were also evident in my study as learners used creativity, did not give up, continued trying, and fixed their mistakes during the IBSE learning process. Additionally, learners were able to draw a correlation between their own experiences and real life, and imagine the practicalities involved in real world science. The child participants thus indicated that it felt realistic, and that they felt like real scientists and engineers when imagining the difficulty involved in constructing fish tanks and building cars.

In expressing themselves as scientists, the child participants from all three classrooms regarded themselves as “being” scientists, and as able to engage in authentic science practices. The learners described their actions, interactions and behaviour in the IBSE context by means of qualities, skills and dispositions typically associated with science, such as thinking, clever, doing, creating, and inventing. The learners furthermore displayed an awareness of their scientific nature, as well as confidence in their scientific abilities. To this end the qualities adult researchers often attribute to children-as-natural scientists, as described by Jirout and Zimmerman (2015), Kirch and Amoroso (2016), Martin (2012), Metz (2011) as well as Trundle (2015) were observed by me, confirmed by the student teacher participants (who reflected on the learners’ inborn sense of inquisitiveness), and expressed by the child participants themselves. These findings confirm the work of the said scholars, who describe children as natural scientists.

The child participants in this study displayed a complex epistemological understanding of the nature of science (what science is and what science does), reflected an awareness of science as a human and cooperative endeavour, and had insight into their role and agency in using the methods of science in doing science like scientists. They furthermore displayed a developing understanding of the value and place of science in society, and expressed themselves as the kind of citizens who would want to understand the world scientifically, and participate in activities that can lead to the advancement of science in society. In this manner the findings I obtained support studies by Ashbrook (2014), Akerson et al. (2011), Janulaw (2014), Lederman (2014), Kirch et al. (2016) and Zhai et al. (2014), who report on the sophistication of young children's scientific thinking and their ability to grasp the nature of science concepts.

As social actors, participation within a community of scientists reflected a culture of inquiry, which shaped the learners' competencies and images as scientists. In this way the findings of my study confirm the potential of IBSE to empower children when they realise their competence of being scientists in the classroom, but also their potential to become scientists. In support of existing literature (Koch, 2013; Martin, 2012; Harlen, 2013a), this study highlights both the critical influence of context, and the importance of deliberate attempts of teachers to educate learners in the culture of science.

6.3 FINDINGS THAT CONTRADICT EXISTING LITERATURE

In this section I discuss contradictions I identified between the findings of my study and those cited in existing literature. I contemplate possible explanations for the contradictions I foregrounded. As background to my discussion, I provide an overview of the contradictions, and then mention possible explanations for these in Table 6.2.

Table 6.2: Findings that contradict existing literature

Author and Year	**Existing knowledge**	**Contradiction**	**Interpretive discussion: Possible explanations for the contradiction**
THEME 1: STUDENT TEACHERS' EXPERIENCES OF IMPLEMENTING IBSE IN FOUNDATION PHASE CLASSROOMS			
Sub-theme 1.1: Being an IBSE facilitator			
• Chowdhary et al. (2014) • Haug and Ødegaard (2014) • NRC (2000)	Foundation Phase teachers typically hold a poor understanding of inquiry, and are often unable to effectively implement innovative	Student teacher participants demonstrated well-developed understanding of IBSE, and displayed confidence and competence in performing the	Following a structured IBSE programme such as LAMAP, with clearly-articulated guidelines and supporting resources may contribute to background understanding and confidence when implementing the approach. This, as well as opportunities to apply IBSE theory as part of their teacher

	approaches in their classrooms.	necessary roles when implementing IBSE.	training programme (doing inquiry-activities) in Foundation Phase classrooms, coupled with the implementation of a reflective practice approach, may have contributed to student teachers' perceived competence in implementing IBSE.
• Krämer et al. (2015) • Seung et al. (2014)	Teachers often find it challenging to shift the locus of control from being teacher-directed to implementing child-centred education, which may in turn result in less effective science education practices.	Student teacher participants in this study exhibited a clear understanding of their role in facilitating child-centred inquiry. They acknowledged learners' competence in co-constructing knowledge, and preferred this approach to teaching.	Current emphasis on contemporary children being viewed as scientists may have contributed to shaping the student teacher participants' views on learners' competence and role in taking agency of their own learning. Their training that emphasised child-centred education, the principles of learning, and learning facilitation may furthermore have contributed to shaping their professional identities as being open to innovative teaching approaches.
• Gillies and Nichols (2015)	Foundation Phase teachers may lack the necessary competence to create a classroom culture of inquiry.	Student teacher participants were able to create a culture of inquiry in their classrooms, and supported learners to work as communities of scientists.	Student teacher participants displayed a well-developed understanding of the importance of the cooperative nature of learning when implementing IBSE, based on their exposure to LAMAP when being trained and the introduction to cooperative learning principles.
Sub-theme 1.2: Challenges experienced in implementing IBSE			
• Kershner et al. (2014) • Tenaw (2014)	Teachers often experience time constraints as challenge for IBSE implementation.	In one case, the student teacher did not experience time constraints as challenge when implementing IBSE.	In this particular case, the school environment encouraged innovative practices and allowed flexibility in terms of the Foundation Phase curriculum and time table.
• Kershner et al. (2014) • Tenaw (2014)	Classroom management is often regarded as a challenge when teaching science as inquiry.	Although student teacher participants experienced some challenges related to classroom management, they did not regard	Based on their well-developed understanding of IBSE and how the learning environment should be structured to accommodate children's learning, student teacher participants expected higher levels of moving, doing, thinking and talking, and thus

		learners' activity- and noise-levels as challenging.	employed classroom management approaches that allowed more freedom.
Sub-theme 1.3: Potential value of IBSE implementation in Foundation Phase classrooms			
• Cofré et al. (2015) • Dickson and Kadbey (2014) • Forbes (2011) • Qablan and DeBaz (2015) • Riegle-Crumb et al. (2015)	Foundation Phase teachers are generally not favourably inclined towards science and science teaching. Negative attitudes may impact their willingness and capacity to teach science innovatively.	Regardless of the fact that the student teacher participants did not come from a science background, they generally displayed a positive orientation towards science education, as well as a willingness and capacity to implement IBSE.	Student teacher participants identified specific personality traits and qualities such as creativity, innovation, introversion, interest, etc. as attributes that predicted their preference for science facilitation. These qualities may have influenced their orientation towards implementing innovative approaches when teaching science. The teacher training they received may have contributed towards shaping their reform-mindedness.
• Riegle-Crumb et al. (2015) • Smolleck and Nordgren (2014) • Tenaw (2014)	Researchers argue that teachers' low self-efficacy beliefs may result in avoidance or less-effective science teaching.	Student teacher participants in this study articulated strong self-efficacy beliefs, and reported feelings such as excitement, fulfilment, and accomplishment in teaching science while following an inquiry approach.	A sound background understanding of IBSE, experience in applying the approach in practice while being mentored, and following a critical reflective practice approach, may have positively shaped the participants' self-efficacy beliefs.
• Riegle-Crumb et al. (2015) • Trundle (2015)	Foundation Phase teachers may model unfavourable attitudes towards science, which children can then in turn potentially internalise.	The way in which student teacher participants in this study guided learners' thinking through the inquiry phases, may have modelled an inquiry-oriented disposition, which learners could in turn adopt.	Teacher training practices that allow student teachers to experience inquiry as both learners (engaged in) and teachers (reflecting on), may have positively impacted the student teachers' developing professional identities as science teachers, and consequently also on them being role models when fostering inquiry attitudes.

6.3.1 Student teachers' positive experiences that may support IBSE implementation in the Foundation Phase

Contrary to numerous studies such as those by Chowdhary et al. (2014), Haug and Ødegaard (2014), Lewis et al. (2014), Nowicki et al. (2013), Tan and Wong (2012), and Tenaw (2014) reporting on primary school teachers' general lack of understanding and reluctance to implement IBSE, the student teacher participants in this study displayed good insight and associated confidence and competence in executing their roles as IBSE implementers. Contrary to my expectations (based on existing literature), and the potential challenges posed to IBSE teachers as pointed out by Hand et al. (2016), Krämer et al. (2015), Seung et al. (2014) and Ødegaard et al. (2014), the student teacher participants did not report difficulty in planning IBSE lessons. They were also not influenced by a lack of confidence in learners' ability to engage in IBSE when implementing IBSE.

These findings contradict existing literature, as both Krämer et al. (2015) and Seung et al. (2014) indicate that teachers generally experience child-centred teaching as challenging. As opposed to the said studies, the student teacher participants displayed competence in and articulated a preference for child-centred learning facilitation. These contradictions may relate to the participants' teacher training that encouraged student teachers' knowledge of contemporary children-as-scientists, including their competence and agency, and focused on how to build learners' skills by structuring learning environments that may support child-centred and inquiry-oriented education. Moreover, teacher training, which emphasises learning-by-doing (thus implementing IBSE in real classrooms), in combination with a reflective practice approach, may have contributed to the student teacher participants' skills development and confidence in their own abilities as IBSE facilitators. However, as this is a mere hypothesis, the potential impact of teacher training in shaping Foundation Phase teachers' professional identities as science teachers requires further investigation.

While student teacher participants reported many challenges generally associated with IBSE implementation (thus supporting literature), I found some contradictions in this area. For example, while two participants regarded time constraints as significant challenge to implementing IBSE in the Foundation Phase context, one of the participants did not experience time constraints as a challenge at all. This contradiction may be ascribed to the willingness of the specific school to accommodate innovative practices, as well as to the flexibility allowed in the Foundation Phase classroom environment and curriculum. Furthermore, while classroom management, and specifically the higher activity and noise levels of learners engaging in IBSE generally poses a threat to IBSE implementation (Tenaw, 2014), all participants in this study accommodated the energy and noise as part of learners' constructive engagement in IBSE. To explain this contradiction, it could reasonably be argued that, based on the participants' developing understanding of IBSE, as well as of the requirements for child-centred education in contemporary society, student teacher participants expected higher levels of moving, doing, thinking and talking, and thus focused on classroom management approaches that could allow more freedom. However, this possibility requires ongoing investigation.

Closely related, existing literature is awash with studies reporting on primary school teachers' negative attitudes to science, and potentially negative consequences for the science education practices they implement (see, for instance, Cofré et al., 2015; Dickson & Kadbey, 2014; Forbes, 2011; Qablan & DeBaz, 2015; Riegle-Crumb et al., 2015; Trundle, 2015). In contradicting this picture of teachers being constrained (Tenaw, 2014), I found that the student teacher participants in this study (specialising as generalists in Early Childhood Education and the Foundation Phase) displayed a positive orientation towards science, more specifically IBSE, based on their personality traits and certain qualities that predicted a preference for science facilitation. Furthermore, while literature generally reports on the negative consequences of the low priority teachers may attach to science teaching, as well as on learners' achievement potential and motivation for science (Riegle-Crumb et al., 2015; Smolleck & Nordgren, 2014: Tenaw, 2014; Trundle, 2015), student teacher participants in this study articulated strong self-efficacy beliefs, and reported feelings of excitement, fulfilment, and accomplishment when teaching science following an inquiry approach. Furthermore, in guiding children's thinking through the inquiry phases through questioning and reflection, student teachers facilitated IBSE, but also modelled an inquiry-oriented disposition – that may in turn positively affect children's orientation towards science.

Finally, Gillies and Nichols (2015) share the findings of their research, indicating the trend of primary school teachers not to focus on sound scientific knowledge building practices – partially due to teachers' perceived competence to create a classroom environment that will support a culture of inquiry. Contrary to this argument, the three student teacher participants in this study all created IBSE environments that could promote a culture of inquiry, and offered opportunities for learners to engage cooperatively in scientific investigations, where they could reap a variety of educational benefits. This contradiction may perhaps be ascribed to student teachers' personal encounters with and training in IBSE, involving them to work collaboratively as community of inquirers during their teacher training practice. These authentic first-hand experiences may have contributed to their ability to create spaces for learners to work as a community of scientists, and feeling confident about the potential value of this experience. This, however, is a mere hypothesis that requires follow-up research.

Several reasons may thus account for the contradictions I identified. For example, the LAMAP IBSE programme supplies underlying principles, pedagogical considerations and specific pedagogical strategies that would support implementation. As such, sound understanding of IBSE, combined with opportunities to apply theory in Foundation Phase classrooms while following a critical reflective practice approach, may have shaped the beginner teachers' self-efficacy beliefs in terms of being competent as science teachers. Teacher training practice may have contributed to their professional identity, reflecting a reform-mindedness and orientation towards implementing innovative approaches such as IBSE. These hypotheses merit further investigation to determine the extent to which the said factors can explain the identified contradictions.

6.4 SILENCES WHEN COMPARING COLLECTED DATA WITH EXISTING LITERATURE

While the findings stemming from my study generally support the findings captured in existing literature, I identified some silences in the data I obtained. I summarise the silences that became evident in Table 6.3, before discussing these in more detail.

Table 6.3: Silences in the data

Trend	Author and year	Interpretive discussion
THEME 1: STUDENT TEACHERS' EXPERIENCES OF IMPLEMENTING IBSE IN FOUNDATION PHASE CLASSROOMS		
Sub-theme 1.1: Being an IBSE facilitator		
Teachers' facilitation skills will determine the effectiveness of IBSE implementation.	• Louca et al. (2013) • Qablan and DeBaz (2015) • Ødegaard et al. (2014) • Tan and Wong (2012)	Although the effects of student teacher participants' facilitation have been observed and documented in terms of the learners' engagement in the IBSE activities, student teacher participants' facilitation skills were not explored or measured against specific criteria in order to determine the effectiveness thereof. Participants were silent about the quality of their facilitation skills and the effect of this on the quality of learning.
Teachers' science subject-matter knowledge and their understanding of aspects such as nature of science are factors determining the effective implementation of IBSE.	• Capps et al. (2012) • Cofré et al. (2015) • Hanuscin (2013)	Although viewed as important factor, I did not determine student teacher participants' subject knowledge and epistemological beliefs relating to science through baseline assessment, nor did I draw a correlation between participants' knowledge and the effectiveness of their facilitation roles in IBSE. As such, a silence exists in this regard. In this study I focused more specifically on participants' views based on their experiences of implementing IBSE in the context of a classroom.
Sub-theme 1.2: Challenges experienced in implementing IBSE		
A major challenge to science teaching in primary school is teachers' lack of science background, limited subject knowledge and	• Chowdhary et al. (2014) • Haug and Ødegaard (2014) • Lewis et al. (2015) • Nowicki et al. (2013)	Regardless of the fact that student teacher participants in this study did not take a university-level science course, they did not report a lack of science knowledge as challenge to implementing IBSE. However, in all cases, selection of appropriate science outcomes seemed to be problematic. The correlation

consequent misconceptions regarding science concepts.	• Tenaw (2014)	between science background and their ability to select appropriate outcomes was not established.
Sub-theme 1.3: Potential value of IBSE implementation in Foundation Phase classrooms		
Teachers' science knowledge predicts their confidence to teach science innovatively.	• Cofré et al. (2015)	Although student teacher participants' competence in teaching science as inquiry was evident in this study, a relation between their science knowledge and their confidence to implement IBSE was not established.
THEME 2: ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE		
Sub-theme 2.2: Identifying ways to investigate and solve the problem		
Children's intuitive scientific theories reveal their current understanding, e.g. as naïve, incomplete, incorrect, or misleading. Learning will accrue through processes of theory revision.	• Goswami (2015) • Vosniadou and Ioannides (1998) • Gooding and Metz (2011) • Hedges (2014)	Due to the participating learners' lack of experience in IBSE, their initial suggestions involved pictures of their imagination, rather than reflections of their conceptual understanding of the phenomenon under study. I could not detect any science theories relating to the activities they participated in, and consequently could not determine if and how conceptual change occurred, and how knowledge accumulated.
Researchers agree that children have natural scientific skills and cognitive tools to act, think and learn like scientists. For IBSE children's inquiry skills need to be intentionally and gradually developed to ensure quality engagement.	• Harlen (2012) • Worth et al. (2009)	In this study I assumed that learners' inquiry skills were not primarily developed within the school context. I merely accepted that the skills learners used during the IBSE activities had been naturally acquired. However, I did not determine the level of their inquiry skills through baseline assessment, nor did I interview classroom teachers in order to gain insight into the learners' prior experiences. As such, I did not obtain data relating to the natural scientific skills and cognitive tools acquired by learners that they could rely on in doing science.
Sub-theme 2.5: Sharing and documenting experiences		
LAMAP IBSE places a strong emphasis on the development of children's communication skills as strategy for reasoning.	• Delclaux and Saltiel (2013) • Harlen (2012) • Worth et al. (2009)	In this study I noted the variety of general communication skills that learners used and developed through IBSE. However, I did not use a pre-determined checklist to determine the specific skills used in reasoning nor the quality of these skills.

THEME 4: PERCEIVING IBSE AS AN EMPOWERING APPROACH		
Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions		
Investment in early childhood science education may potentially have long-term positive effects.	• Cremin et al. (2015) • Flores (2015) • Howitt et al. (2012) • Kermani and Aldemir (2015) • Saçkes (2014) • Siry et al. (2012) • Tao et al. (2013) • Zogza and Ergazaki (2013)	In this study IBSE was implemented for a short period of time and merely focused on the participants' experiences of IBSE following the activities. The long-term impact of IBSE was neither investigated nor reported on by the participants when collecting data.

6.4.1 Silences on student teachers' background science knowledge, facilitation skills and related experiences of implementing IBSE

Due to the complexity of IBSE, and the subsequent complex roles teachers need to manoeuvre in guiding learners' thinking and knowledge construction through the inquiry phases as explained by Louca et al. (2013); Ødegaard et al. (2014); Tan and Wong (2012); Qablan and DeBaz (2015) the quality of facilitators' skills may influence the quality of learners' engagement, and ultimately, the quality of learning that occurs. Although I assumed that the interaction between facilitators and learners may impact the quality of learning events, I did not specifically measure the quality of the student teachers' facilitation skills against specified criteria, and as such, did not obtain data to this end. This silence in data may thus be ascribed to the specific focus of the study, being participants' experiences of a teaching-learning process, and not the evaluation of quality of actions and interactions in the teaching-learning process. Further research may provide valuable insight into the possible correlation between the quality of facilitation (teaching) and the quality of learners' engagement (learning) in IBSE.

Furthermore, while teachers' deep science content knowledge and epistemological beliefs relating to science can be viewed as critical factors determining their capacity to teach science when following an inquiry approach (Capps et al., 2012; Cofré et al., 2015), this study more specifically focused on gaining insight into student teacher participants' experiences in applying IBSE as teaching approach in Foundation Phase classrooms. I therefore did not attempt to relate participants' content knowledge to their competence to implement IBSE. Although I acknowledge the importance of sound science knowledge, my study did not expose any related findings. Consequently, further investigation may fill this lacuna.

Another silence in the data I obtained relates to findings reporting on teachers' lack of science background, their limited science subject matter knowledge and consequent misconceptions they may carry into the classrooms that can cause challenges for science teaching in primary grades (see, for example the work of Chowdhary et al., 2014; Haug & Ødegaard, 2014; Lewis et al., 2015; Nowicki et al., 2013; Tenaw, 2014). While the student teacher participants in this study did not hold prior qualifications in Natural Science, and did not take university level science as part of their PGCE-qualification, none of them indicated a lack of science knowledge as challenge when implementing IBSE in their classrooms. However, in all cases, the selection of relevant basic science outcomes they facilitated was experienced as challenging. Follow-up investigations focusing on student teachers' views on the impact of their own science background on their ability to teach science to young children may shed more light on this potential effect. More specifically, a relationship between student teachers' science background knowledge and their ability to select IBSE outcomes can contribute to a better understanding in this area.

Finally, while it is generally accepted that teachers' sound science knowledge will predict their confidence to teach science innovatively as proposed by Cofré et al. (2015) the relation between the student teacher participants' science knowledge and the confidence and competence they displayed in implementing an innovative approach when teaching science was not drawn. While being important, this was not addressed in the current study, and therefore requires deeper exploration through further research in order to determine the possible impact.

6.4.2 Silences in terms of learner skills that may promote engagement in the IBSE phases

The work of researchers such as Goswami (2015), Vosniadou and Ioannides (1998), Gooding and Metz (2011) as well as Hedges (2014) emphasises the importance of theory revision and conceptual change during the process of science knowledge acquisition. Due to participating learners' lack of experience in IBSE, I found that their initial predictions often represented pictures of their imagination, rather than reflections of their conceptual understanding of the phenomenon under study. I could not detect any intuitive science theories related to the activities learners participated in, and could consequently not determine if and how conceptual change had occurred, and thus how science knowledge accumulated as a result of active learner involvement. This is a possibility that requires ongoing research.

Another silence in the data I obtained for this study relates to learners' levels of inquiry skills. Participation in IBSE requires deliberate development of inquiry skills, as explained by Harlen (2012) as well as Worth et al. (2009). As IBSE is not an approach that is currently actively promoted in the South African Foundation Phase education context, I assumed that learners' scientific inquiry skills were not developed in school, and therefore accepted that the skills they used during the activities were acquired naturally. As I did not determine the level of their inquiry skills through baseline assessment, nor interviewed classroom teachers to gain insight into the learners' prior experiences, this potential gap in my data needs to be investigated further.

A final silence I became aware of when analysing and interpreting the data relates to the quality of learners' communication and reasoning skills displayed during my study. As proposed by Delclaux and Saltiel (2013), Harlen (2012) and Worth et al. (2009) a main goal of LAMAP IBSE focuses on the development of children's curiosity, creativity, critical thinking and reasoning skills, as well as their language and argumentation in the context of science. However, I noted a variety of more general communication skills used and developed through IBSE, rather than specific reasoning skills. As I did not use a pre-determined checklist to determine precise language skills or the quality of communication learners used in scientific reasoning, participants were silent about this. Seeing that language plays a central role in argument-based approaches to science education, this area requires further in-depth exploration.

6.4.3 Silences on the potential long-term effect of IBSE on Foundation Phase learners' science development

Researchers such as Cremin et al. (2015); Flores, (2015); Howitt et al. (2012); Kermani and Aldemir (2015); Saçkes (2014); Siry et al. (2012); Tao et al. (2013) as well as Zogza and Ergazaki (2013) argue for the introduction of science at early childhood level, based on its long-term positive effects (such as the potential positive effects on establishing solid foundations, academic achievement, promoting scientific literacy and a STEM-related workforce). This study focused on the possibility of IBSE being implemented in the Foundation Phase context, based on the experiences of the participants, immediately following implementation of the approach. However, the impact of any approach needs to be measured over time by means of longitudinal studies, which this study is not. With a growing need for a scientific literate citizenry, and a STEM-related workforce in South Africa, future research that focuses on the long-term effect of IBSE (as investment or intervention effort) on learners' continued interests, later academic achievement and possible pursuits of science-related endeavours may in this manner contribute valuable insight to this area of research.

6.5 NEW INSIGHTS STEMMING FROM THE STUDY

In the final section of this chapter I discuss new insights revealed by the investigation on implementing IBSE in Foundation Phase classrooms. As my study represents both teacher and learner viewpoints, I first present the insights I obtained from student teacher participants' reports (summarised in Table 6.4), and then the new insights I obtained from child participants' reports on their experiences (Table 6.5).

New insights gained from this study are primarily linked to the implementation of a French IBSE programme in the South African Foundation Phase context. Findings on the implementation of a particular programme (LAMAP), following a specific approach to science education (IBSE) that is not specifically prescribed for

Foundation Phase teaching, may consequently add theory unique to the South African context, with potential application possibilities for related contexts. These findings consequently contributed to the development of a framework for implementation of IBSE (LAMAP) in the South African Foundation Phase context, which I present in Chapter 7.

Table 6.4: New insights based on student teacher participants' experiences of IBSE implementation

New insight	Interpretive discussion
THEME 1: STUDENT TEACHERS' EXPERIENCES OF IMPLEMENTING IBSE IN FOUNDATION PHASE CLASSROOMS	
Sub-theme 1.1: Being an IBSE facilitator	
Despite the implied complexity associated with IBSE implementation, the student teacher participants displayed competence in translating the LAMAP IBSE approach for use in Foundation Phase classrooms.	Student teacher participants' roles were informed by a specific programme, LAMAP, and further developed through the training they received, where a reflective practice approach was followed. This finding indicates that the LAMAP IBSE approach can successfully be applied to Foundation Phase practice in the South African context.
Regardless of the fact that Foundation Phase teachers are typically not inclined to teach science innovatively, the student teacher participants in this study felt empowered, competent and confident about their abilities to teach science following the LAMAP IBSE approach.	This finding indicates that the implementation of an IBSE approach (such as LAMAP) that provides the necessary structure, guidelines and resources, may empower Foundation Phase teachers with the necessary confidence to teach science as inquiry.
Sub-theme 1.2: Challenges experienced when implementing IBSE	
Based on their experiences, student teacher participants indicated challenging factors when implementing IBSE in Foundation Phase classrooms. While they successfully overcame some challenges, they experienced ongoing difficulties with factors related to planning, facilitation, CAPS and Foundation Phase classroom practice, regardless of having a well-developed understanding of IBSE.	Challenges experienced when implementing IBSE in the Foundation Phase classroom may be alleviated by preparing students more effectively. This finding indicates that teacher training programmes should focus more attention on preparing students for curriculum adaptation; pacing IBSE activities to ensure sufficient time for all the IBSE phases, providing constructive support during the minds-on phases of IBSE, implementing strategies to manage classrooms (including group work), effectively and using the flexibility of the Foundation Phase curriculum for science integration.

Sub-theme 1.3: Potential value of IBSE implementation in the Foundation Phase	
The teacher training of the participants had positive effects on shaping their professional teacher identity and identity-agency, and allowed them to acquire competencies for implementing innovative inquiry-based and child-centred teaching approaches.	It is possible to shape Foundation Phase beginner teachers' identities positively, specifically towards IBSE, by means of training and specialised support. While the LAMAP IBSE programme is usually utilised as an in-service teacher professional development programme, findings of this study indicate that the programme can also be implemented in higher education contexts to train pre-service student teachers to implement IBSE. This finding furthermore points to the importance of sustaining student teachers' acquired skills by means of professional development courses.
The recommendations that the student teacher participants made were primarily based on personal and practical experiences, and specifically relate to Foundation Phase practice.	Recommendations on IBSE implementation can inform guidelines and a framework for IBSE within the South African context, more specifically for teacher training, policy, Foundation Phase classroom practice, and the broader education community.

6.5.1 Factors influencing student teacher participants' implementation of IBSE

The lived experiences of the student teachers who participated in this study can predict the potential of implementing IBSE in Foundation Phase classrooms. In the three cases, student teacher participants' experiences provided meaningful insights into what worked, what can potentially work, and what needs to be worked on in terms of IBSE implementation in the South African context, with potential application value for similar contexts. This new insight informed the framework for implementation that I present in Chapter 7.

Researchers generally agree that IBSE is a complex approach to translate into classroom practice (Harlen, 2013b; Smolleck & Nordgren, 2014; Haug & Ødegaard, 2014; Tenaw, 2014), yet the student teacher participants displayed competence to translate the LAMAP IBSE approach into Foundation Phase classroom practice. They revealed clear awareness of their roles as IBSE implementers, but also of certain personal characteristics and efficacy-based beliefs that are favourable to IBSE implementation, for example, the ability to plan for IBSE, promote child-centred learning, guide learners' investigations, build learners' ideas, and support knowledge construction. Student teachers furthermore displayed confidence in and a distinct preference for teaching science innovatively to Foundation Phase scientists. As the participants' roles were informed by the LAMAP programme, this finding highlights the application value of the LAMAP IBSE approach for Foundation Phase practice.

Regardless of the bleak picture often maintained of science education in South Africa, and studies highlighting the limitations of Foundation Phase teachers in terms of innovative teaching (Patrick & Mantzicopoulus, 2015; Slavin et al., 2014; Smolleck & Nordgren, 2014; Trundle, 2015), the student teacher participants in this study felt empowered, competent and confident about their abilities to teach science following the LAMAP approach, and emphasised the possibility of effectively applying IBSE theory to Foundation Phase classroom practice. This finding furthermore highlights the value of implementing the LAMAP IBSE approach, where the necessary structure, implementation guidelines and resources empowered Foundation Phase student teachers to teach science as inquiry confidently. Important to note in this regard is the fact that all three student teachers specifically indicated the value of the hands-on activities they themselves experienced while being prepared to implement IBSE in the classroom. As such, this finding provides insight into the importance of including hands-on activities when training future teachers in applying LAMAP IBSE.

To this end, the findings I obtained emphasise the potential of teacher training programmes in preparing student teachers for the complexities often associated with IBSE. While the student teacher participants displayed qualities and competencies favourable to IBSE implementation, the challenges they continually experienced also provide insight into context-specific factors that may inhibit IBSE implementation and need to be addressed during training programmes. These challenges relate to planning procedures, facilitation, CAPS, and Foundation Phase classroom practice in South Africa. Although one can expect that some of these challenges will be overcome as experience grows, the findings of this study highlight specific areas to focus on in order to prepare Foundation Phase student teachers more effectively for the implementation of IBSE in the South African context. As such, this finding has implications for teacher training, policy, Foundation Phase practice, and the broader education community.

In this study student teacher participants revealed strong emerging identities as IBSE teachers, displaying qualities, orientations, competencies and professionalism that are favourable in implementing innovative and child-centred teaching approaches. They furthermore took responsibility for their own learning by critically reflecting on and suggesting ways to improve their practice. The reform-minded, inquiry-oriented professional identities that the student teacher participants displayed may be ascribed to the opportunities they had as teachers-in-training to engage regularly in teaching and reflective practice. To this end, their competence to reflect on and refine their own science teaching practice continually, critically and accurately may thus have contributed to their professional development as science teachers. As such, student teachers' self-confidence and self-efficacy beliefs can be shaped by the teacher training and teaching practice experience they receive, as well as the reflective practice approach they follow during teacher education. Follow-up research may provide a clearer understanding of these possibilities.

Even though the LAMAP IBSE programme is usually utilised as an in-service teacher professional development programme, the findings of this study indicate that the programme can also be successfully implemented in higher education contexts to train pre-service student teachers to implement IBSE. However, while the LAMAP programme generated positive effects in preparing student teachers, the LAMAP foundation's recommendation for implementing support initiatives to sustain teachers' acquired competencies (Delclaux et al. 2012), highlights the importance of ongoing professional development while in practice. The broad-level suggestions that the student teacher participants proposed for IBSE implementation were based on their experiences of some practical realities associated with implementing IBSE in Foundation Phase classrooms. As such, their suggestions to create awareness and encourage positive attitudes towards science education, allow for specialised training, and create a network of support, contributing insight unique to the practical implementation of IBSE in Foundation Phase classrooms in the South African context against the international recommendation to attend to follow-up training of individuals who implement this approach.

Table 6.5: New insights based on child participants' experiences of IBSE

New insight	Interpretive discussion
THEME 2: ACTIVE ENGAGEMENT IN THE VARIOUS PHASES OF IBSE	
Sub-theme 2.1: **Understanding the problem and taking ownership of the learning process**	
Child participants could understand the stated problems and were driven to become cognitively invested in the learning process in order to solve the problems they encountered.	Learners displayed the necessary curiosity that can often be observed in children-as-scientists, and consequently approached the problems and learning process with a natural inclination to learn. This finding confirms Foundation Phase learners' potential to participate actively in the engage phase.
Sub-theme 2.2: **Identifying ways to investigate and solve the problem**	
Child participants' predictions were often not problem-focused and therefore less useful when solving problems. However, although their prior theories were sometimes impractical, learners' insight into the origins and impracticality of theories, together with their cognitive flexibility enabled them to modify existing theories, thereby revealing meta-cognitive abilities as well as a reflective disposition.	Children's voices revealed the necessary sophistication in terms of their insight into, and ability to adapt their thinking creatively. This finding confirms Foundation Phase learners' potential to engage in the investigation phase. As it is essential for constructivist teachers to gain insight into learners' intuitive science theories, this finding also points to the importance of teachers' awareness of learners' competence, but also of their role in supporting learners to formulate clear problem-focused predictions. The finding furthermore highlights the responsibility of the teacher to guide learners purposefully from initial theories through theory revision towards science concept acquisition, thereby guiding teachers to support learners more effectively during the investigation phase.
Important discoveries occurred after lengthy periods of cooperative interaction and deep immersion into investigations. Child participants, however, spent less time on reflecting on their thinking.	This finding point to the important role of teachers to build learners' science inquiry skills gradually for them to become more fluent, but also to utilise the integration and flexibility built into the Foundation Phase curriculum, to allow for lengthy investigations. It highlights the role of teachers to pace activities and award equal prominence to all phases.
Sub-theme 2.4: **Gaining new insight and drawing conclusions**	
While child participants drew contextualised conclusions, these were generally non-science related, and disconnected from the science outcomes planned for the relevant activities.	This finding confirms Foundation Phase learners' potential to engage in the drawing conclusions phase and to self-construct knowledge based on their hands-on experiences. It points to the important role of teachers to plan suitable outcomes, but also to support learners to engage

	in drawing legitimate science conclusions. In this way, guidance is provided on the role of constructivist teachers in supporting learners to review and reflect on their findings in order to draw evidence-based conclusions.
Sub-theme 2.5: **Sharing and documenting experiences**	
Since the learners' conclusions were mostly self-constructed, they communicated their own conclusions and not necessarily science knowledge inherent to the activity.	This finding confirms Foundation Phase learners' potential to engage in the communication phase. It points to the need for constructivist teachers to guide Foundation Phase learners towards reaching and communicating conclusions in terms of science facts, using appropriate scientific language.
Child participants were generally able to record their thinking in writing competently. They furthermore articulated the value they attached to recording their scientific thinking in science journals. As active agents and citizens of a community of scientists, they revealed competence in using cultural tools of science to expand their scientific literacy. However, variation was evident in the quality and completeness of the science journals.	This finding confirms Foundation Phase learners' potential to record their thinking scientifically. Learners' competence to function as members of a community of scientists, and to take agency in using the tools of the culture of science should be acknowledged and supported. The finding also points to the need to provide learners with sufficient opportunities for recording their ideas in order to expand their competencies.
THEME 3: EXPERIENCES OF SOCIAL LEARNING	
Sub-theme 3.1: Perceived value of social learning	
IBSE relies on learners' ability to engage cooperatively as scientists in their classrooms. In this study child participants benefitted from cooperatively engaging in IBSE, and displayed agency, social efficacy and a developing internalised sense of expectations of appropriate behaviour in formal learning contexts. Their personal experiences of engagement in authentic scientific contexts (learning through doing) shaped their awareness of and skill in human interaction in a scientific context.	This finding confirms Foundation Phase learners' potential to engage in IBSE as members of a scientific community and to benefit from social learning experiences. The finding also highlights the importance of classroom experiences that focus on learners as competent scientists, where they get opportunities to engage practically in science as human and social activity.
Sub-theme 3.2 Dealing with associated challenges	
The way in which child participants handled the conflict and challenging personal relations while participating in IBSE points to their agency in and ability to traverse human interaction in science learning contexts. The challenges they experienced may be ascribed to a lack of experience with social learning in the classroom.	While learners displayed the potential to work cooperatively with others in IBSE, this finding indicates that Foundation Phase learners may benefit from structured guidance, and ongoing opportunities, in order for them to take agency and autonomy in practising and in developing social competence while working scientifically.

THEME 4: PERCEIVING IBSE AS AN EMPOWERING APPROACH	
Sub-theme 4.1: Value of owning the learning process	
The child participants took agency for their science learning and knowledge-construction processes, and displayed confidence in their ability to learn science by doing science.	This finding confirms Foundation Phase learners' potential to take the centre stage in IBSE and take agency in their learning and knowledge construction through action. The finding suggests that Foundation Phase learners can engage in IBSE, and may benefit from such participation.
Sub-theme 4.2: Acquiring science-related knowledge, skills and dispositions	
The empowering potential of IBSE in terms of developing learners' science knowledge, skills and dispositions was evident, as were their motivational attitudes and self-efficacy beliefs.	The educational benefits expressed by learners as a result of engaging in IBSE point to the possible long-term positive effects of implementing the LAMAP approach in the Foundation Phase context.
Child participants experienced empowerment by taking agency.	As scientists-in-waiting, context seems critical in mobilising learners' potential into action. The environment should allow opportunities for learners to develop a sense of agency as scientists in authentic contexts. This finding emphasises the teacher's role as facilitator of child-centred active learning, but also in implementing science programmes that support learners' scientific competencies through autonomous involvement.
Sub-theme 4.3: Becoming aware of the broader application of science	
Child participants in this study displayed awareness of the correlation between their experiences in the classrooms and science in real life.	Participating in IBSE helped learners to realise that they possess the capacity to engage in science like real scientists. This finding confirms the potential of IBSE to contribute to learners' sense of being scientists in their classrooms.
Sub-theme 4.4: Being and becoming scientists	
Child participants expressed the potential for both being scientists and becoming scientifically literate. The authenticity of IBSE and actions of others within the culture of inquiry contributed to shaping their identity and sense of agency as scientists.	This finding points to context as critical factor impacting children's empowerment, their sense of agency and their identities. Human beings become members of a culture on the basis of their experiences (i.e. becoming as a result of doing). To mobilise the inherent potential of scientists-in-waiting asks for education that focuses on the promotion of children's identity and agency.

6.5.2 Child-scientists' active engagement in the various IBSE phases

Sufficient evidence exists that acknowledges the potential of children as scientists (see, for example, Bell & St.Clair, 2015; Eshach, 2011; Gopnik, 2012; Trundle, 2015), as is also confirmed by this study. My study confirms the potential of Foundation Phase learners to engage in the various IBSE phases as set out by the LAMAP framework. In agreement with Malaguzzi's (1993) image of the so-called "rich child" (i.e. rich in potential, strong, powerful, and competent), I regard richness within learners as starting point for educational practice. In this section I discuss some opportunities that can enhance learners' scientific potential through appropriate intervention in their science education, based on the findings I obtained. The lacunae found in the learners' skills, however, point to areas in need of expansion in terms of student teacher skills, which may have implications for teacher training.

6.5.2.1 Learners' potential and skills to engage in the various phases of IBSE

The child participants in this study displayed the potential to engage in the inquiry process, driven by their natural inclination to solve scientifically oriented problems. Elaborating on the notion of children possessing intuitive science theories, this study reveals learners' confidence in having ideas, but also points to their metacognitive awareness of the origin of such ideas. Additionally, learners' flexibility in thinking, as well as their adaptability and reflexivity was evident in the way in which the child participants modified their initial less-powerful imaginary plans, once they realised the impracticality of their suggestions to solve problems. Despite the complexity of the investigation phase, child participants displayed the necessary qualities and competencies to act, think and learn like scientists. Consequently, the findings of this study confirm the potential of Foundation Phase learners to engage in the investigation phase.

In addition to observing the learners' potential to investigate naturally, important discoveries and associated expressions of excitement occurred after lengthy periods of immersion in the investigation phase, where the powerful influence of shared information on knowledge-construction could be observed. As proposed in IBSE, learners' active physical and mental engagement resulted in them being able to draw evidence-based conclusions. As language plays a central role in science, both oral and written modes of communication are crucial elements in science knowledge construction. In this regard, the study reveals that child participants can confidently and expertly share their experiences with an audience and record their scientific thinking processes, even though not necessarily in detail and scientific terms. The study furthermore highlights learners' understanding and appreciation of the value of recording, and the importance they attached to autonomy in documenting their thinking in science journals. The potential displayed by the learners who participated in the study can be regarded as an asset for investment through LAMAP IBSE.

6.5.2.2 Teachers' role in supporting learners' engagement in the various phases of IBSE

In terms of the challenges that he child participants experienced during each of the inquiry phases, my study reveals certain areas in need of expansion, and consequently some areas where learners may benefit from more structured guidance. For example, the imaginative and impractical predictions that the learners made during the think-on-your-own stage were often not problem-focused, and were thus less useful in solving inquiry problems. In terms of reaching conclusions, learners' initial non-problem-focused ideas, impacted on the non-scientific conclusions they communicated. While their conclusions were contextually based, these were generally disconnected from the science outcomes underlying the activities. As such, the essential learning goal of IBSE of learners acquiring a small number of core concepts through active engagement, seemed problematic, and negatively influenced their engagement in the drawing conclusions and communication phase.

While the findings of this study indicate that the learners can communicate their experiences to an audience, participants mostly shared self-constructed knowledge instead of consolidated consensus-version knowledge expressed in scientific terms. Judging by the variation in quality and degree of completeness of the science journals, learners' scientific vocabulary development and recording of their thinking processes in scientific terms seemingly require attention. In this regard, my study suggests that learners, while still inexperienced, may benefit from more time and opportunities to make science notes, but also from an enrichment of vocabulary, and structured guidance to expand their skills in recording their thoughts more scientifically.

Another important insight stemming from this study relates to the lengthiness of engagement in the investigation phase. Although not measured precisely, the child participants' engagement throughout the IBSE phases gave an indication of the time they spent on each of the inquiry phases. Even though the findings of this study confirm existing literature in that learners engaged in the investigation (hands-on) phase much longer than in any of the other phases, they also indicate that the learners engaged for shorter periods of time in the phases involving the drawing of conclusions, communication and reflection (minds-on). Despite the fact that this finding may be ascribed to time available during lessons, it points to some areas for consideration in Foundation Phase classes when implementing IBSE. More specifically, an understanding of science concepts may be strengthened through discussion, debates, reasoning, reflections, the linking of findings to scientific facts, and engagement throughout the entire cycle of inquiry. Even though I assume that the limited time spent on the minds-on phases could be ascribed to inexperience on the part of both the child and the student teacher participants, or, more likely, to the time available for the activities, it would be advisable, as generally suggested by other studies, to spread IBSE activities over a few days to award equal status to each of the inquiry phases.

The lacunae I found in terms of the learners' inquiry skills, underscore the important role of the teacher as planner and facilitator when wanting to follow the IBSE approach. In this regard, constructivist teachers need to support learners' knowledge construction by strategically guiding their thinking throughout the IBSE cycle. While the student teachers displayed natural competence in facilitating learning, I found that their guidance more specifically focused on encouraging the learners to think for themselves (in general), rather than supporting them to reflect on their thinking in terms of science concept acquisition. The findings of this study more particularly point to the importance of following a focused guidance approach with inexperienced learners, thereby guiding learners' thinking through the cycle of IBSE by way of thoughtful instruction. In particular, these findings highlight areas in which training programmes can expand on student teacher skills acquisition, in order for them to be able to guide learners to knowledge construction.

6.5.3 Benefits of social learning for Foundation Phase learners

In Fisher's (2013) opinion, the idea of learners talking with one another in an education context is a relatively new phenomenon. Within the South African Foundation Phase context, this may be an underdeveloped practice, despite the general belief that learning (and learning science in particular) is a cooperative and communicative activity in which the learner can co-construct knowledge and make meaning in social contexts (Dahlberg et al., 2013). The successful implementation of LAMAP IBSE, however, relies on learning environments that make provision for learners to work cooperatively like scientists in the context of their classrooms. According to Dahlberg et al. (2013), children – as members of a culture – become cultured on the basis of what they see and do in a particular social context. As such, learners' ability to participate in science as human and cooperative activity will therefore predict the potential of implementing LAMAP IBSE in Foundation Phase classrooms.

The image of children as beings rather than becomings, implies that Foundation Phase education needs to focus on developing learners' current potential as scientists rather than preparing them for becoming future scientists (Dockett et al, 2011; Kellet, 2011; Lansdown, 2005; Percy-Smith & Burns, 2013; Hammersley, 2015). As a consequence, science learning experiences need to allow for learners to become engaged as scientists and function within democratic spaces so that they can practise the skills required in 21st century society living. As noted by Percy-Smith and Burns (2013), with children being situated in a context and understanding their own position in relation to the context, children will most likely become aware of their own possibilities for action. In this study, learners' situatedness in the IBSE context, while working cooperatively to solve IBSE problems, thus offered them an opportunity to establish their places within this community, to make sense of and practise human interaction, and become aware of their possibilities to act as scientists. In this manner, participation in a community of scientists may have awarded the learners with the opportunity to authentically experience, but also to develop and expand their competencies as young scientifically literate citizens. As the findings of this study specifically relate to South African Foundation Phase learners' experiences of being part of a scientific community, the contribution provides context-specific insight.

In my view, the findings of this study confirm learners' agency and social efficacy, as well as their developing understanding of socially acceptable roles and responsibilities in formal learning contexts. This study has revealed the competence of Foundation Phase learners to traverse social interactions in the IBSE context, regardless of their limited experiences of inquiry-based and cooperative learning in the classrooms. The findings suggest that Foundation Phase learners will not only prefer to work in a non-threatening environment, but also possess the ability to devise strategies to resolve conflict in a non-violent way efficiently. In the same way that learners learn science by doing science, they acquired social interaction skills by practising these during such interactions. As such, findings of this study foreground the potential influence of authentic experiences in developing social competence in order to work cooperatively with others in science.

While the learners in this study displayed increased social competence, they undoubtedly also experienced some challenges generally associated with social learning in formal contexts. While the findings of this study correspond to existing literature in this field, I further found that these challenges can possibly be ascribed to a lack of experience and opportunities to practise social learning in the classroom. As social competence will influence the quality of learners' interaction in IBSE activities, the findings of my study point to the need for teachers to provide structured guidance to inexperienced learners, and for ongoing cooperative learning opportunities that can nurture social learning skills so that learners eventually develop a more mature and internalised motivation for collaboration in the school context. These findings furthermore highlight teachers' responsibility to acknowledge learners as competent scientists and to expand their competence in working scientifically through classroom experiences that focus on enhancing social learning skills. This furthermore points to considerations such as creating classroom spaces where learners take agency to practise social learning, and autonomy to resolve challenging encounters in a group context through their own efforts.

I thus found that participation in a community of scientists awarded the child participants with the opportunity to practise human interaction, and to learn about being human, being scientists, being citizens, as well as about democratic values. In this regard the current study emphasises the importance of learners taking a more active and central stance in learning science within a community of scientists in order to develop not only their scientific skills, but also to become empowered as citizens, acquiring the skills they require for 21st century living.

6.5.4 Empowerment of child participants as a result of IBSE participation

While existing literature highlights the educational benefits of IBSE participation for learners (Scott, 2014; Siry et al., 2012; Tao et al., 2013; Zogza & Ergazaki, 2013), studies reporting on the benefits of IBSE in the South African Foundation Phase context are limited. In South Africa, the need furthermore exists to build on learners' inherent potential, but also to educate young learners towards scientific literacy (or pursuing scientific careers). The findings I obtained highlight the benefits that Foundation Phase learners may experience, based on their participation in IBSE activities. These findings add insight to the existing body of knowledge on the potential of IBSE, more specifically for educating young South African scientists.

In this study student teacher participants facilitated IBSE with learners in Foundation Phase classrooms and engaged them in authentic investigations to solve scientifically oriented problems, with the intention of building their scientific competence. As such, a context was created for Foundation Phase learners to learn science by doing science in order to develop scientific literacy and science-related competencies required for modern times. The findings of the study reveal that the learners indeed gained confidence in their ability to engage independently in the learning process; that they acquired science-related knowledge, skills and dispositions, and that they developed motivational attitudes as well as self-efficacy beliefs in terms of working scientifically. Learners could furthermore make a connection between their classroom experiences and the work of scientists, in this way also developing a sense of being scientists working scientifically in an authentic context.

Findings of this study therefore indicate a distinct link between learners gaining confidence, being involved in the learning process, obtaining science-related knowledge, and being motivated to learn while enjoying the experience. In addition, the link between learners' classroom experiences and the real work of scientists became clear. These findings add new insight to the importance of teachers creating intellectually complex situations (as required by IBSE) that may solicit cognitive and emotional functions that can in turn contribute to learners' understanding and memorisation of new knowledge. These findings support the work of Willis (2007), who conducts research in the field of neuroscience, and indicates that learners who are motivated and engaged will experience affective ease and be able to better perform in cognitive tasks. The work of Willis (2007) furthermore indicates that input via the senses, when sensorial activities are implemented through e.g. investigations, will activate somatosensory cortex areas and connect with related memorisation areas, which will in turn support information transmission and storage. As such, IBSE has high implementation value in terms of the understanding, retention and application of new knowledge.

The findings of this study therefore suggest that student teachers implemented IBSE in such a way that learners could develop a continued interest in science education. As such, the empowering potential and educational benefits often associated with IBSE may be applicable to the South African context when teaching Foundation Phase learners. Consequently, this study suggests that IBSE implementation can potentially generate short-term benefits for South African learners (i.e. investing in young scientists' current potential), yet also long-term benefits (investing in their futures as scientifically literate citizens and scientists).

Adair (2014), Scott (2014) and Schweisfurth (2015) emphasise the critical influence of context in shaping human lives. In this study the advancement of children's motivation for science, but also their acquisition of knowledge, skills and dispositions were based on their authentic experiences of participating in IBSE, thereby confirming the work of the said scholars. Learners experienced empowerment by taking agency. As such, learners seemingly developed a critical consciousness and a sense of competence when they applied their ideas and put action into practice while participating in the IBSE activities, instead of being passive recipients of education, as foregrounded by Percy-Smith and Burns (2013). Moreover, engagement in authentic science experiences (positioning learners as active agents that do, think and learn like scientists) seemingly contributed to the learners' emerging identity as scientists. Learners' actions within the IBSE context thus contributed towards shaping their developing identity and sense of agency as scientists.

As agency is a dynamic process, constructed in interaction within specific contexts (Kumpulainen et al., 2014), the findings of this study suggest that, in order to sustain the empowering potential of IBSE, learners may require opportunities continually to construct, contest, negotiate and re-negotiate their developing sense of agency as scientists through interaction and dialogue within a classroom that mirrors authentic science practice. Thus, to cultivate the potential benefits of IBSE in learners, they need to be exposed to a science programme that considers how best to engage them in scientific investigations so that their science development can grow.

The findings of the study also elaborate on teachers' role in making deliberate connections between learners' scientific actions, behaviour and interaction with science as a subject by creating a consciousness of being and doing like scientists. Student teacher participants emphasised the role they fulfilled in linking science concepts across the Foundation Phase subjects, and making the learners scientifically aware. This highlights the important role of the teacher constantly to reinforce acquired concepts, but also to transfer learning (for example the competencies acquired in science) to other contexts in order to enhance the meaningfulness of the learning experience. In this way learners can become empowered to apply the knowledge acquired in one subject to other subjects, as well as to real life.

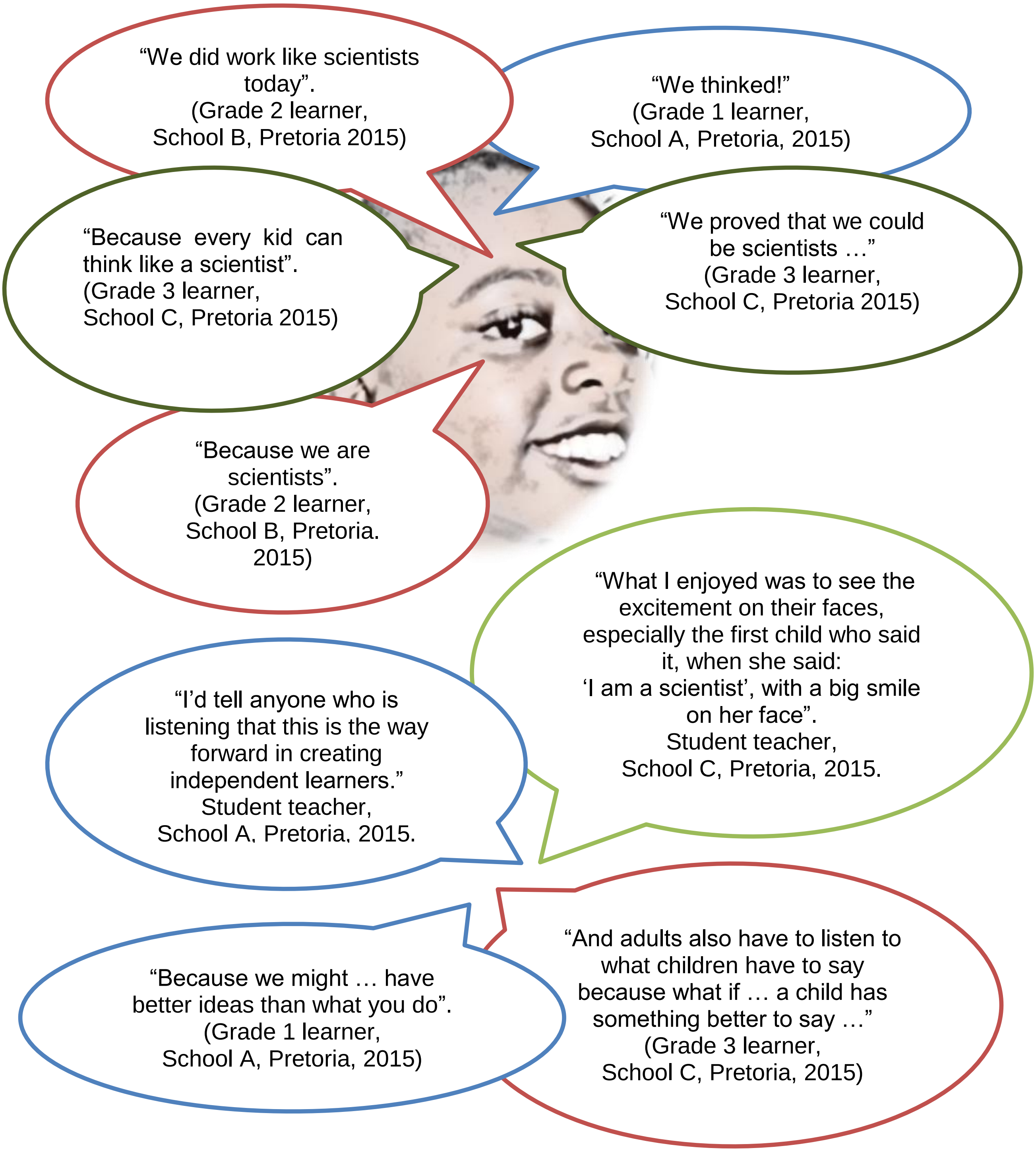
6.6 SUMMARY

In this chapter, I related the results I obtained to existing literature. I highlighted areas where the findings support existing literature, and indicated areas that contradict the literature I consulted. I also elicited the silences I identified when presenting my results in Chapters 4 and 5, and interpreted these against the literature I reviewed in Chapter 2. I concluded the chapter by discussing new insights stemming from the findings of this study.

In the final chapter of this thesis, I present an overview on the preceding chapters and draw conclusions by reflecting on the research questions that guided the study. I relate the conclusions I came to by referring to the contributions of the study, in terms of a framework with implementation guidelines, and also reflect on the limitations I identified and the challenges I experienced. I conclude my study by formulating recommendations for training, further research and science education practice.

Chapter 7

CONCLUSIONS, RECOMMENDATIONS AND IMPLEMENTATION FRAMEWORK



7.1 INTRODUCTION

In the previous chapter I presented the findings of my study against the background of existing literature relating to IBSE in early childhood education contexts. I highlighted areas where my findings correlate with and contradict existing literature, and indicated silences in the data. I also foregrounded the new insights I identified.

In this chapter I provide an overview of what was presented in Chapters 1 to 6. I draw conclusions in terms of the research questions formulated in Chapter 1, and reflect on the study in terms of contributions, strengths and some challenges I experienced. I present the framework for IBSE implementation I developed as an outcome of this study and conclude with recommendations for policy, teacher training, and further research in terms of Foundation Phase science education practice.

7.2 OVERVIEW OF PRECEDING CHAPTERS

Chapter 1 served as orientation and background to the thesis. I clarified the phenomenon I decided to focus on and introduced the purpose of the study, namely to explore, describe and explain the implementability of IBSE for Foundation Phase learners in the South African context. For this purpose the focus fell on the voices of both children-as-scientists engaged in scientific inquiry, as well as student teachers who facilitated science teaching following the LAMAP approach. I formulated research questions, contextualised the key concepts underlying the study, and stated the assumptions of my research. I introduced my conceptual framework, for which purpose I integrated child-centred and constructivist concepts with LAMAP IBSE. I briefly stated my paradigmatic choices, introduced the methodological strategies I followed, and referred to the ethical principles and quality criteria I considered in order to ensure rigour. I also presented the roles I assumed as researcher in undertaking this study.

In **Chapter 2** I reviewed existing literature relevant to the field of early childhood science education, more specifically contemplating inquiry-based education as preferred pedagogical approach to facilitating science with young learners. I discussed selected theoretical frameworks that can provide structure to science education at the Foundation Phase level, foregrounding contemporary perspectives on childhood, the theory theory and constructivism. As transformation within the childhood landscape affects the total ecology of early childhood pedagogy, I justified my decision to draw on current views of children and childhood to help me understand children-as-scientists in a contemporary context. In support of my view on children's science learning, I furthermore foregrounded constructivist perspectives on teaching, and the role of teachers in facilitating and supporting inquiry-based learning.

In **Chapter 3** I explained the empirical part of my study. I described and justified my choice of utilising an interpretative, qualitative multiple-case study research design in the early childhood research context. I discussed the way in which I combined convenience and purposive sampling to select three schools in Pretoria as cases, as well as 70 Grade 1 to 3 learners and three student teachers as participants. Next I explained how I collected and documented data by means of observation, focus group discussions and document analysis; I described the inductive thematic analysis process I completed, and the way in which I interpreted the results. Next I summarised the methodological considerations for the research, including the quality criteria and ethical principles I strived to adhere to.

In **Chapters 4** and **5** I presented and reported on the results of the study, focusing on the experiences of the student teacher participants who implemented IBSE in Foundation Phase classrooms for the purpose of this study in Chapter 4. This is followed by the results pertaining to the experiences of the child participants, which I presented in Chapter 5. The main themes I identified are (i) student teachers' experiences of implementing IBSE in Foundation Phase classrooms (Chapter 4); (ii) learners' active engagement in the various phases of IBSE (Chapter 5); (iii) learners' experiences of social learning (Chapter 5); and (iv) learners perceiving IBSE as an empowering approach (Chapter 5).

In **Chapter 6** I presented the findings of the study. To this end I discussed the correlations and contradictions between the results I obtained and existing literature as presented in Chapter 2. I related the results I obtained to the theories and conceptual framework underlying the study in order to reach conclusions and address the research purpose. In addition to highlighting the areas where my findings correspond and contradict existing literature, I identified the silences in my data, and foregrounded new insights stemming from the study.

7.3 CONCLUSIONS IN TERMS OF RESEARCH QUESTIONS

In this chapter I draw conclusions by addressing the secondary research questions. Based on these discussions, I reach final conclusions in Section 7.4 where I revisit the primary research question and present the framework for IBSE implementation that I developed.

7.3.1 Secondary research question 1: How do Foundation Phase learners engage in IBSE?

In the quest for gaining insight into South African learners' ability to engage in IBSE, I found that Foundation Phase learners possess the competency to act, think and learn like scientists, and as such, hold the potential to engage in and benefit from IBSE. The episodes reported on in this study provide rich evidence of learners' natural disposition towards exploration, which was evident in their curiosity sparked by the problems that were stated, but also in the way in which they were driven to take ownership of the investigation process. I therefore posit that Foundation Phase learners have the desire to explore, understand and master new things and will thus be driven to engage cognitively throughout the inquiry processes they participate in.

I furthermore found that learners used cognitive strategies similar to those of real scientists to use inquiry skills intuitively for theory formation and revision in order to continually and innovatively modify and restructure their working theories based on the evidence they found first-hand. To add to their success as scientists, the learners displayed dispositions that typically characterise the behaviour of scientists; for example, creativity, playful experimentation, courage, confidence and perseverance. As such, the Foundation Phase learners in this study displayed the necessary emotions and dispositions involved in science as human endeavour (as also articulated by TT theorists) throughout the IBSE investigation process.

As proposed by TT theorists, I too experienced that the learners were individually, but also socially and relationally active in their engagement in the inquiry, and consequently in their science learning. Their ability to engage actively with team members when co-constructing knowledge confirms Foundation Phase learners' potential to work as citizens in a community of scientists, and to engage in science as cultural practice. In line with modern trends, the learners engaged as agentic beings and actors to influence and be influenced by their peers, student teachers and the IBSE context. To this end I argue that the social learning environment created by IBSE support and promote learners' engagement, and so, their learning and development in science. As such, this study confirms the views of TT theorists and sociocultural-constructivists on the importance of engaging in community-oriented learning environments so as to advance knowledge construction.

Learners in this study approached the problems they encountered in the same way as professional scientists, and in such a way that they could also learn from making mistakes. Moreover, the challenges that the learners experienced indicate a need for structured guidance in order to engage efficiently during each of the inquiry phases of the IBSE process. This specifically applies to learners' engagement in the minds-on phases. Although I found evidence of Foundation Phase learners' possession of scientific habits and metacognitive skills as they engaged in the hand-on phases of IBSE, learners required support to reflect on their predictions and conclusions. This may be due to inexperience in terms of IBSE engagement, or to the IBSE activities being presented in one session rather than across a few sessions.

Based on the findings of this study I can conclude that Foundation Phase learners' engagement in IBSE reflects the essential features and associated actions of scientific inquiry. In support of TT principles, I thus found that learners engaged in IBSE as natural scientists that were cognitively capable of engaging in scientific investigations to construct knowledge through mental and physical action. In line with the assumptions of contemporary childhood theories, this study foregrounds Foundation Phase learners as able to take centre stage in an IBSE learning situation, thereby taking responsibility for their own science learning. To this end I argue that learners' engagement in the IBSE activities reflects TT theorists' conceptualisation of children as exploring little scientists who are equipped with sophisticated cognitive skills that can enable them to think and work scientifically in order to accumulate science knowledge.

7.3.2 Secondary research question 2: What are the reflections of Foundation Phase learners on their experiences of IBSE?

As previously mentioned, IBSE offers learners the opportunity to experience authentic science in the classroom, allowing them to do science like scientists. To this end my study indicates that Foundation Phase learners will generally experience IBSE as a fun-filled way of learning, which the participants in this study wished to experience more often. Learners' expressions furthermore indicate that such an active learning process is experienced as rewarding, satisfying and exhilarating. In this regard I propose that the physical and mental challenges presented by IBSE potentially contributed to their being intrinsically motivated, which in turn positively impacted on their engagement in the activities. This reaction manifested in energy and passion among the learners when they approached the activities, and as determination and persistence to solve the problems put to them.

In this study learners furthermore experienced empowerment as a result of their participation in IBSE. Their reflections point to their acquiring confidence while taking ownership of the learning process. Other results include the development of a motivational attitude and gaining science-related knowledge, skills and dispositions due to active participation in IBSE, and related feelings of empowerment. The empowerment learners experienced can be linked to their autonomous involvement and confidence gained in the ability to fulfil an active role in the learning process. As such, this study confirms the value of IBSE participation in terms of learners experiencing empowerment through agency.

Learners' experiences of their engagement in IBSE can also be related to their becoming aware of the connection between their being, doing and thinking like scientists in the classroom on the one hand, and the work that scientists do on the other. In this regard IBSE can enable Foundation Phase learners to relate their experiences to the practicalities involved in real world science, which will contribute to their understanding of what science is, what scientists do, and how science is carried out in "real" life. The importance that learners attach to learning by making mistakes points to the ability to monitor one's own learning, reflect on thinking and revise plans accordingly. In this way Foundation Phase learners possess clear potential for self-regulation and reflection as required by active learning, as highlighted by the findings of this study.

The child participants in this study furthermore showed an appreciation for being involved in social learning, and the ability to engage in science as cooperative and communicative activity, as citizens in democratic spaces created by IBSE. To this end the child participants' reflections on being members of a community of inquirers imply both beneficial as well as challenging experiences in such cases. By being social actors, learners can learn to regulate their own and social interaction, and practically experience agency in shaping themselves, yet also to be shaped by their actions and interaction in a social context. In this way I argue that IBSE provide learners the opportunity to view and practise science as a complex, cooperative human endeavour, this also being a possibility in the safe space of a classroom.

Based on the findings I obtained, I can thus conclude that participation in IBSE will award learners with opportunities to practise human interaction and to learn about being human, being scientists, being citizens, and about democratic values. In this regard I propose that Foundation Phase learners take a more active and central role in learning science within a community of scientists in the general classroom in order to develop – not only their own scientific skills – but also to become empowered as citizens who possess skills needed in the 21st century society.

7.3.3 Secondary research question 3: How do Foundation Phase learners view and express themselves as scientists?

Exploring child participants' identities as scientists was core to my understanding of the impact of IBSE on their experiences, and how this could support their coming to being. In this respect this study confirms learners' confidence and competence in using a variety of ways to reflect their identity as scientists. Being experts in their own experiences, learners were outspoken about their scientific identity, nature, qualities and capabilities – which they articulated verbally, in writing and by using drawings. As such, Foundation Phase children's voices as scientists became known in different ways in this investigation.

I furthermore found that Foundation Phase learners themselves were able to report the qualities, competencies, dispositions and sophistication in thinking often observed in and attributed to children-as-natural scientists. To this end learners' views of themselves as scientists expressed in their own ways reflected a strong sense of who they are, and what makes them feel like scientists. In this regard I can conclude that learners' identities will be shaped by their circumstances, and as such, that their views and expressions of themselves as scientists will be based, among other things, on their situatedness within the IBSE context. Thus, learners' expressions of their identity as scientists will typically involve specific actions (doing and thinking like scientists) in a specific situation (community of scientists) where they may cooperatively engage in order to achieve a common goal. In this study the child participants' views about themselves as being scientists included experiences that made them feel smart and capable (i.e. self-efficacy), resulting in their acquiring a positive sense of the self as scientists. Their involvement in activities led to their experiencing autonomy and control of learning, further contributing to their experiences of being scientists. In addition, being part of a group and having a collective identity, contributed towards their identity construction.

In addition to my conclusion that engagement in authentic science experiences can position Foundation Phase learners as active agents that do, think and learn like scientists, thereby contributing to shaping their identity as scientists, I postulate that when children participate in science, they learn what science is and can be, but also who they are and can become. As such, learners' being and doing within the IBSE context will contribute towards shaping their developing identity and sense of agency as scientists. To this end I argue that learning science by doing science will shape learners' conceptualisations of themselves as being scientists (*I am*), but also their conceptualisation of their scientific abilities (*I can*) as a result of doing science, and consequently, their conceptualisation of their potential for becoming scientists (*I can become*), based on their participation in IBSE.

In this way the findings of this study indicate that Foundation Phase learners can acquire a complex epistemological understanding of the nature of science (what science is and what science does), and an awareness of science as a human and cooperative endeavour. They can understand their role and agency in using methods of science when doing science like scientists. They can furthermore understand the value and place of science in society, understanding the world scientifically with the aim to participate in activities that can lead to the advancement of science in society.

The image of children as beings rather than becomings implies the importance of Foundation Phase teaching focusing on the development of learners' existing potential as scientists rather than preparing them for becoming future scientists. In this respect child participants in this study viewed themselves as scientists in their own right. I maintain that children-as-scientists will view themselves as beings and social actors who hold the capacity to act, based on the agency they can take to construct their own identities. This claim confirms TT theorists' image of children being natural scientists, as well as contemporary childhood theories viewing children as "beings" who are active in their identity construction.

As such, the findings of this study confirm Foundation Phase learners' strong voice as scientists, and the idea of an identity being something that can be acquired. I therefore argue that any expressions of learners' identities, specifically related to IBSE experiences, need to be acknowledged, as this can serve as starting point to strengthen the education community's commitment to invest in learners' potential through science education practice that may nurture their identities and agency as scientists. As identity construction is socio-culturally mediated and fluid, I posit that young scientists require continued opportunities to affirm and strengthen their being and becoming scientists by doing in a community-oriented classroom environment that embodies a culture of inquiry.

7.3.4 Secondary research question 4: How do student teachers reflect on their experiences of facilitating IBSE with Foundation Phase learners?

Despite the implied complexity associated with IBSE implementation, the student teacher participants in this study displayed a well-developed understanding of

LAMAP IBSE and the necessary competence to translate the approach into Foundation Phase classroom practice. They revealed strong emerging identities as IBSE teachers, with qualities, orientations, competencies and professionalism that are favourable to implement innovative and child-centred teaching approaches. In this regard I posit that, notwithstanding the fact that student teachers are typically trained as generalist early childhood and Foundation Phase teachers, they will possess the ability to teach science to young learners and to employ constructivist principles in creating contexts for inquiry and facilitating learners' thought processes throughout IBSE phases in order to support science knowledge construction.

I furthermore found that the act of facilitating IBSE with Foundation Phase learners in authentic classrooms can contribute to student teachers' experiences of competence and confidence in their ability to teach science as inquiry. I therefore argue that the LAMAP IBSE programme can provide student teachers with no formal science background with the necessary structure and guidelines to empower them to implement this approach in Foundation Phase classrooms. Moreover, student teachers' facilitation skills will stem from their knowledge of theories supporting IBSE, yet also be informed by their views of children-as-scientists, their understanding of how leaners learn, and their views on teaching. In this way student teachers may be able to centre learners within the IBSE situation, and consequently fulfil a child-centred role when facilitating learning and supporting learners in doing science. In terms of their role as facilitator, I found that the student teachers in this study were aware of the different roles they had to fulfil, but also of the complexities involved in facilitating inquiry-based learning as well as their capabilities to perform these roles. Participants furthermore displayed the ability to reflect critically on and detect shortcomings, yet also to suggest ways to improve their own practice.

In addition I found that facilitating IBSE activities in Foundation Phase classrooms contributed to student teachers' professional development as science teachers as they were able to experience the application of the theory in practice, and reflect on it as a way of teaching science to young learners. Such practical application contributed towards the student teachers' sense of accomplishment as they could experience first-hand what the effect of the approach on learners' skills development and their motivation to become engaged in science activities was. This in turn, further contributed to the student teachers' self-efficacy beliefs and sense of being competent IBSE teachers, yet also confirms the effectiveness of the approach for use with Foundation Phase learners.

In this regard I found that student teachers experienced empowerment by taking agency. This enabled them to participate actively in and take responsibility for their own learning and to reflect critically on and suggest ways to improve their practice. This study thus highlights the value of teacher training focusing on shaping reform-minded and inquiry-oriented professional teacher identities through mentorship investment, and by offering authentic contexts and experiences where students can apply their knowledge in practice, following a reflective practice approach.

Despite the positive experiences, the challenges that the student teachers in this study faced while facilitating IBSE with Foundation Phase learners (i.e. challenges relating to planning, facilitation, CAPS and Foundation Phase classroom practice) also have implications for the implementability of IBSE in South Africa. In this regard knowledge and insight into such context-specific challenges, in conjunction with sound teacher training, clear policy guidelines and support by the broader education community can enable beginner teachers to deal with challenges when they occur.

Based on the findings of this study, the value of IBSE for both learner and student teacher development, and the recommendations of the student teacher participants, I propose that IBSE should be implemented in all schools in Foundation Phase classrooms as a means of developing learners' scientific potential. I echo the voices of student teachers who participated, and propose efforts to raise awareness of the value of IBSE and the potential of children as scientists among the Foundation Phase education community, the encouragement of positive attitudes to science education among Foundation Phase teachers, the provision of specialised training in IBSE, and the establishment of a network of support to promote and sustain IBSE implementation in schools. As such, I maintain that the approach should be adopted by higher education institutions to prepare student teachers for IBSE implementation. As professional teacher identity is a fluid construct, I furthermore propose that beginner science teachers' identities be encouraged by means of ongoing professional development when they are in practice.

7.4 CONTRIBUTIONS OF THE STUDY

In this section I present the contributions of this study. In presenting the theoretical contribution, I address the primary research question formulated in Chapter 1, namely *How can insight into the experiences of participants in IBSE broaden existing knowledge on the implementability of IBSE in the South African Foundation Phase context?* I also discuss the profession-related contribution and practical application value of the study, following the findings I obtained.

7.4.1 Theoretical contribution: How can insight into the experiences of participants in IBSE broaden our knowledge on the implementability of IBSE in the South African Foundation Phase classroom context?

The findings of this study add to the growing body of knowledge on early childhood science education, more specifically in terms of the use, benefits and challenges of inquiry-based education as pedagogical approach to facilitating science with young learners in preparing them for modern demands. Theoretically this study thus adds to existing literature on early childhood science education, in particular on the implementation possibilities of IBSE for Foundation Phase learners. As both Foundation Phase learners and student teachers who facilitated IBSE participated in the study, insight can be added from both teaching and learning perspectives, and as such broaden the existing knowledge base while informing future practice on the implementation possibilities of IBSE. In this regard the study contributes to refining the practical application of IBSE theory to Foundation Phase practice.

Based on the findings of this study and in drawing on my conceptual framework and existing theories on contemporary childhood, and cognitive and constructivist perspectives that support LAMAP IBSE, I propose the framework captured as Figure 7.1 for implementing this approach with the South African Foundation Phase classroom context.

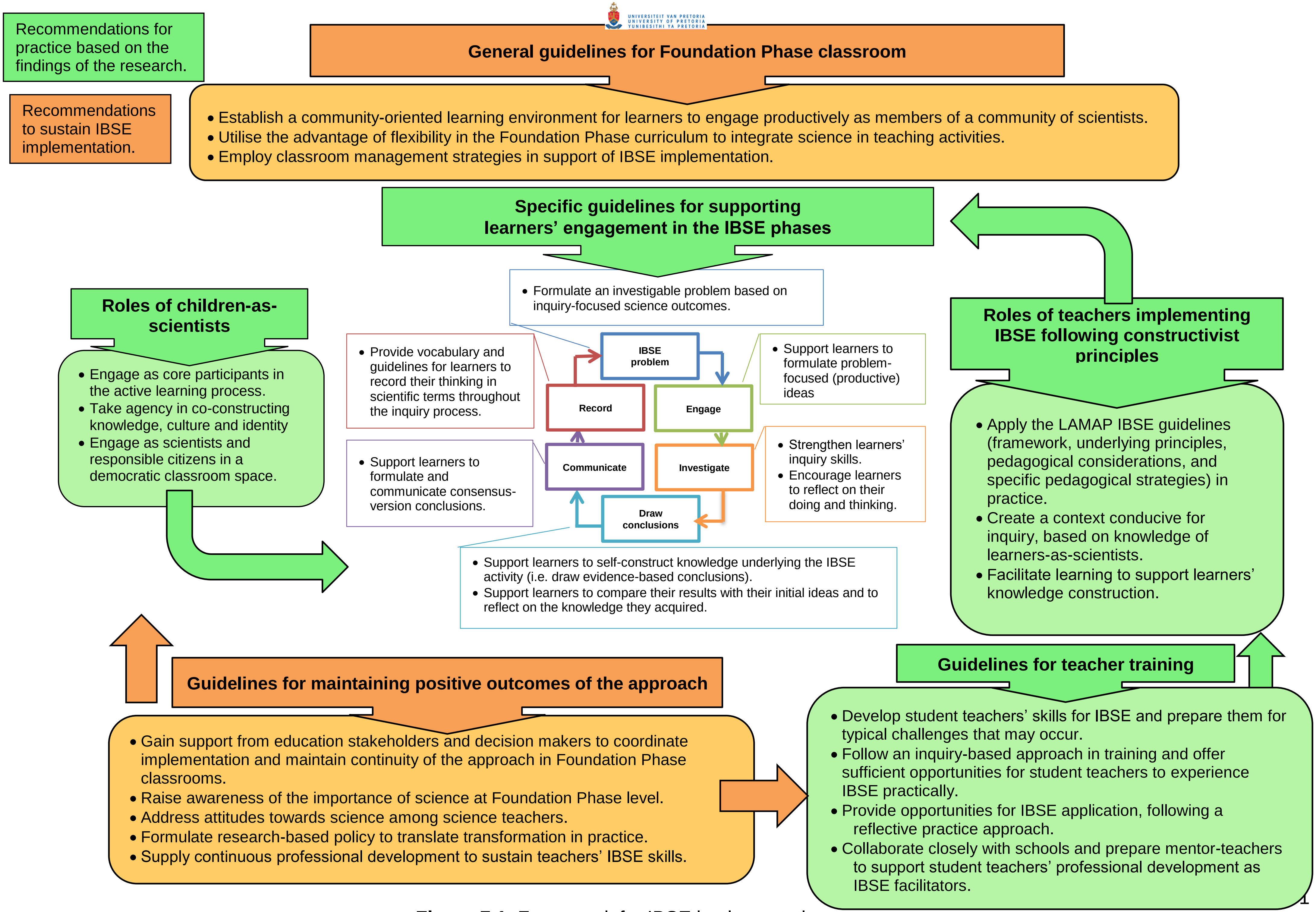


Figure 7.1: Framework for IBSE implementation

As the child participants acted according to the assumptions of TT in that they presented as natural scientists who possessed intuitive theories, and who had the necessary cognitive capacity to revise theories and construct science knowledge, this study contributes to understanding learners as natural scientists. It furthermore emphasises the role of the teacher in terms of expectations of the learners' scientific potential in the classroom context. In this regard the LAMAP IBSE approach proved to be efficient in creating a context where learners could engage as scientists and enabled them to use their inherent scientific skills in order to accumulate science knowledge. Consequently, this study contributes to understanding how Foundation Phase classrooms can be structured based on the knowledge of learners-as-scientists, and how they can learn as scientists.

Drawing from existing theory on children and childhood furthermore contributes to an understanding of the notion of children-as-scientists in a contemporary context. In this regard the child participants in this study acted according to the images of contemporary children, with consequences for the choice of certain pedagogical practices. As such, this study contributes to current understanding of Foundation Phase learners as scientists, agentic beings, and as capable of co-constructing knowledge. Furthermore, insight is highlighted in terms of culture and identity formation in a scientific context, and consequently the need for adopting IBSE practices that can enable child-centred learning. In this regard the LAMAP IBSE approach is demonstrated as suitable to apply in the Foundation Phase in order to educate young South African scientists for modern demands. Consequently this study contributes to current theory on how Foundation Phase classrooms can be structured as community-oriented learning environments that will respect learners as scientists, knowers, and experts in their own experiences.

In support of children's science learning abilities, I also considered constructivist perspectives on teaching, and the role of teachers in facilitating and supporting inquiry-based learning throughout the IBSE phases. Theoretically this study adds insight into how the student teachers applied constructivist principles to create contexts that were conducive to inquiry, facilitated learning, and supported learners' knowledge construction. Implementing the LAMAP IBSE programme enabled student teachers to apply constructivist principles in facilitating learners' scientific investigations and in supporting their construction of long-lasting understanding. In this regard this study adds to the knowledge base on the implementability of IBSE as approach to science education in the Foundation Phase context.

The implementability of IBSE furthermore relies on higher education institutions and teacher trainers to prepare student teachers to implement LAMAP IBSE according to constructivist principles. As such, this study contributes to existing literature on the possibilities for IBSE implementation, but also the expected challenges and complexities associated with such implementation that student teachers need to be prepared for. This study furthermore contributes insight into appropriate practices teacher training institutions may potentially follow to prepare beginner teachers for IBSE implementation.

The sustainability of IBSE relies on the broader education community taking ownership of IBSE as approach in the Foundation Phase context and on a network that will support its implementation. IBSE implementation furthermore relies on a research-based policy that can guide the transformation in Foundation Phase practice. This study contributes to current debates on changes or additions to policy in terms of science education in the Foundation Phase classroom as well as to the structures that need to be established in order to ensure the sustainability of IBSE implementation.

7.4.2 Profession-related contribution: How might Foundation Phase education stakeholders gain from the findings of this study?

By providing a range of perceptions of the implementation possibilities of IBSE as voiced by both student teachers and learners, the findings of this study may benefit various education stakeholders. The worldwide trend of promoting IBSE as preferred approach to science education at primary school level has implications for how Foundation Phase student teachers in South Africa are currently prepared for science teaching. As such, higher education institutions and teacher trainers may benefit from including the LAMAP programme when training students as possible approach to utilise when they enter the profession.

As IBSE is generally regarded as a complex approach to translate into practice, the findings of this study can thus potentially benefit teacher trainers to prepare student teachers for the challenges that may be expected in the South African context when following this approach. In this regard the findings of this study suggest a number of areas to attend to in teacher training programmes to support generalist Foundation Phase teachers to implement IBSE in the classroom. In addition to identifying some challenges, teacher training institutions can benefit from the study's findings highlighting the effectiveness of using the LAMAP IBSE approach in conjunction with a reflective practice approach in shaping reform-minded inquiry-oriented teacher identities for science. By applying newly generated theory, training institutions may thus be able to deliver beginner Foundation Phase teachers who are potentially prepared to implement child-centred, inquiry-based approaches to science education in their classrooms.

The findings of this study can thus potentially support in-service teachers in getting acquainted with the principles, pedagogical considerations, and specific pedagogical strategies of IBSE, and how they should be applied in Foundation Phase classrooms. Such knowledge may also benefit mentor-teachers when they support student teachers to apply IBSE theory in Foundation Phase classrooms during teaching practice cycles.

The findings of this study may furthermore be of benefit to education departments (national and district), more specifically subject advisors who guide in-service teachers in terms of the importance of science education at Foundation Phase level and the way in which curriculum goals can be realised through inquiry-based pedagogies. Education departments offering continuous professional teacher development (CPTD) programmes may also build on the findings of the study when preparing in-service teachers to implement innovative approaches according to new trends.

7.5 STRENGTHS, CHALLENGES AND LIMITATIONS OF THE STUDY

In following an interpretative qualitative multiple-case study research design, I was able to obtain rich and in-depth information about the implementation possibilities of IBSE, based on the lived experiences of children as scientists and student teachers as facilitators of learning. Capturing participants' engagement in the school context provided me with a holistic perspective of how IBSE occurred in the Foundation Phase classroom. In this regard the choice of methodology seems suitable to utilise when researching children and the adults who work with them in an early childhood context. In addition, the child-friendly data collection methods I employed with the learners were effective as these enabled them to express their experiences in a variety of ways, which added value to the possibility of understanding IBSE from a child perspective.

Another strength of my study is that I involved PGCE student teachers as participants. The one year PGCE qualification is distinctly different from the four year BEd qualification offered to the majority of future teachers in South Africa. The PGCE group consisted of a small number of students (as opposed to large numbers typically found in BEd classes) which enabled me to work with them on a more personalised level. The flexibility in the PGCE timetable furthermore allowed me to involve students in a number of lengthy hands-on activities – which would normally not be possible in a BEd timetable.

The study involved a small scale project where only three schools and a limited number of participants took part during the time of data collection. The study is furthermore limited in that I focused on participants' experiences of IBSE in a more general sense, without exploring student teachers' subject matter knowledge, and the quality of their facilitation skills. In the case of the child participants, I focused on their experiences of engagement in IBSE and not so much on the quality of their inquiry skills. Based on the onto-epistemology, research design and methodological processes I selected, this focus and procedures allowed me to gain an understanding of a specific phenomenon in a specific context for which the findings may potentially be transferred to similar contexts. Generalisable findings were never my aim.

The study was, however, ambitious in seeking to gain insight into teaching and learning processes in classrooms, and the perspectives of both learners and student teachers. Although this focus added depth to my understanding of the implementability of IBSE in Foundation Phase classrooms, I found working with two groups of participants – that generated distinctly different kinds of data – challenging. The vast amount of data I collected was difficult to manage and time consuming to transcribe, analyse and interpret. While focusing on two groups of participants presented me with an opportunity to view the situation from different perspectives (teaching and learning), it also implied that I had to reduce and condense the data to report the findings.

Even though the data I collected from the child participants was particularly valuable in terms of hearing children's voices, I found the analysis and interpretation of children's data to be challenging. Also, working with learners in a school context determined the specific level of child-participation and thus posed challenges in terms of my aspiration to involve children more actively during the entire research process (i.e. doing research with children instead of on or about children). My aim, however, was to involve children as consultants, and for this purpose I could employ elements of participation and reflection to give children a voice on their engagement in IBSE within the formal school context.

Next, I also experienced the support provided by some of the teachers who acted as mentors to the student teacher participants during their teaching practice experience as a challenge. In this regard the teachers' apparent limited knowledge of the inquiry-based approach and related requirements for structuring an IBSE learning environment seemingly limited these mentor-teachers' ability to support students sufficiently in implementing IBSE, for example in terms of time allocated for the IBSE activities.

A final challenge I experienced relates to my dual role of lecturer and trainer of IBSE on the one hand, and researcher of the study on the other. Hence, I had a personal interest in the success of the implementation, and could perhaps have been affected by bias when interpreting the student teacher participants' learning-to-teach IBSE experiences. To this end I guarded against biased interpretations by means of continuous reflections, regular discussions with my supervisors, and member checking in order to confirm the authenticity of my interpretations.

7.6 RECOMMENDATIONS

In conclusion I make some recommendations for future research, teacher training practice, Foundation Phase classroom practice, and potential policy implementation in this section. I propose these recommendations as way of potentially supporting the implementation of IBSE in the Foundation Phase context.

7.6.1 Recommendations for future research

Based on the findings of this study, I recommend future research on the following:

- The long-term impact of the LAMAP IBSE programme on learners' science potential by means of a longitudinal study.
- Exploring the possibilities of implementing LAMAP IBSE as science intervention programme that may address low learner achievement in science.
- Using LAMAP IBSE as professional development programme for in-service Foundation Phase teachers.
- Determining the correlation between teachers' IBSE facilitation skills and the quality of learners' engagement during the different phases of IBSE.
- Determining the correlation between student teachers' science subject matter knowledge and their ability to implement IBSE.
- Exploring how learners naturally acquire scientific inquiry skills.
- Investigating the impact of IBSE on developing learners' communication skills as strategy for reasoning.
- Exploring the outcomes of a well-resourced IBSE programme on developing generalist student teachers' sense of competence to implement IBSE in the Foundation Phase classroom.

- Investigating the effect of teacher training on student teachers' orientation to implement innovative science teaching approaches in the Foundation Phase context.
- Determining the contribution of schools and teachers in encouraging innovative science teaching practices in the Foundation Phase and creating classrooms that reflect a culture of inquiry.
- Exploring the possible correlation between the level of structure provided by an IBSE training programme and teachers' development of self-efficacy beliefs.

7.6.2 Recommendations for teacher training practice and teacher trainers

The LAMAP IBSE programme is generally utilised as professional development programme focusing on the preparation of in-service teachers over a period of three to six years to implement IBSE in their classrooms. Based on the conclusions I came to in this study, I recommend that LAMAP IBSE can also be utilised in higher education contexts as programme to prepare student teachers for IBSE implementation in Foundation Phase classrooms. However, teacher trainers will require training on how to present and utilise this inquiry approach in higher education contexts to allow for sufficient hands-on training, and for students to learn inquiry through inquiry.

Furthermore, for pre-service teachers to become efficient in IBSE implementation, they will require time and space to apply IBSE theory to authentic contexts. In this regard I recommend that a close purposeful collaboration between teacher training institutions and schools (where student teachers are placed for teaching practice), should be established to enable student teachers to apply IBSE in practice with the support of mentor-teachers. Such collaboration may not only positively impact initial teacher training, but can also contribute to school development and practicing teachers' professional development.

Additionally, teacher trainers may benefit from following a reflective-practice approach, and engaging in a continuous cycle of critical self-observation and evaluation to gain insight into their teaching and the outcome, in order to improve on practice. I furthermore recommend that teacher trainers continuously focus on developing their professional identity as IBSE trainers, and invest in self- and further education, collaborate with peers and share expertise in order to influence change in terms of the potential for IBSE implementation in Foundation Phase classrooms.

7.6.3 Recommendations for Foundation Phase practice

Based on the findings I obtained, I recommend that awareness of young children's potential to engage in IBSE be raised among preservice and in-service teachers. In this way Foundation Phase teachers may hold appropriate expectations of and capitalise on the sophistication of learners' thinking in order to expand their scientific habits of mind by means of IBSE. I also recommend that teachers attend to their classroom practice as the efficacy of inquiry approaches largely depends on the teacher.

While the current Foundation Phase curriculum and programme is designed flexibly to allow for extended learning experiences by means of integration, the importance attached to science education in a specific school will determine whether or not such allowance will be made. To this end I propose that teachers search for ways to integrate IBSE meaningfully into the Foundation Phase programme. Teachers can furthermore plan IBSE units across a time span in order to allow for more lengthy investigations, and award sufficient time for learners to engage sufficiently in all the phases of the inquiry process.

With regard to the planning and facilitation of the IBSE phases, I recommend that teachers formulate well-considered problems based on carefully selected science outcomes that can address basic science concepts and allow learners to reach evidence-based conclusions by means of active learning. For learners to benefit fully from building new knowledge on existing knowledge, I propose that teachers support learners' formulation of clear problem-focused ideas, and guide them meticulously from their initial ideas to constructing science concepts underlying the activity they are involved in. Such a focused guidance approach may support learners to ultimately reach, formulate and communicate the “consensus version” of the science knowledge inherent to the activity.

In order to support learners’ engagement in the minds-on phases, I furthermore propose that Foundation Phase teachers guide learners to reflect on their conclusions so that concepts can be confirmed, expanded or changed, whichever is required for learning to accumulate. To support learners in developing scientific communication skills as tools for reasoning and knowledge construction, teachers can introduce scientific vocabulary, guide learners in terms of articulating their thinking processes in scientific terms, and offer sufficient practice for communicating science ideas in both oral and written modes.

In order to create a suitable context of inquiry, teachers are required to provide a space for learners where they can work like scientists in the classroom, and co-construct science-related knowledge, skills, dispositions and an identity as scientists. Additionally, teachers should promote consciousness and scientific awareness among learners by linking their scientific actions to science so that they ultimately view themselves as scientists.

7.6.4 Recommendations for policy and potential policy implementation

Although the positive impact of inquiry-based learning on the advancement of learners’ scientific potential is demonstrated by this study, the implementation of IBSE as approach in Foundation Phase classrooms depends on research-based policy development and implementation. While the findings of a small scale qualitative study may have limited impact on the policy making audience, I believe that this study can highlight the need for clear and long-term policy concerning Foundation Phase science education and therefore the need for ongoing debate between researchers, professionals and policy developers on how to bridge the gap between IBSE theory and practice *via* curriculum implementation.

The findings of this study emphasise the importance of recognising Foundation Phase learners' scientific capabilities and the early years for building on early childhood experiences and promoting the development of science-related knowledge, skills and dispositions among learners. Based on current trends in terms of South African learners' achievement in science, the need exists for the country to put workable guidelines in place that may promote learners' scientific development, starting as early as the Foundation Phase. Adopting approaches such as IBSE, however, implies the need for research-based policy making, which can inform transformation in Foundation Phase classroom practice in order to foster learners' scientific development.

In order to promote an approach such as LAMAP IBSE within the South African context, a key recommendation involves broad level collaboration of decision makers and authorities that can coordinate and support the continuation of inquiry-based science practice in the Foundation Phase. Such networks can involve role players such as the DBE, district departments of education (e.g. GDE), higher education institutions concerned with teacher education, scientific associations (for instance ASSAf), scientific structures (such as Sci-Bono[32]) and businesses. As key role players the DBE and local departments of education are instrumental in ensuring change in classroom practice, following the principles of inquiry-based learning.

The negative effect of limed guidelines for science as a subject included in CAPS (Life Skills) for the Foundation Phase is also demonstrated by this study. As a result I propose that the national curriculum should include clear guidelines in terms of appropriate science outcomes, progression and assessment across the Foundation Phase. Other identified areas such as pressure of the languages and mathematics curricula, limited space and time for science education, and assessment requirements that may constrain IBSE implementation furthermore emphasise the need to highlight science education in the South African national curriculum, and to ensure that sufficient time is devoted to science education.

[32]Discovery centre supporting maths, science and technology education and learning experiences that build science, engineering and technology capacity in South Africa.

Although curricula typically do not prescribe approaches to curriculum implementation, I recommend a greater focus on teaching science as inquiry at Foundation Phase level. Based on the participants' (student teachers) experience of not having sufficient IBSE resources, I furthermore propose the development and distribution of teaching resources (modules), planned around themes (for example those stipulated in CAPS Life Skills) for each grade in the Foundation Phase. Such resources can, for example, contain learning sequences that stipulate appropriate outcomes and IBSE problems, and provide guidelines on teaching science following an inquiry approach. Such modules may enable Foundation Phase teachers who are not scientifically inclined to gain confidence in teaching science as inquiry.

Finally, deliberate supportive attempts are required to translate policy into transformation in practice to encourage classroom contexts that can nurture learners' scientific growth. In this regard I propose that beginner Foundation Phase teachers (trained to implement IBSE) are offered ongoing opportunities for teacher professional development to support their transition to IBSE. In the case of in-service teachers, I recommend that education departments initiate initial IBSE training, and then also extend opportunities for ongoing professional development in order to build teachers' confidence in teaching science as inquiry. This includes space and time for teachers to practise inquiry approaches and gain confidence with the support of a local and national support network.

7.7 SUMMARY

Understanding and supporting children's scientific development is vital in today's dynamic world, where the changing environments of childhood, education, and 21st century societies challenge learners' scientific competence. As young scientists and worthy citizens, learners should have a say in their science education. In this regard I argue that adults need to better understand how children understand themselves as scientists in relation to the world of science when making decisions about science education. In this regard science programmes should start with children, and who they are.

The findings of this study imply that children view themselves as scientists, but also that being and becoming scientists is something that can be taught. In this regard I posit that the scientists-in-waiting are dependent on South African policy-makers, researchers, and the education community to nurture their potential and their growth as scientists. In essence I assume that, what both contemporary childhood and science education theorists are arguing for and I echo here, is the transformation of classrooms into child-centred learning communities, characterised by participation and dialogue in which learners can actively engage in co-constructing knowledge, identity and culture, ultimately to become acculturated into a community of inquiry, in which they can advance their potential as scientists. In this regard, I conclude with the words of Yves Quéré (co-founder of LAMAP):

> *Let us hope that our children, worldwide, if they have practiced science at school, if they have loved it, … will take science for what it is in reality: not an isolated land, somewhere far away, but a superb continent of human culture* (Quéré, 2010).

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Appendix A: Gauteng Department of Education

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no. D2016 / 180 A
Enquiries: Diane Buntting 011 843 6503

GDE AMENDED RESEARCH APPROVAL LETTER

Date:	20 July 2015
Validity of Research Approval:	28 July 2015 to 2 October 2015
Previous GDE Research Approval letter reference number	D2015 / 257 dated 12 August 2014
Name of Researcher:	Bosman L
Address of Researcher:	40 Morrison Avenue; Rietondale; Pretoria; 0084
Telephone / Fax Number/s:	012 420 5990; 082 566 2069; 012 420 5595
Email address:	linda.bosman@up.ac.za
Research Topic:	Considerations in the implementation of inquiry-based Science education in the Foundation Phase.
Number and type of schools:	FOUR Primary Schools
District/s/HO	Tshwane South and Ekurhuleni North

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter;

2015/07/28

1

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix B: Consent Letters

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

1 August 2015

LETTER OF CONSENT FOR RESEARCH_CHILDREN

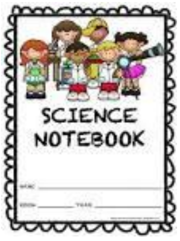
It will be verbally explained to children what the project entails and what will be required of them.

This form will be completed together with the student-teacher and/or researcher before commencing with the activities.

For office use only

Name of participant:

Code of School	Gender (B/G)	Group	Number

		Yes	No
	**Did I explain to you what today's activities are all about?** **Do you understand what I explained to you?**	☐	☐
	**Do you understand that I will be using a camera and video recorder today?**	**Yes** ☐	**No** ☐
	**Do you understand that I will be looking at your work?**	**Yes** ☐	**No** ☐
	**Do you understand that I will be talking to you about your work?**	**Yes** ☐	**No** ☐
	**Do you understand that it is your choice to help me today?**	**Yes** ☐	**No** ☐
	**Do you understand that you can stop at any time you want to?**	**Yes** ☐	**No** ☐

	**Do you have any questions?** ✓ ✗ **Do you understand the answers I have given you?**	**Yes**	**No**
	**Are you happy to help me today?**	**Yes**	**No**
Signed by participant: **OK**			

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UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

1 August 2015

LETTER OF CONSENT FOR RESEARCH: PARENTS

Title of PhD Project: Implementability of Inquiry-based Science Education in the Foundation Phase classroom

Researcher: Mrs Linda Bosman
Supervisor: Prof Ronél Ferreira

Dear Parent

Your permission is being sought to have your child participate in this research project. Please read the following information carefully before you decide whether or not to give your permission.

Purpose of the research: Studies increasingly reveal that young children are surprisingly capable scientists. They are often referred to as "natural scientists" or "scientists-in-waiting", with the inborn capacity to think and reason scientifically. Little is known however about how young children view themselves as scientists and the thinking processes involved during participation in science. For this reason we are interested in finding out how Foundation Phase children think and act as scientists during participation in inquiry-based science activities, and how they express their thinking in verbal and visual format (i.e. what they say, draw and write). The purpose of this research is not only to determine how children reveal themselves as scientists, but also to determine how we should train and support our student-teachers to implement inquiry-based science education in the Foundation Phase classroom.

Procedure to be followed: The PGCE student teacher (placed in your child's classroom) will be presenting an inquiry-based science activity to the Foundation Phase children during her teaching practice period. As lecturer and researcher I will be observing the student teacher during the presentation of the activities to take notes on how children think and act as natural scientists (i.e. how they engage in scientific inquiry). I therefore request your permission for me to be present in your child's classroom during these activities and to collect evidence of your child's work and participation. The observation will involve note taking, but also photographs of your child's work and videos of the group's participation. Please note that care will be taken to respect and protect your child's identity in the case of photographs and videos.

Discomforts/risks: The risks in this research are minimal. There are no foreseeable discomforts or dangers to either you or your child in this research. No harmful substances, content or procedures will be used during the presentation of the activities.

University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 420 5595
Cell +27 (0)82 566 2069
Email linda.bosman@up.ac.za
www.up.ac.za

Incentives/benefits for participation: There are no material benefits to your child. Your child will get the opportunity to participate in an inquiry-based science activity facilitated by his/her student-teacher. The results of this research, however, will increase our knowledge of children's scientific abilities and the implications thereof for initial teacher education, teacher professional development and curriculum development.

Time duration of participation: The science activities will be presented as part of the normal school programme for Foundation Phase during school hours. Activities will take approximately one hour, broken down into age-appropriate time slots.

Statement of confidentiality: All records will be kept confidential and will be available only to the researcher and the supervisor. If the results of this research are published, individual children will not be identified.

Voluntary participation: While all the children in the class will participate in the learning activity presented by the student-teacher, your child's participation in the research part of the project is voluntary. We also ask that you read this letter to your child (if age-appropriate) and inform your child that participation is voluntary. At the time of the research, your child will once again be reminded of this by the student teacher and researcher.

Termination of participation: If at any point during the research you or your child wishes to terminate participation, we will do so.

All questions or concerns regarding participation in this research should be directed to:

Mrs Linda Bosman (Lecturer/Researcher)
Department of Early Childhood Education

Cell: 082 566 2069
E-mail: linda.bosman@up.ac.za

Prof Ronél Ferreira (Supervisor)
Department of Educational Psychology

Tel: 012 420 5504
E-mail: ronel.ferreira@up.ac.za

Should you agree, please sign the letter of consent (next page).

Please note: SIGNING THE FORM BELOW WILL ALLOW YOUR CHILD TO PARTICIPATE IN THE PROJECT DURING SCHOOL HOURS WITHOUT YOUR PRESENCE.

Please return to the classroom teacher by______________.

If you do not sign and return this form, the researchers will understand that you do not wish to allow your child to participate.

Parent's Signature Box:

Title of project:
Implementability of Inquiry-based Science Education in the Foundation Phase classroom

I, the parent/caregiver/guardian of ________________________________, years of age, permit his/her participation in the research project named above and being conducted by the lecturer Mrs L Bosman and the PGCE student-teacher, under the supervision of Prof R Ferreira.

I give my permission for the following:

- An observation visit to my child's classroom
- Using my child's work (e.g. science journal)
- Taking photographs of my child's work
- Videotaping my child's participation (identity protected)
- Having discussions with my child about his/her participation

__________________________________ __________________

Signature of Parent/Guardian Date

____

Please print your name here

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UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

1 August 2015

LETTER OF CONSENT FOR RESEARCH

Title of PhD Project: Implementability of Inquiry-based Science Education in the Foundation Phase classroom
Researcher: Mrs Linda Bosman
Supervisor: Prof Ronél Ferreira

Dear Principal

As PhD student and lecturer in the Department of Early Childhood Education at the University of Pretoria, I am conducting research as part of my post-graduate studies. The topic of inquiry-based science education (IBSE) at Foundation Phase level is of particular interest to me and I have therefore chosen *Implementability of Inquiry-based Science Education in the Foundation Phase classroom* as my focus.

Studies increasingly reveal that young children are surprisingly capable scientists. They are often referred to as "natural scientists" or "scientists-in-waiting", with the inborn capacity to think and reason scientifically. Little is known however about how young children view themselves as scientists and the thinking processes involved during participation in science. Together with the PGCE student teachers placed at your school, and under the supervision of Prof Ronél Ferreira, I aim to develop a deeper understanding of how Foundation Phase children think, act and express themselves as scientists during engagement in IBSE, and of the meaning they attach to their experiences as expressed through verbal, visual and written means. As researcher I furthermore aim to determine the possibilities and challenges involved in implementing IBSE in the Foundation Phase classroom, as well as the support that is required to efficiently implement this approach in the Foundation Phase context.

In order to address the research questions, a qualitative approach will be followed which will involve several data collection methods:

1. With regard to children's participation in IBSE, I would like to be present in the classroom as *observer* while a PGCE student teacher (during the teaching practice period) facilitates IBSE with Foundation Phase children. Through observation, I aim to collect evidence of children's scientific ideas as represented through language in verbal, written and visual format.
2. My observations will be enhanced by means of an *observational checklist* that contains the elements of scientific inquiry required to be present in an IBSE situation.
3. I will furthermore enhance my observations by means of *photographs* and *video recordings* of children's participation.
4. In order to gain insight into their experiences of engaging in IBSE, I also plan to conduct *informal conversations* with children and invite them to elaborate (in their own words) on their participation.

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Email linda.bosman@up.ac.za
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Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

I have gained the approval to conduct research in schools from the Gauteng Department of Education as well as from the ethical committee at the University of Pretoria. I shall furthermore gain the necessary permission from the parents and the children to conduct my research. Once permission has been granted, I shall arrange a convenient time for the observation visit with the student and mentor-teacher to begin my data collection without infringing on their teaching or learning time.

I can assure confidentiality and anonymity by omitting the school's and the children's names in any publications and by blurring out any identifying details in photos or videos. I will also assure you that the school and children in your school will not be harmed in any way. Please be informed that the research may be terminated should you or the children in your school wish to end participation in this research. Similarly, should the data collection process elicit negative outcomes, participation in the research will be terminated.

Taking part in this research will hopefully give your school the opportunity to gain insight into the possibilities of young children to engage in scientific inquiry, and the challenges involved in implementing IBSE in the Foundation Phase classroom. It may also potentially highlight, to various role players, the benefits of and support needed for introducing IBSE during the early years of schooling.

Should you require any further information, please feel free to contact me or my supervisor.

Mrs Linda Bosman (Lecturer/Researcher)
Department of Early Childhood Education

Tel: 012 420 5990
Cell: 082 566 2069

E-mail: linda.bosman@up.ac.za

Prof Ronél Ferreira (Supervisor)
Department of Educational Psychology

Tel: 012 420 5504

E-mail: ronel.ferreira@up.ac.za

Your assistance is greatly appreciated.

Should you agree, please sign the letter of consent (next page).

PERMISSION FOR RESEARCH

Title of project:

Implementability of Inquiry-based Science Education in the Foundation Phase classroom

I,…………………………………………………………., herewith grant permission for my school, ……………………………………………………………. to be involved in the research project on the implementation of inquiry-based science education in the Foundation Phase classroom.

I am aware that data collected from the participants will be used for further reference.

If any research is published, the names and photographs of participants, as well as confidentiality, anonymity and privacy of participants will be protected at all times.

Signature……………………………….. Date: ……………………………………

School Stamp

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

1 August 2015

LETTER OF CONSENT FOR RESEARCH

Title of PhD Project: Implementability of Inquiry-based Science Education in the Foundation Phase classroom

Researcher: Mrs Linda Bosman
Supervisor: Prof Ronél Ferreira

Dear PGCE student teacher

Since I am exploring the possibilities of implementing inquiry-based science education (IBSE) in the Foundation Phase classroom, and specifically how young children respond to scientific inquiry, I would like to request your consent to involve you in my research project. It will be required of you to facilitate an IBSE activity with the children in your class during your teaching practice period, and allow me to be present during this lesson to observe children's engagement in IBSE. I will enhance my observation by means of observation notes as well as by taking photographs and video-recordings of children's participation to use for data analysis purposes. I will also have a reflective discussion with you regarding your experiences of facilitating IBSE, and I will ask your input during a focus group discussion. I also request to use the information in your teaching practice portfolio on IBSE for research purposes.

In order to safeguard your privacy and to ensure anonymity and confidentiality, I will handle all information in a confidential manner. Only myself and my supervisor and I will have access to the raw data. I will furthermore anonymise all identifiable data (real names, personal records, visual data) in all published reports.

Aldoel 2-66
Groenkloof Campus
University of Pretoria
PRETORIA 0002
Republic of South Africa

Office number: (012) 420 5990
Mobile number: 082 566 2069

E-mail address: linda.bosman@up.ac.za
http://www.up.ac.za/faculty-of-education/

Please be informed that participation in this project is voluntary, and may be terminated at any time should you wish to end participation. Similarly, should the data collection process elicit negative outcomes, your participation may be terminated. I can assure you that participation in the research will not impact your assessment in any way, and that withdrawal from the project will not have any negative consequences.

Taking part in this research will give you the opportunity to apply the theory of IBSE in the authentic school context, practise your facilitation of IBSE skills, and experience the response of children to inquiry-based pedagogy. This may potentially contribute towards your development as reflective practitioner and expand your professional development. Your contributions will also allow me to improve on my own practice, and to share with the education community the potential and challenges involved in the implementation of IBSE in the Foundation Phase classroom.

Should you wish to query anything further, please feel free to contact me or my supervisor:

____

Mrs Linda Bosman (Lecturer/Researcher)
Department of Early Childhood Education

Cell: 082 566 2069
E-mail: linda.bosman@up.ac.za

____

Prof Ronel Ferreira (Supervisor)
Department of Educational Psychology

Tel: 012 420 5504
E-mail: ronel.ferreira@up.ac.za

Should you have any concerns about your involvement in this research project, you are welcome to communicate your concerns with Dr Sonja Coetzee (Coordinator of the PGCE programme) or Prof Ina Joubert (Acting Head of Department: Early Childhood Education).

Dr Sonja Coetzee
(Coordinator: PGCE)

Tel: 012 420 5555
E-mail: sonja.coetzee@up.ac.za

Prof Ina Joubert
(Acting Head of Department, ECE)

Tel: 012 420 5636 / 5568
E-mail: ina.joubert@up.ac.za

Your assistance is greatly appreciated.

Should you agree, please sign the letter of consent. Kindly deliver to me by hand your letter indicating your consent/non-consent to participate in the research.

PERMISSION FOR RESEARCH

Title of PhD Project:

Implementability of Inquiry-based Science Education in the Foundation Phase classroom

I,…………………………………………………………….., herewith grant permission to be involved in the research project on the implementability of inquiry-based science education in the Foundation Phase classroom.

I am aware that the lecturer/researcher will

- be present in the classroom during my facilitation of IBSE activities with Foundation Phase children to observe children's engagement in IBSE;
- have a reflective discussion with me individually and as part of a focus group;
- use information from my Teaching Practice portfolio for research purposes.

If any research is published, the name and any identifying details of the participant, as well as confidentiality, anonymity and privacy of participant will be protected at all times.

Signature……………………………….. Date: …………………………………….

Observation tool: Children’s activities

Adapted from *Tools for Enhancing Inquiry in Science Education.* Available from http://www.fondation-lamap.org/sites/default/files/upload/media/1-tools_for_enhancing_inquiry_in_science_education.pdf

Items ST = student-teacher; Ch = child/ren		Explanations and examples	Evaluation			Complementary information
Carrying out an investigation	Ch pursue questions which they have identified as their own, even if introduced by the T	Their ownership of the questions is shown by Ch being able to explain in their own words what they are trying to do or find out.	Yes	No	N/A	
	Ch make predictions based on their ideas	They give a reason for what they predict, even if it is inaccurate, showing that it is not just a guess.				
	Ch take part in planning an investigation	Ch do not need to propose their own plan but comment on the teacher’s proposed plan or adapt it during the investigation.				
	Ch carry out their own investigations	Ch are active in collecting and using evidence themselves, not observing someone else doing this.				
	Ch gather data using methods and sources appropriate to their inquiry question	The appropriate data may be observations, simple measurements, or information from books.				
	The data gathered by Ch enable them to test their prediction	The nature of the data collected through observations, measurement, or secondary sources is appropriate for testing Ch’s predictions.				
	Ch consider their results in relation to the inquiry question	In discussion with others and the T, Ch use the observed evidence to answer the inquiry question.				
	Ch try to give explanations of their results	Ch give possible reasons for what they found or how the results can be explained based on their previous experience and knowledge.				
Children’s records	Ch make a simple record of what they did and found	This can be an individual or group record in the form of a drawing with labels or brief writing, or by responding to a worksheet prepared by the T.				
	Ch share their records of what they did and found with others during reporting to the class	Ch try to find out others’ ideas about what they were investigating. They listen to each other.				

Observation tool for: Teacher-Child interactions

Adapted from *Tools for Enhancing Inquiry in Science Education.* Available from http://www.fondation-lamap.org/sites/default/files/upload/media/1-tools_for_enhancing_inquiry_in_science_education.pdf						
Items ST = student-teacher; Ch = child/ren		Explanations and examples	Evaluation			Complementary information
Building on children's ideas	T asks questions requiring Ch to give their existing ideas	T's questions include open questions (requiring more than a one-word answer) which probe what Ch are thinking not only at the start but at other times in the activity. E.g. 'What do you think is the reason?' rather than "what is the reason?'.	Yes	No	N/A	
	T helps Ch to formulate their ideas clearly	T asks Ch to explain their ideas so that others can understand, if necessary asking 'is this what you mean?' and giving them some time, perhaps in small groups, to discuss and clarify what they think.				
	T provides Ch with positive feedback on how to review or take their ideas further	T responds to Ch's ideas by suggesting how they could be investigated in the current activity or later, or by referring to the Ch's ideas at some stage during the investigation asking 'do you still think that…?'				
Supporting children's investigations	T encourages Ch to ask questions	T asks, for example, 'What would you like to know about…?'				
	T encourages Ch to make predictions	T asks Ch to give their ideas about what they think might happen in the investigation, for instance: 'What do you think will happen if we… or when…?'				
	T involves Ch in planning an investigation	T makes sure that Ch take part in planning the investigation, e.g. by asking questions such as 'How can we find out whether our prediction is correct or not?' Teachers suggest a plan but it should be understood and agreed to by Ch.				
	T encourages Ch to check their results	T asks Ch to be sure to check their results by repeating observations or measurements where appropriate.				
Guiding children to conclusions	T asks Ch to state their conclusions	T makes it explicit that Ch should bring their results together in a statement of 'what we have found out about…'				
	T asks Ch to compare their conclusions with their predictions	T asks Ch to recall what they predicted and to compare it with what they found.				
	T asks Ch to give reasons or explanations for what they found	T asks Ch to explain and not merely describe what they found, for example by asking: 'Have you seen something similar before? Can you compare what you found with something you saw before? What could be the reason for…?'				
	T helps Ch to identify new or remaining questions	This could be by asking Ch what else they would like to know about the topic of their investigation and discussing the questions that have arisen.				
Guiding children to share ideas	T encourages Ch to make a group drawing, poster or model of what they have produced.	This could be by asking Ch to prepare, for example, a group poster that involves them putting their ideas together.				
	T takes notice of the Ch's ideas and encourages Ch to do the same	T uses exact expressions of Ch to highlight the different ideas, avoiding direct comparison (e.g. "S thinks that… B thinks that…").				
	T encourages Ch to listen to each other .	T ensures Ch speak one at a time and pay attention when someone else is speaking				

Children's perspective protocol

Foundation Phase learners' participation in inquiry-based science education (IBSE)

The purpose of the discussion is to listen to the opinions of young children on matters that affect them; to better understand their views and priorities regarding their participation in IBSE; and to empower children to state their opinions by means of participation-friendly methods.

Note: Questions will be based on the evidence of children's participation during observation of the IBSE activities in the Foundation Phase classroom. Questions/discussions will be used during three parts of the lesson
(1)DURING participation
(2)During the REFLECTION session (whole class reflection after the lesson)
(3)AFTER the lesson (focus group discussion)

The questions will follow a conversational approach as naturally as possible and should rather be seen as a "structured discussion" with the learners whose views and experiences I am interested to know (rather than a formal interview).

Follow-up and prompting questions will be used to extend the discussions.

Children's inputs will be captured digitally for further action.

The discussions will take place in the children's own classroom/school environment.

Date:
Duration:

Opening comments:
(To state the aim)

In this activity you acted as real scientists to solve a problem. My aim is to listen to your experiences as scientists (how you were thinking, acting, talking and feeling during your participation in the science activity). I would like you to share your ideas with me so that I can understand how young children express themselves as scientists. It is also important for me to listen to your ideas, because they are valuable, and they help adults make important decisions with your help.

In our discussions we will share knowledge and experiences individually and in small groups, draw pictures and make posters will all our shared ideas.

Examples of possible questions:

(1) Questions/discussions DURING the activity

Questions will be formulated to elicit discussion about children's participation in the lesson based on their hands-on/minds-on participation.

Anticipated questions to be asked DURING participation in the activity:

What problem are you trying to solve? Did you have an answer right away? Tell me about it. What are you noticing here?
Can you explain to me what you are doing now? What do you think will happen if… Do you think there is another way?
What questions do you have now?

Are you working together well as a group? How? Did you hear "S's" idea? Did you all agree? How did you negotiate the best solution as a group?
ETC.

(2) Questions/discussion during the reflection session (reflecting on the process of learning)

To allow children to reflect on their participation and their process of learning throughout the IBSE cycle – from engagement through designing and conducting investigations, drawing conclusions to communicating with others.

Questions will be formulated to elicit discussion about children's participation in the lesson based on their hands-on/minds-on participation.

Anticipated questions to be asked at the end of the activity:

In this activity you acted as real scientists to solve a problem. Can you remember what the question/problem was?
Did the teacher just give you the answer? How did you find the answer/solution?
Did you immediately have the answer? What did you do to solve the problem?
What did you do first? And then? Did it work? And if it failed, what did you do then?
How did you work together as a team to solve the problem? What worked well in your group? What was challenging?
How did you use your science journal? Did it work well for you? Do you think it is a good way of recording your ideas?
Who made the poster in your group? How did you decide what to write on it? Who presented your poster to the group? How did you feel about presenting your poster to the class?
How did you feel when you solved the problem?
How do you feel about this type of learning?

Is it important for you to tell us (adults) what you know? Do you think it is important for adults to listen to what you have to say? Why?
How would you like to share your ideas with adults? (Prompt: draw pictures, tell, write, …). What do you think should we do next?

(3) Questions/Discussions AFTER the activity
To work collaboratively with children to share decision-making and to check the validity of the data collected from them.

Questions/discussions will be formulated to elicit discussion on children's <u>products</u> as evidence of their involvement in the inquiry process (any evidence of their participation, e.g. written text/picture/poster/image).

Anticipated questions to be asked AFTER the activity

E.g. Tell me about this … (written text/picture/poster/image i.e. evidence of participation).
What happened here? How did you feel when that happened?
Can you tell me what you meant here…
Do I understand correctly … / Am I right if I say you meant…
ETC.

WHOLE CLASS REFLECTION SESSION (All schools)
Guidelines for questions

Questions on the PROBLEM/INITIAL SITUATION
Can you remember what the problem was?

Questions on children's OWN IDEAS (Engagement phase: think on your own)
Did the teacher just give you the answer/tell you exactly what to do?
So what did you have to do? Did you have an idea? Did you just know immediately what to do?
And then? After writing your own idea… what did you have to do? (e.g. Work in a group)

Questions on WORKING IN A GROUP/sharing ideas
How did you work together as a group?
Did you all have different ideas? Did you listen to everyone's ideas?
How did you choose the best one?

- What worked well in your group?
- What was difficult?

Questions on COLLECTING MATERIALS
(If appropriate)

Questions on the INVESTIGATION process/change of plans in the design
Did your first design work out?
So what did you do? (refer to investigation)
How did it feel like when you had to change your design/ plans?

Questions on "What did you learn?" (Drawing conclusions phase. Scientific knowledge and other IBSE skills)
What are the most important things that you learned through this activity?
Knowledge & Other skills

Questions on making notes/writing (Communicating ideas/making notes)
You had to make notes (write/draw your own ideas and the group's idea; what you changed, etc.)
You also had to make a poster of what you have learned.
How did it work for you?
How did it work for you to tell the rest of the class about your ideas?

Questions on children's views on the type of learning (Child-centred, inquiry-based learning)
How did you feel about this type of learning (i.e. where you do all the thinking and working yourself)
Can you do it, or should teachers rather tell you what to do?
Would you like to learn in this way again?

Questions involving children's voice
Do you think it is important to tell adults what you know and think (e.g. about science learning)?
Do you think it is important for adults to listen to what you have to say? Why?
How would you like to share your ideas with adults (draw pictures / tell / write / …)

Questions on children's views on working scientifically
Do you think you worked like scientists? Why do you say so?
Is it important for you to work in this way?
Is it important for you to tell adults …

DRAW a picture of yourself working like a scientist during the activity.

END session
Thank children for their participation and discuss the way forward

Focus group discussion: Student teacher participants

30 October 2015, 10:30 – 12:30
(PGCE lecture room, Groenkloof campus)

Well-being / How are you?

- Discussion on student teacher participants' involvement in the project.
- How did you feel about participation in my research project?
- Thank student teachers for participation.
- Discuss the way forward.

RESEARCH FOCUS/QUESTIONS

With the classroom observations, I focused on how children engaged in IBSE / how they viewed and expressed themselves as scientists / how they reflected their experiences.

Today's focus group discussion will help me answer the following questions:

- How you reflect your experiences of facilitating IBSE in a FP classroom
- How prepared you feel to implement IBSE
- What challenges you experienced
- What support you need to implement IBSE

I will use this session to ask questions.
I will also ask you to fill out additional reflection documents. NOTE: These are **OPTIONAL** if you feel you need to contribute more to the discussion. To save time you can complete these documents in your own time and return to me by 5 November 2015.

YOUR IBSE ACTIVITY

You were all in different school settings. Please share a short description of your IBSE activity. Co-present the PPT I designed based on my observations.

WHY DID YOU DECIDE ON THIS PARTICULAR ACTIVITY?

***1.Facebook page** (Give a case a name + post comments)

SITUATIONS IN YOUR TEACHING PRACTICE SCHOOL

***1.Facebook page**

What science practices did you observe (mentor teacher/school) during your teaching practice period?

What, according to you, makes the situations in your (teaching practice) school ideal for implementing IBSE?

Or …not ideal? How can these challenges be addressed?

What can be done to make IBSE work in a school context?

IBSE FRAMEWORK, STEPS & FACILITATION PROCESS

***QUESTIONS FOR DISCUSSION** (First think on your own – make a few notes, share individually and then share in the group…).
Please elaborate on the document:
***2.Steps of IBSE…** (Make notes on the steps - left side – YOUR facilitation experiences; right side – children's participation)

Comment on the PROBLEM or QUESTION you posed that led to the investigation.
Were you able to craft a "good /productive question"?
What **challenges** did you experience in this regard?
Were children able to commence with the investigation?

Problem/question is based on OUTCOMES
Outcomes (objectives) for IBSE would be to acquire science knowledge and skills – investigation skills, language and other skills (e.g. social skills).
How did you experience the formulation of outcomes for the IBSE activity?

What did you do to ENGAGE children in the activity (during the engage stage?).
During engagement children need to become familiar with the phenomenon under study.
Comment on the effectiveness of the engagement stage.

All of you created a **"real life"** situation (transcendental paradigm) …
Tell me about this experience.
Do you think "real life" will always be necessary to initiate IBSE?

One of the trademarks of IBSE is that children's own ideas (prior knowledge) are taken into consideration. Did you use children's prior knowledge (experiences and ideas) to build new ideas? How did you manage to do this?

What were your experiences of the "think on your own"-stage?

What were your experiences of the sharing ideas in the group-stage?

How did you facilitate the DESIGN AND CONDUCT SCIENCE INVESTIGATIONS stage?
Were you able to facilitate children's investigations? How did you do this?
Were children able to use inquiry skills to answer the question (solve the problem)?
(Student teacher 1: Children have not been taught the investigative skills)

How did you facilitate the DRAW FINAL CONCLUSIONS stage?
Did children learn what you intended them to learn? (…according to your lesson plan?)
Did the children reach the outcomes of your lesson?
WHAT DID CHILDREN LEARN? (What were the most important things children learned through this activity?)
Did children manage to give evidence to support their newly constructed ideas?

Did they acquire science concepts only, or did they acquire other skills as well?

How did you enable children to COMMUNICATE WITH OTHER AUDIENCES?
What are children's abilities in this regard?

When the groups were required to communicate their understanding to the class…
Were you able to facilitate and manage group discussions during the inquiry process?
What **challenges** did you experience in this regard?

RECORDING/NOTES/Notebook/Journal/Posters

How did you experience the recording (making notes) part of IBSE?
In what way did children record their scientific ideas (talking, text, drawings, charts, posters, etc.).
What are children's' abilities in this regard?

Were children able to tell their "science story"?

What do you think is the value of recording ideas?

What support do children need in this regard?
How did you support children in recording their science work?

SHOW EXAMPLES OF CHILDREN'S WORK – and discuss.

Student teacher 3 focused attention on reminding children to keep up with the note-making.

*3. SELF-REFLECTION TOOL: PUPILS' RECORDS
*2. Steps of IBSE

ROLE OF THE FACILITATOR

How did you experience your role as facilitator of inquiry-based learning to foundation phase children? Refer to your personal experiences.

*4. I CAN FACILITATE IBSE-INDEX

Rate yourself on the index; Also add your qualities.

*5. SELF-REFLECTION TOOL: THE TEACHER'S ROLE

You presented one IBSE activity for me to observe.
Did you present any other IBSE activities during your teaching practice period? How successful were they?

PLANNING, CLASSROOM ORGANISATION AND MANAGEMENT

What were your experiences of planning for an IBSE activity? (Lesson format, selecting outcomes, science content, inquiry skills …)

Were you able to organise the classroom according to the requirements of IBSE? Comment here on the physical environment as well as the classroom culture ("culture of inquiry").

Did you find it easy to plan & prepare for a hands-on activity?
Resources for hands-on activity?

Classroom management in IBSE?

What were your experiences of GROUPWORK?

What SUPPORT do you need to plan for a smooth IBSE activity?

CHILDREN'S ENGAGEMENT IN IBSE

Many of the questions asked in the previous section already addressed questions in this section.

For children, this was a new / first experience…
Do you think ECD/FP children can engage in the cycle of IBSE? (Can they do it)? Elaborate.

*6. SELF-REFLECTION TOOL: PUPILS' ACTIVITIES
*2. Steps of IBSE

CHILD-CENTRED / INQUIRY-BASED LEARNING

How did children respond to the hands-on/mind-on approach (this type of learning)?

Have you noted any particular benefits for children learning through this approach?

*7. Key-Principles of IBSE – list (in classroom).

IBSE principles (highlight)
What have you observed / experienced. Add if necessary.

WHAT DO YOU ABOUT CHILDREN'S SCIENTIFIC ABILITIES?

I asked children whether they think they are scientist.
Children seem to think that they have scientific abilities / that they are scientists.
What is your opinion on this? Are they natural scientists?

(Can they think and act like scientists?) Why do you say so?

What makes the ECD/FP ideal (or not ideal) for IBSE

What have you noticed / what did children say/do? (Student teacher 2's booklet)

What support do you think do children need in order to engage in IBSE?

CHALLENGES

What, if any, were the main challenges you experienced in the implementation of IBSE in the foundation phase classroom and/or school?

Prompts
IBSE approach
School factors
Classroom factors (e.g. classroom management; group work)
Teacher/Teaching
Learner/Learning
CURRICULUM. Do you think CAPS makes provision for IBSE?

*8. CHALLENGES! CHALLENGES!

PREPAREDNESS

You do not necessarily have a science background.

Does it take a specific type of person to be able to do IBSE?
Can anyone do it?

How prepared do you feel to implement IBSE? (Please elaborate).

***9. Strategic development star** (You will need Pollen notes to complete this star).
FILL in the ***10. Preparedness Index**

What could be done to better prepare you for facilitating IBSE?
***Sticky Note Poster (class)**

DO YOU HAVE A TAKE-HOME MESSAGE?

Despite the many challenges you mentioned …
Student teacher 1 said: IBSE should be implemented in all schools as it is a great way to improve the learners' cognitive and practical skills and it will be beneficial to the learners in all aspects …
***1.Facebook page**

ADD? What are your final thoughts?

Anything else you would like to mention?

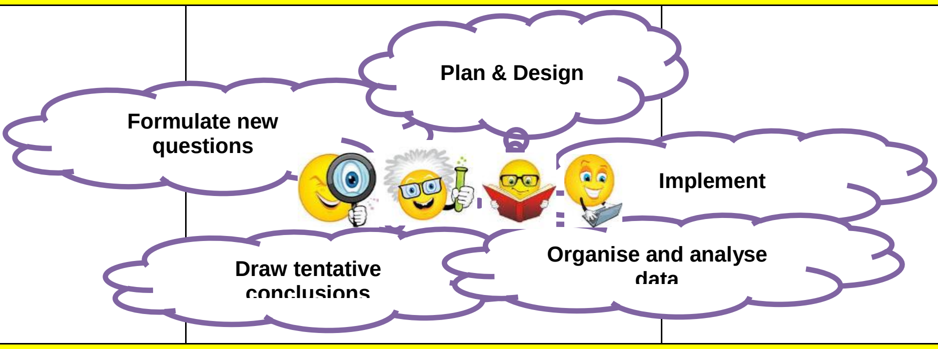
1.

JOIN US
CLICK HERE

Profile	My name is
	My TP school
	My IBSE activity…
	I chose this activity because…
-------------------------------	I wanted the kids in my class to…
IBSE made the kids feel…	
I think I am…	
IBSE made me feel…	
The craziest thing I realised through presenting IBSE …	
The most special moment …	
The weirdest thing that happened …	
If I could change anything…	
My perspectives on the implementability of IBSE in the FP…	
My perspectives on the implementability of IBSE in my TP school …	
To help my school become more IBSE friendly…	
(Don't like)	
(What is there to like?)	
Like (Like)	
(Share)	
(Search IBSE friends)	
(Request IBSE friends)	
(Unfriend IBSE non-friends)	
(Message for stakeholders)	
Become a Fan	
My ultimate share message …	

2. STEPS of IBSE

Based on your experiences facilitating IBSE, please write comments (on the framework) to state your views on (1) children's participation (right); (2) your facilitation (left)

You (Facilitation)	STEPS	Kids (Learning)
	PROBLEM	
	Scientifically-oriented problem / investigable question	
	ENGAGE PHASE	
	Think-on-your-own (prior knowledge)	
	Share ideas in the group. Choose the best option, plan investigation	
	DESIGN AND CONDUCT SCIENCE INVESTIGATIONS PHASE	
		
	DRAW FINAL CONCLUSIONS PHASE	
	Draw conclusions to answer the question (and reach the outcomes)	
	COMMUNICATE WITH OTHER AUDIENCES	
	Communicate understanding to others (in different formats) & justify explanations	

	RECORDING SCIENTIFIC IDEAS	
	Record all steps (science journal & poster)	

(3)Self-reflection tool for facilitator/teacher (For student teachers to use after presenting IBSE).

Adapted from the LAMAP *Tools for Enhancing Inquiry in Science Education.* Available from http://www.fondation-lamap.org/sites/default/files/upload/media/1-tools_for_enhancing_inquiry_in_science_education.pdf

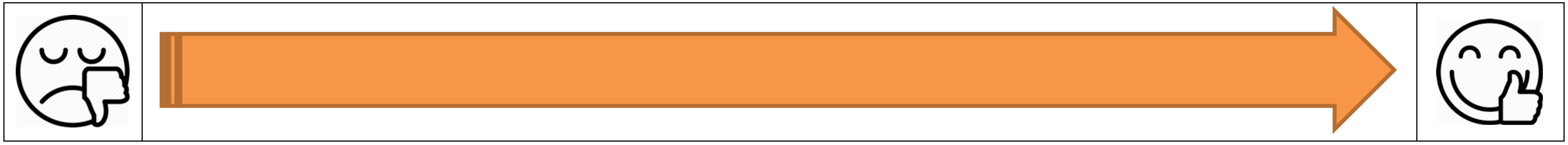
Items ST = student-teacher; Ch = child/ren		Examples of good practice	Evaluation			Notes
Building on children's ideas	Did you ask questions requiring Ch to give their existing ideas?	You asked Ch open questions (requiring more than a one-word answer) which probed what they were thinking, not only at the start but at other times in the activity. E.g. 'What do you think is the reason?' rather than 'what is the reason?'.	Yes	No	N/A	
	Did you help Ch to formulate their ideas clearly?	You asked Ch to explain their ideas so that others could understand, if necessary asking 'is this what you mean?' and giving them some time, perhaps in small groups, to discuss and clarify what they thought				
	Did you provide Ch with positive feedback on how to review or take their ideas further?	You responded to Ch's ideas by suggesting how they could be investigated; or referred to the Ch's ideas at some stage during the investigation asking 'do you still think that…?'				
Supporting children's investigation	Did you encourage Ch to ask questions?	You asked, for example, 'What would you like to know about…?'				
	Did you encourage Ch to make predictions?	You asked Ch to give their ideas about what they thought might happen in the investigation, for instance: 'What do you think will happen if we… or when…?'				
	Did you involve Ch in planning investigations?	You involved Ch in planning the investigation, e.g. by asking questions such as 'How can we find out whether our prediction is correct or not?' You suggested a plan but Ch understood it and agreed to it.				
	Did you encourage Ch to check their results?	You asked Ch to check their results by repeating observations or measurements where appropriate				
Guiding children to conclusions	Did you ask Ch to state their conclusions?	You explicitly asked Ch to bring their results together, i.e. by asking them 'what have we found out about…'				
	Did you ask Ch to compare their conclusions with their predictions?	You asked Ch to recall what they predicted and to compare it with what they found.				
	Did you ask Ch to give reasons or explanations for what they found?	You asked Ch to explain and not merely describe what they found, for example by asking: 'Have you seen something similar before? Can you compare what you found with something you saw before? What could be the reason for…?'				
	Did you help Ch to identify new or remaining questions?	This could be by asking Ch what else they would like to know about the topic of their investigation and discussing the questions that have arisen.				
Guiding children to share ideas	Did you encourage Ch to make group drawings, posters, or models of what they produced?	This could be by asking Ch to prepare, for example, a group poster that involves them putting their ideas together.				
	Did you take notice of Ch's ideas and encourage Ch to do the same?	You used Ch's exact expressions to highlight their different ideas, avoiding direct comparison (e.g. 'S thinks that… B thinks that…').				
	Did you encourage Ch to listen to each other?	You made sure that Ch spoke one at a time and paid attention when someone else was speaking.				

4. I CAN FACILITATE IBSE INDEX

How do you experience yourself as facilitator of IBSE?
Position yourself on the index below (use a sticker)
Stick a **sticker** on the arrow, and justify your position (in the cloud)

Justify:

INDEX



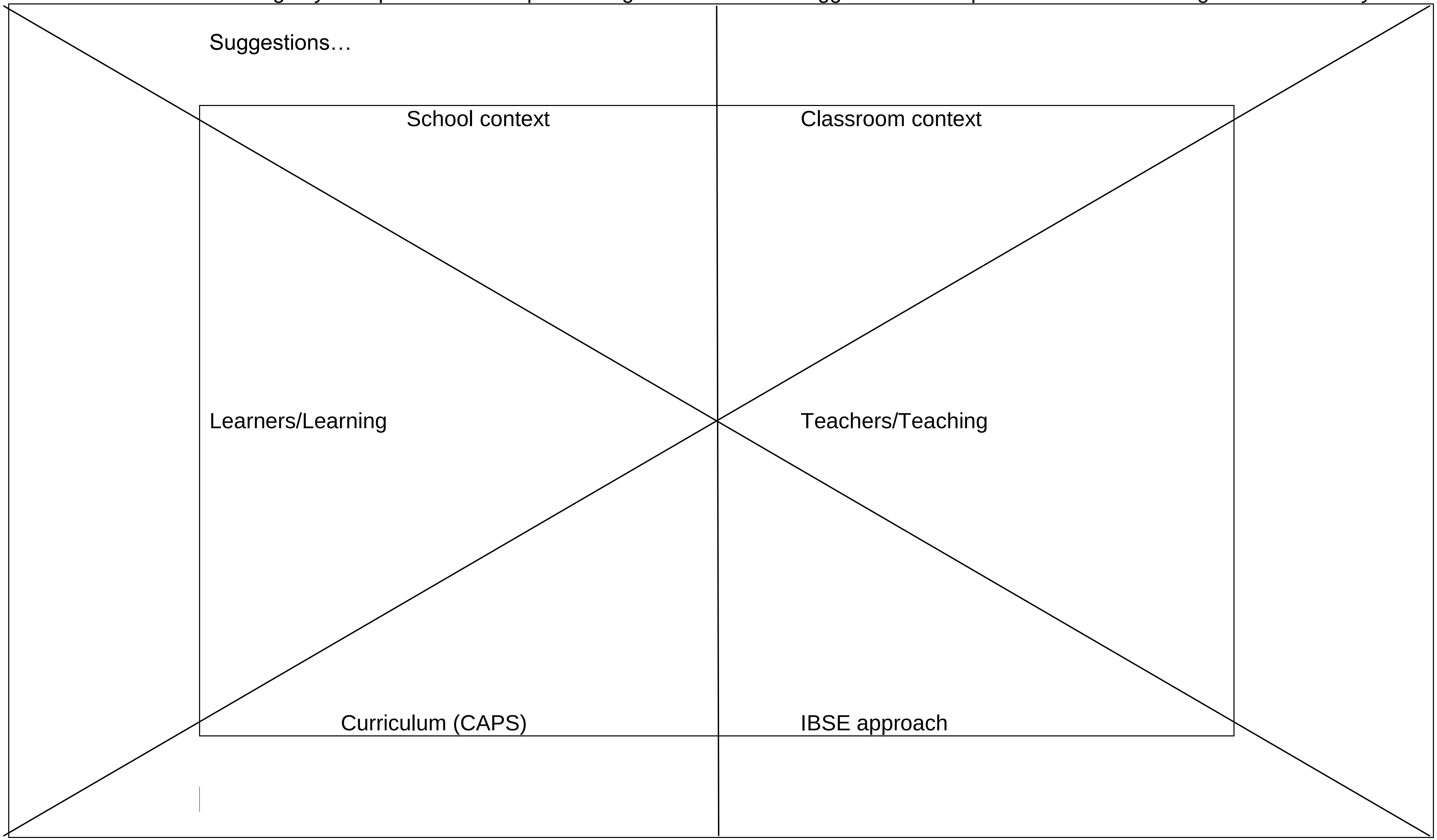
How about your IBSE facilitation **qualities**?

Qualities I need

Qualities I have

8. CHALLENGES! CHALLENGES!

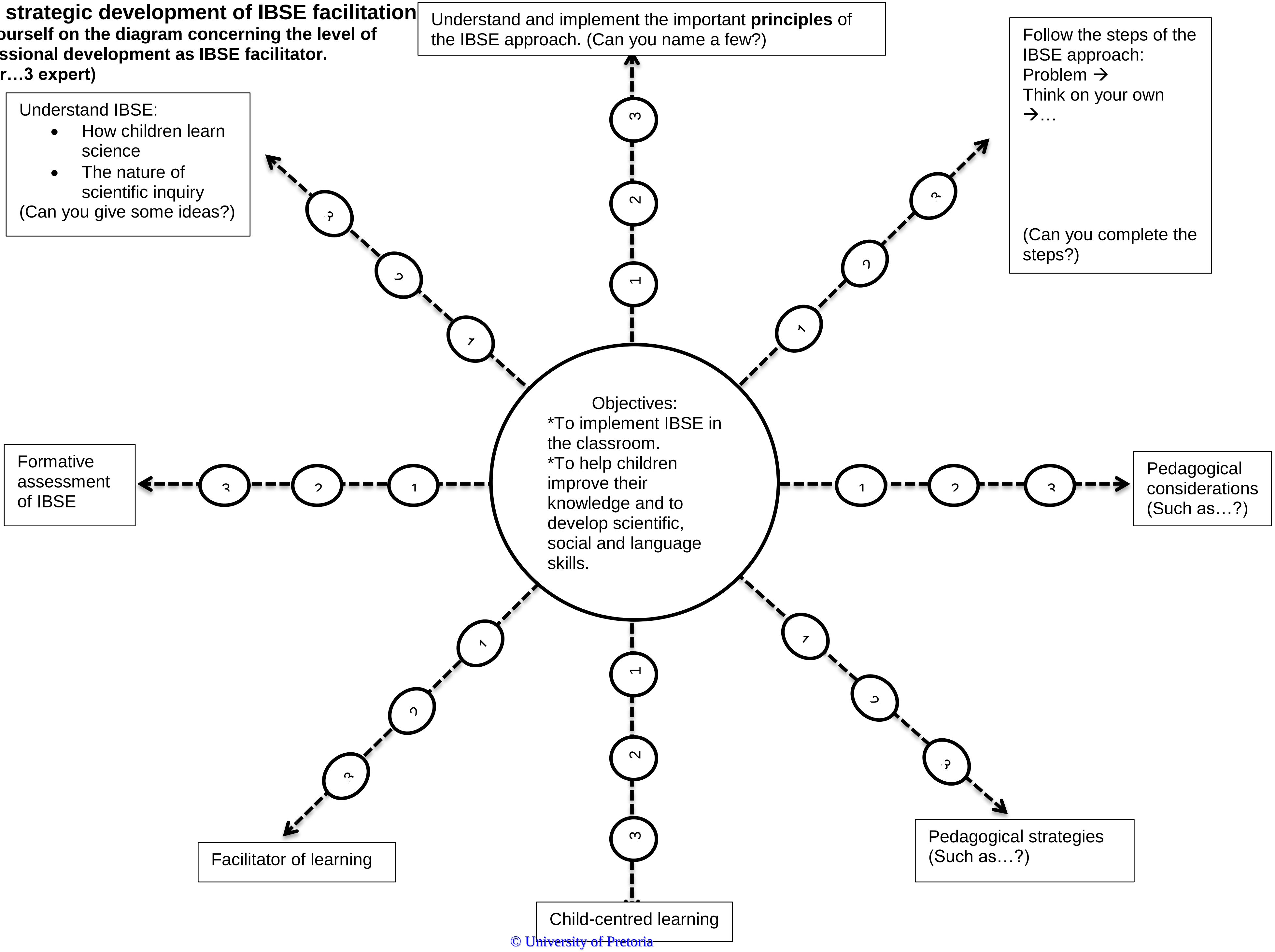
What are the main challenges you experienced in implementing IBSE? Provide suggestions to help overcome the challenge in the outer layer.



9. STAR: strategic development of IBSE facilitation

Position yourself on the diagram concerning the level of your professional development as IBSE facilitator. (1 beginner…3 expert)

Consider the entire star …. Indicate where you see yourself now, and also say what it will take to help you reach the objectives (make notes on the axis).



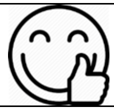
Sticky note poster

What do you consider to be the most problematic when trying to implement IBSE activities in the classroom?

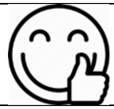
How can your lecturer support you better to overcome these challenges?

How do you think should student-teachers be prepared to effectively implement inquiry-based education in practice (early childhood and foundation phase)? Please share your suggestions.

10. PREPAREDNESS INDEX
Consider your preparedness to implement IBSE
How prepared do you feel to implement IBSE?
(Tick, and please elaborate)

Poor	OK	Great
		

Did you receive sufficient sources and documents to expand your knowledge and skills on how to facilitate IBSE lessons?

Poor	OK	Great
		

How effective were the approaches (below) to prepare you to facilitate IBSE?	Tick one of the options (preparedness index): **(1 Poor) / (2 OK) / (3 Great)**	N/A	Why/How	Suggestions to improve	Do more (+) Do less (–) OK as is (✓)
PPT lectures: What is science / Children's science / Components of science / Different approaches to teaching science / …	1 – 2 – 3 →				
Hands-on session (Two bottles experiment) to experience IBSE from two perspectives: as learner and as facilitator - and reflection	1 – 2 – 3 →				
LAMAP French videos on Kindergarten science (seed germination, earthworms, magnets), and reflection	1 – 2 – 3 →				
Establishing the steps and key principles of IBSE from own participation in hands-on activity and watching videos (See key principles document)	1 – 2 – 3 →				
LAMAP French videos on Grade 2 activities, and reflection	1 – 2 – 3 →				
Hands-on sessions (e.g. car race) to experience IBSE from two perspectives: as learner and as facilitator - and reflection	1 – 2 – 3 →				

Showing examples of previous year's students (videos and lessons)	1 – 2 – 3 →				
Jigsaw session to learn the content of LAMAP IBSE – e.g. important principles, pedagogical considerations, pedagogical strategies…	1 – 2 – 3 →				
Working in groups to design own lesson based on the themes for Grades 1, 2, 3.	1 – 2 – 3 →				
LAMAP IBSE (Pollen) booklets	1 – 2 – 3 →				
IBSE Frameworks (x2) and explanatory notes	1 – 2 – 3 →				
Chapter on "Teaching science through inquiry" (clickUP)	1 – 2 – 3 →				
Reader: Notes on inquiry (articles and ideas)	1 – 2 – 3 →				
Websites suggested in class / on clickUP	1 – 2 – 3 →				
Vosniadou's principles of how children learn	1 – 2 – 3 →				
TP2 IBSE guidelines	1 – 2 – 3 →				
Facilitating IBSE during TP1 & TP2 (i.e. to apply in practice)	1 – 2 – 3 →				
What other sources or methods do you find useful for your own professional development regarding IBSE (E.g. Any particular effective training; mentor-teacher; peers; clickUP, Internet, Pinterest, etc.)					

My training prepared me appropriately for understanding		**Suggestions to improve**
…how young children learn	1 – 2 – 3 →	
…what science is (all about)	1 – 2 – 3 →	
…what science education entails at early childhood and foundation phase level	1 – 2 – 3 →	
…the importance of science education at ECD/FP level	1 – 2 – 3 →	
…what IBSE is and entails	1 – 2 – 3 →	
…the key principles of scientific inquiry	1 – 2 – 3 →	
…how children engage in scientific inquiry	1 – 2 – 3 →	
…the IBSE framework		
My training prepared me appropriately for		
…**planning** IBSE units/activities	1 – 2 – 3 →	
…selecting suitable content for IBSE	1 – 2 – 3 →	
…developing children's inquiry skills	1 – 2 – 3 →	
…facilitating IBSE units/activities	1 – 2 – 3 →	
…designing a learning environment that promotes inquiry	1 – 2 – 3 →	
…organising a classroom for IBSE	1 – 2 – 3 →	
…managing an IBSE classroom	1 – 2 – 3 →	

I needed a whole lot more training on….

Appendix D: Transcripts

Whole class reflection (Interview)

School A, Grade 1 (6-7 years), 25 children

Date: 24/8/2015

C: child
R: researcher

PROBLEM. R Can you remember what the problem was?

C: To build a tank for the fish

R Why?

C Because they can only spend two hours in a bag

OWN IDEAS. R Did the teacher just give you the answer? (Did she tell you exactly what to do)

Class No

R So what did you have to do?

Class (About 3 children) No she said make it your own way

R So did you know how to do that?

Class (Majority of group responded) YES

Class (Some said) No

R Did you just know immediately what to do?

C No we first had to listen to our teacher

C I kind of had an idea

C We had to think

R responded, did you hear what she said – you had to think

R Was it possible for you to think?

Class (Majority of group responded) yes

WORKING IN A GROUP. R After writing down your own ideas, what then?

C We put them all together!

R You put all your ideas together in the group?

R So did you all share your ideas in your groups?"

Class (Majority) YES

R How did you work for you to work in a group?

C Teamwork (Girl, Excited about the answer). We did teamwork

Comment [LB1]: PROBLEM
Children able to formulate problem in own words. To build a tank for the fish

Comment [LB2]: Problem
And give reasons

Comment [LB3]: Followed instructions

Comment [LB4]: I kind of had an idea

Comment [LB5]: THEORY TT

Comment [LB6]: THINKING child

Comment [LB7]: We had to think

Comment [LB8]: Children all seem to think they can think

Comment [LB9]: THINKING = natural

Comment [LB10]: Put ideas together (social learning)

Comment [LB11]: SHARE IDEAS

Comment [LB12]: CAN SHARE IDEAS - COS

Comment [LB13]: Teamwork

Comment [LB14]: COS

R Yes, but how did you feel about the teamwork?

C Boy "Good"

R Why?

C Because we working together

R Why is it important for you?

C Because then life will go easy..easier…more not difficult anymore

R Why will it be easier for you?

C Because then like, then you don't have to do it all by yourself and it becomes boring

R And then it becomes boring to do it all by yourself? Who wants to add to that?

C Girl Sometimes, hm sometimes you have to because it's going to take long to do it. So you have to have somebody to use it, then, then you going to do it very late and you're going to get tired

C One boy answered (soft voice – but lawnmower overpowered the sound – couldn't hear on any device).

R Was there something that was difficult to do in a group?

C Everyone thought of different ideas and it was hard to choose one of them

R --- hard to choose because all the ideas were so good?

R And what did you do?

C We made up one

R Did you choose one or did you make a new one?

R We made a whole new one that the whole group decided

R But what was difficult (Refer to Zia; invite Zia to talk about her experience)

C (Zia) I couldn't really understand why no-one took any one of my ideas

R So Zia told me she felt left out, because she thought that no-one listened to her ideas. How can we solve that problem? What should we do if we work as a team?

C Girl We must all listen to everyone's ideas

R So we must all listen to everyone's ideas

C Boy Maybe we can make two tanks and attach them together

R – You have such clever ideas.

COLLECTING MATERIALS. R Okay. And then then you had to collect materials. And you already made your plans. And when you got there, someone already took the materials you needed. How did you feel about that?

Comment [LB15]: Teamwork good
(social learning)
COS

Comment [LB16]: Roleplayer
COS (social learning)

Comment [LB17]: (social learning)
COS
Teamwork good
Because we working together

Comment [LB18]: COS/Role player

Comment [LB19]: EMOTION
(social learning)
COS

Comment [LB20]: Social learning
Teamwork good EMOTION

Comment [LB21]: Teamwork good

Comment [LB22]: EMOTION

Comment [LB23]: Teamwork good
EMOTION

Comment [LB24]: EMOTION
(PSW)

Comment [LB25]: EMOTION
(PSW)

Comment [LB26]: Teamwork difficult

Comment [LB27]: Made up an idea

Comment [LB28]: EMOTION
PSW

Comment [LB29]: NEW THEORY
(TT-revision)
COS

Comment [LB30]: Group - Made new idea TT-revision

Comment [LB31]: No-one took my idea

Comment [LB32]: EMOTION
PSW (develop)

Comment [LB33]: ROLE PLAYER / COS – learn roles

Comment [LB34]: Learn skills to work together (social learning) PSW

Comment [LB35]: Learn skill to work together (social learning) PSW

Comment [LB36]: ROLE PLAYER / COS – make plans

C Boy Made new ideas!

Class (Two children added) We had to make new ideas

R You had to make new ideas! And how did you feel about that?

C Girl: "Hmm, sort of nice" (showing sort of with hand)

R Sort of nice? And what does that mean?

Class (One / more children replied) Little bit

C A little bit nice and a little bit not nice

R And how did you solve that problem?

C Girl We listened to everyone's ideas and put it all together

R She listened to everyone's ideas and put it all together again…

C And do teamwork

C Boy We didn't have a tank and we (COULDN'T hear properly)

C Girl And you also mustn't throw a tantrum if they .. if they also… if they take your idea… and they come up with a new idea, you mustn't throw a tantrum.

(Some talk to get children's/red group's attention)

INVESTIGATION/CHANGE OF PLANS. R So who of you had a design…your own idea…and your tank looked exactly like your idea?

C Boy Mine didn't look exactly like how I planned it.

R So did you have to change your plans?

Class (Many answered) YES

R So did your first plan work out?

Class NO

R And then, if it didn't work out? What did you have to do?

Class (Many voices) We had to change it

Class We had to make a new plan

R How did you feel when you had to make new plans / change your plans?

C Boy A little bit good and a little bit sad

R Why sad?

C Because if you really wanted that …that part that you wanted…

R, ya, and then?

C (Boy continued) Then you make up with a new idea and then you feel happy.

Comment [LB37]: Made new ideas!
TT-revision

Comment [LB38]: THEORIES NEW
TT-revision

Comment [LB39]: Made new ideas

Comment [LB40]: TT-revision
Change ideas
"Hmm, sort of nice"

Comment [LB41]: TT-revision
NEW THEORIES = nice / hard

Comment [LB42]: TT-revision
Change ideas
A little bit nice and a little bit not nice

Comment [LB43]: TT-revision
NEW THEORIES = nice / hard

Comment [LB44]: TT-revision
Used group skills to put new ideas together

Comment [LB45]: COS / Role player - put ideas together

Comment [LB46]: Teamwork good

Comment [LB47]: COS / Role player teamwork (social learning) PSW

Comment [LB48]: Teamwork skills (social learning) PSW

Comment [LB49]: Role player (social learning) PSW

Comment [LB50]: Initial idea – relevant (TT … predictive power)

Comment [LB51]: Initial idea – had to change

Comment [LB52]: TT-revision
THEORY revision

Comment [LB53]: Initial theories needed revision

Comment [LB54]: Revise ideas

Comment [LB55]: TT-revision

Comment [LB56]: Revise ideas

Comment [LB57]: TT-revision
Revise ideas
A little bit good and a little bit sad

Comment [LB58]: TT-revision
feels good + sad

Comment [LB59]: Emotional
Deal with disappointment / resilient
PSW

Comment [LB60]: TT-revision
= happy

Comment [LB61]: TT-revision
Revise plan = feel happy

R And how did you feel about the end result (the tanks you made) …were you happy about that? Did it work out well for you?

Class Yes…

(Group is getting restless and tired; Some talk to get attention)

LEARN. R What are the most important things that you learned through this activity?

C Boy Helping God's creatures

C (Zia) – difficult to hear… explaining how the new sack should be put in the tank…

C (Boy explains about the channel he watches on TV about fish)

R OK, but what did you learn from participating in this activity?

C Girl To work as groups

R Okay, yes to work together as a group. Yes that was also an important thing to learn.

R And what did you learn about the tank?

C It is not that easy to make

R It is not that easy to make, and what else? How should a tank be like?

C Girl They must be empty, and you fill it up with water

R And what would happen if the water leaks?

(Children too restless – inconclusive discussion)

WRITING NOTES. R How did you feel about writing down your ideas?

C It felt good

C Girl: It was a little hard

R What made it hard?

C Cause you had to design still and you had to do a lot of working

R (repeat) You had to design still and you had to do a lot of working

R (Try to get Green group's attention). How did you feel about the writing?

C Boy It felt good

R Why?

C Because … you could write what you were thinking of and see if you made any changes or not for the real one

R So, writing down helped you to…

Comment [LB62]: LEARN
Scientific VALUE

Comment [LB63]: COS / Role player
Groupwork (social learning) PSW

Comment [LB64]: Real life problem solving – not easy
21st century skills

Comment [LB65]: Science knowledge

Comment [LB66]: Writing = Good

Comment [LB67]: COMMUNICATOR / SYMBOL USER

Comment [LB68]: Writing = hard

Comment [LB69]: Writing is a lot of work

Comment [LB70]: Writing is good

Comment [LB71]: Write what you are thinking
Keep track of thoughts

C (Boy finished the sentence) … to think of it

R And how did you feel about the writing (pointing to another group)

C Hard

C Pretty good

R Why pretty good?

C Boy To save God's creatures, so that's why it felt good

R Repeat question to another group: How did you feel about the writing?

C Good. We made up with an idea and then we happy, feel happy

HOW DO YOU FEEL ABOUT THIS TYPE OF LEARNING?

Class (many voices) Good…Good…Good

R Now why should we not just tell you what to do? Can you think on your own?

C Girl: No.

R Not?

C Girl: If you think on your own it will get a little hard; … if you listen to your teacher it will get much more better.

R Is it? Is it better if the teacher tells you what to do?

C Girl: Yes

CHILDREN'S VOICE. R Do you think it is important for adults to listen to what you have to say?

C Yes.

(Girl Nodding, looking excited)

R Why?

C Because it's good

R Why? What is good about that?

C Girl continues. Uuhh, …(thinking) (sound bad – can't hear) …. Uuhh … I don't know

WORKING LIKE SCIENTISTS. R I can see you are tired now, but do you think you worked like scientists?

C Boy: Too tired to think

R Can you think like scientists?

Class: YES!

R Now all of you said yes, but you have to tell me why you say so (Children tell about science stuff at home…not related to classroom)

Comment [LB72]: Writing help to think of it

Comment [LB73]: Writing feels pretty good

Comment [LB74]: Activity generated good feelings EMOTION PSW

Comment [LB75]: Making up new idea = feel happy

Comment [LB76]: TT-revision = happy

Comment [u77]: IBSE

Comment [u78]: IBSE = Good…Good…Good

Comment [LB79]: IBSE Think on your own = hard Listening to teacher = easier

Comment [LB80]: Children knows listening to teacher is required

Comment [LB81]: Adults should listen

Comment [u82]: SCIENTISTS

Comment [LB83]: Natural scientists

Comment [LB84]: Science experiences not school-based

C Girl I like scientists because I practise being a scientist

C (Another girl): I know already how to be a scientist because I just got science stuff in my room

R But in the classroom?

R Girl: Now I'll try and be

C Boy I have a science book at my house

R You have a science book at your house.

(DISCUSSION ENDED - Kids too tired/restless to continue)

Comment [LB85]: I know already how to be a scientist because I just got science stuff in my room

Comment [LB86]: Science experiences outside classroom

Comment [LB87]: Science book at home

Comment [u88]: Natural??? Science experiences = out of school

Focus Group Discussion

SCHOOL A; Grade 1 (6-7 years)
GROUP 4 (Green) Questions based on PPT on group's participation.
Date: 25/08/2015 (09:00)

Key:
R: researcher
C: Child

R Opening communication. Do you see your names there? I wrote the names of the scientists that participated in the science activities.

R (Can you remember what my project was all about). Are you scientists?

Class (Whole group responds) Yes

R Why do you say so?

C Because we're clever

R repeats "Because we're clever". And why else? Why do you say scientists are clever?

C Oh because they think of clever things

R They think of clever things. Can YOU think of clever things?

C Yes

R Where, and when? Can you give me examples of when you were working on the fish project?

C The day before yesterday

R OK, so how did you think clever?

C We thinked!

R We thinked! That's perfect! That is what a scientist should do. And what else?

C And we put all of our ideas together

R And you put all your ideas together. Is that also what scientists do?

C Yes

R Ya, of course, because they can't keep all the cleverness to themselves hey?; They share!

C Like we did with the other groups

PROBLEM (Show PP, picture of fish in bags). Can you remember what the problem was?

C (Looking at the picture) … because it can't stay long in the plastic bag

R OK so what did you have to do?

C There's no air in the bag

R There's NO air?

C And it's not big enough

R Is there no air in the bag?

C There is

R There is, but …

C Children … not that much

R Not that much that will keep them alive for too long

C It's about three hours

(R explain the oxygen tablets in the bag so that they can last longer)

GROUP 1: Miss A went to the pet shop and the people that owned the fish's tanks were broken and you had to take them and then he said they can only live two hours in a sack. So we had to build a tank for them.

Miss Bronwyn also asked you if a fish was a living being, and why you said so. How do you know that the fish is living?

C It's swimming

C It's moving.

R He said swimming, so is moving and swimming the same thing?

C Yes

C And the guiles are moving

R And why is that a sign of living thing?

R Because they breathe

C And if they're upside down it means that they are sick

R Yes, that is not a good sign

(Discussion about upside down fish – dead)

(Group 1 ideas added: They are not dead yet. Moving. Heart pumping. Tail moving. The eyes must be open. Not upside down)

R And the plastic fish I gave you the other day. Were they living or non-living?

C Non-living

R Why do you say so?

(Discussion on how the fish grew in the water)

R Did you feed your plastic fish?

C I did!

R With what?

C With fish food

R Really?

R And living fish, do they also need food?

C Yes!

C If they don't get food they will die

(PP Think on your own). R This was when you had to think on your own. Did you have any ideas?

C Yes, I wanted to make it with a big box, and tape the cello tape around

(Interrupted by child finalising arrangement for sports-event …)

R OK, when you had to think on your own, did you have any ideas, or was there just nothing?

C Child explaining … (Inconclusive talk)

Group 1 (Long discussion about Dylan's initial ideas, summarised). Dylan explains that water is needed to keep fish alive. He planned to decorate the fish tank to represent conditions in the sea. He explains the use of seaweeds to produce oxygen. "On land the trees make us oxygen. So it works the same in the water"

R Let's just watch a video of you. Working together.

R And then I said shouldn't you test it? Did you test it?

C No

WORKING IN A GROUP. GROUP 1. R How did you feel about working in a group?

Happy … happy. We feeled happy.

R So what was good about working in a group?

We made a big tank. So it was really feeling happy. So for the fish when they get in the tank then they feel happy and they didn't feel stressed because they're only allowed to stay … they can only stay in the water for two hours and that's going to be boring for them.

R But working in a group…How did that work for you?

C Good. Sometimes it feels bad because they don't use your idea and then you feel really really really mad, then you can't be like really mad, because it's actually mean to be mad

WRITING (Note: When I went through the written work, one by one, one boy pointed out that I made a mistake. I had the wrong name written on his work, so we checked, and corrected it.)

LEARNING. R SO what have you learned in this project?

C To save God's creatures

C To look after animals

C To put them back in their home, and to also help other people (referring to the pet shop owner)

R OK, and through making a tank, what did you learn?

C How to share

R How to share

C And that you had to use different materials, and not everything has to be the same

R And some materials are…?

C Difficult to use

R And tell me more about the materials? Are some better to use than others, or are they all the same? What have you learned from your first tank, and the tank you ended up with?

C You can use anything

C No you can't use anything

R Can you use anything to build a fish tank?
(Incomplete…)

GROUP 1. We learned that they need food and a big place to swim

R How do you feel about learning this way… Where you had to…

(Interesting discussion)

C It was hard

(Discussion)

C It was easy for me

R Quite hard for you, and easy for you… why was it easy for you?

C Uhm because everyone had different ideas so that we could choose one. If it was just me then we wouldn't of … we wouldn't of had so many ideas

R And why was it hard for you… to work in this way? Was it hard to think?

C Uhm … Chuckles … No!

C It was easy to think

C It was quite nice

R It was quite nice?

C Yes it is nice to work in a team

C (another boy adds)… and a group

R Yes, it's nice working in a team and sharing ideas. So, do you like learning in this way?

(Overwhelming) YES!

R Ok, and would you like to do it again?

(Overwhelming) YES! We should save more fish.

Should adults listen? Do you think it is important for us to listen to your ideas?

C (whole group) YES!

R Why? You're just children, why should we listen to your ideas, you're still tiny…

C Because we might … we might have better ideas than what you do

R Aah really? (Lots of chuckles) Do you agree?

C Yes (chuckles)

R Why?

C I don't know

R We are just bigger and older and wiser…

C Because…

R No but I like your idea, but you have to convince me now. Do you agree with him? Sometimes you have better ideas than adults?

C Oh yes, I know why … because then because then … Sometimes we can beat the adult's ideas

R So we should listen to children's ideas. And how would you like to tell adults? Should we talk about it, or should we make drawings, or notes, or write like this (pointing to their science journals)…

C Talk about it … Talk about it

C I would write so that they don't know it's me

R Why don't you want them to know it's you?

C (Child hesitant to answer)

C… because…

R Because I think your idea is valuable. Don't you think your idea is valuable?

Giggling… (Discussion got distracted when one child pointed to the teacher in the photograph - finger on the lips, hushing kids to keep quiet).

C She does that all the time

R (Coming to her defence) yes, but you made a lot of noise during that activity

(Valuable discussion about how to reduce noise during activities)

VIDEO: onsite observation

SCHOOL A, Grade 1

Date: 21/8/2015

C:Child
R: Researcher

VIDEO 2 SHARE IDEAS & PLANS

C This will be extremely hard … to make a fish tank

C No, we just put blocks on the bottom and then we click it together and then we put it up and then it's done

R Do you think the blocks will hold the water?

C Yes (Hesitant) No

C We're saying we'll use blocks and then put cello tape around

C I think we should put duck tape all around so that it doesn't fall apart

C I also think we should tape it so that the water doesn't fall out

R I think you must build it and test it

VIDEO 3 THINKS IT WON'T WORK

C I don't think this is gonna work

C It is. We first anyway gonna test it

C And if it doesn't work we need to start all over again

C And also if the water goes out we can use this (picking up the tape)

VIDEO 4 CHANGE PLANS

C Let's take it out

C Oh nooo, stop it!

C Now let's put this (putting the sea weed in the container)

R Was there a change in plans now?

Children Yes!

C Teacher, we'd taken all the blocks out

A_V_p1

Whole class reflection (Interview)
School B, Grade 2 (7-8 years), 30 children

Date: 27/8/2015

C: child
R: researcher

Questions on the PROBLEM. R Can you remember what the problem was?

C Uhm, because he did…he doesn't know how to build an engine out of… He didn't know how to build an engine.

R He didn't know how to build an engine?

R So what was the problem that you had to solve?

Class (Many excited voices wanting to answer)

C We had to make the car for him

R OK, and how did he want the car to be like?

C Well…he wanted the car to uhm …we made a model and then he wanted a car… he wanted the car to be um brilliant and nice for ... um and so that he could show his boss

R Yes, but he had two specifications for that. Can you remember?

C He wanted it to go fast and straight.

R Fast and straight or …?

(Many children answering "far")

R Far and straight. So that was the problem.

Questions on children's OWN IDEAS. And now… did Miss Mundy just give you the answer?

Class (Many children) No

C She gave us material to make the car

R So she didn't make the car for you? What did she want you to do?

C She wanted you to make the car yourself.

R OK she wanted you to make it yourself? And what was the first thing that you had to do? (On your paper?).

C You had to design your own design.

R OK, you had to design your own design, so you had to think on your own?

R Were you able to think on your own?

Class (Many answer) Yes

B_R_p1

Comment [LB1]: PROBLEM

Comment [LB2]: Problem

Comment [LB3]: Problem

Comment [LB4]: Problem

Comment [LB5]: Problem

Comment [u6]: PROBLEM
Accurate recall of problem

Comment [LB7]: Problem

Comment [LB8]: PROBLEM

Comment [LB9]: OWN IDEAS

R Yes?

C Cause it was your own um design that you wanted to make yourself.

R And did you all have your own ideas?

Class (Many) Yes

R Where did your ideas come from? Where do your own ideas come from? The ideas that you had to write down? Where did it come from?

C It came from our group.

R No, when you had to design on your own. Where did you get your own idea from?

(Many children excited to answer)

C It came from your brain.

R He said it came from his brain. Do you think that's true?

Class (Many) Yes

R So do you all have ideas in your brain?

Class (Many) Yes

R Wow such a clever class

Questions on WORKING IN A GROUP. R OK then the next thing… What was the next thing Miss Mundy asked you to do?

C She asked us to work as a group.

R OK, she asked you to work as a group and to share your ideas. R How did that work out for you?

Class (Many) "Good". "Fine"

C Hard.

R You said hard?

C Yes.

R Very hard? Take the microphone and tell us everything about it.

C Because… It was hard because we didn't know what we should do and we didn't want to do the same thing as the other one that wanted to do the other thing.

R Because you all had such clever ideas and it was difficult to choose one idea, not true?

C It was hard, but we also got used to it (gasp of air) and then we realised that both of our ideas were good, so we mixed all of our ideas together.

B_R_p2

Comment [LB10]: OWN IDEAS
TT

Comment [LB11]: Own idea TT

Comment [LB12]: Ideas come from group
TT – social learning

Comment [LB13]: Ideas come from brain (TT-inherent)

Comment [LB14]: Class agree – ideas come from brain
TT

Comment [u15]: IDEAS
Children seem confident that they HAVE ideas (TT)

Comment [LB16]: WORKING IN GROUP (social learning)
Good / Fine

Comment [LB17]: WORKING IN GROUP (social learning)
Hard

Comment [LB18]: WORKING IN GROUP (social learning)
Hard

Comment [LB19]: WORKING IN GROUP (social learning)
Good = mix ideas together
TT (PSW)

R Oh that's such a brilliant answer. So you all had different ideas but then you mixed them all together and you could come up with a good solution. Is that how it worked out?

Class "Yes"

R Do you want to tell me about your work in a group (asking a specific group where one boy initially refused to participate, and was then the most excited in the end). Not?

C He's shy

R Are you shy? I'm also shy. Did you know that?

C He's really shy

R Do you still want to talk about working in a group?

C Yes, Uhm we worked as a group. We tested it but it didn't work, but … but we worked together so ours uhm could go faster and not skew all the time. So we…

R And was it helpful to work together in a group?

C Yes it was [it was helpful to work as a group].

R Why?

C Because all of us are friends and (handing the microphone over to her friend…) we love working together and we like deciding everything together because we all best friends.

R OK, so it helps to be best friends.

R But what makes work in a group difficult?

(Many children excited to answer)

C What makes working in a group difficult uhm let's say that you have a problem and one of…and one of the person in your group decided to make it worse, the uhm, it's hard so that the other kids can make a more beautiful car than us.

R So what should we do for a group to work well together?

(Many excited voices)

C We should work together and work properly, uhm … and not shouting at other children.

R Who wants to add to that?

C And you should you should include other people's ideas.

R And you should include other people's ideas!

C And you could also make your own idea and you could make that all of the ideas into one idea

R That's a clever one.

R OK, Last one.

B_R_p3

Comment [LB20]: WORKING IN GROUP (social learning)
Worked together – improved
COS

Comment [LB21]: WORKING IN GROUP (social learning)
Friends
Like working together
Like deciding together
COS

Comment [LB22]: WORKING IN GROUP (social learning)
Hard – when one decision makes it worse
COS

Comment [LB23]: Group work (social learning)
ROLE PLAYER
Work together
Work properly
Not shout at other children
TT (PSW)

Comment [LB24]: Group work
ROLE PLAYER (social learning)
Include other people's ideas
TT (PSW)

Comment [LB25]:
Group work (social learning)
ROLE PLAYER
make your own idea and you could make that all of the ideas into one idea
TT (PSW)

C And we should also be kind to one another and always respect one another.

R Kind and respectful. Yes.

C Well, the last one of ours, yes…uhm…it's better to work in a group than work just by yourself, 'cause if you work in a group you have more people to help you but if you work by yourself you just have you.

R Questions on the INVESTIGATION process/change of plans in the design. R Who of you made a design (the first, think-on-your-own design) and your car came out exactly like that, and it worked perfectly. Who had that?

Class "No", some "Yes"

C Mine didn't

R No it didn't. How did you feel about that?

R OK. When your first design didn't work out well (I know yours worked out well in the end), but was it exactly like the one you designed first?

C No, we put our things together and then we realised that it actually didn't look the same than our pictures. It looked completely different but it's still, it's still we add some of the stuff that we did put in our one that we thought would look like but it looked actually different.

R So how did you come up with new ideas?

C We put all of our ideas together and we just, we just thought of other things.

R You thought of other things? And did you all agree on the change of plans?

Class answers… "Yes"

R And how did it feel when you had to change your ideas? When it did not work out well, you tested it and it didn't work out well. How did it feel?

C We felt like we will never pass, but we did because we worked together as a team and we helped each other so that's what made our…our car go faster and better.

LEARNED. R What are the most important things that you have learned from this car design? Now think about all the things you had to figure out.

C I know, I know

C That you don't have to be perfect. You can… you mus' just try your hardest.

R That's a good thing to learn, hey! Because we all make mistakes, and then we learn through those mistakes, hey?

C Yes

R And it doesn't have to be perfect; we just need to try harder? OK But what did you learn about the cars?

C Uhm we learnt that sometimes the wheels uhm also need to be a little out than close, 'cause if the wheels are too close to the car, the wheels won't roll because the wheels are too stuck to the car because the car can make the aah, the parts

Comment [LB26]: Group work (social learning)
ROLE PLAYER
Kind and respectful
TT (PSW)

Comment [LB27]: Group work (social learning)
Sharing ideas = more ideas
TT (PSW)

Comment [u28]: Feelings about theory revision?

Comment [LB29]: INITIAL IDEAS – revised (TT – revision)

Comment [LB30]: PUT IDEAS TOGETHER = new idea TT

Comment [LB31]: CHANGE IDEAS
TT-revision

Comment [LB32]: TT-revision
Group work (social learning)
Working together helped

Comment [LB33]: LEARNED

Comment [LB34]:
SCIENCE VALUE
That you don't have to be perfect. You can… you mus' just try your hardest

of the car can make the wheels stop because the wheels don't have any space to uhm roll.

R So she learned some important things about the wheels. What did you learn?

C I learned that uhm we uhm all…the problem was that uhm uhm we had too muchhhhh paper, uhm …what was that? …pipe cleaners on the uhm and prestik on the wheels so it couldn't roll and was too close to the tinfoil and the side.

R OK is there something else that you have learned from this?

C We realised that the wire at the bottom made the car slow down, but we thought that it would work because the wire actually didn't touch the ground.

R So you learned that that didn't work, and then what?

C Then we just took the wire off and then we realised that the car was perfect.

R Ok good. Is there anything else that you have learned from this?

C Yes, that when you try and do your own things and try and shout and scream at each other, you realise the next design where you do it all together makes it perfect.

R Last thing that you have learned about the car?

C We learnt about the car that it doesn't matter if your car is not the best…it might still win, and that not everything has to be uhm perfect and stuff.

C It doesn't matter if you win, it just matters how you have fun.

Making notes/writing. R Ok now, …how did you feel about the writing? There was a lot of writing. On your page, and on the poster. So, how do you feel about that?

C We learnt about the writing that we must always write our stuff that we made with our car.

R And why is that important for you to write down everything? Why is it important for you?

C Because then when you write down everything it makes an idea and then you can put that idea together with your friend's idea.

R And does it help to write it down?

C (Same child) Yes

C (Another child) Then you'll forget it.

R Then you'll forget it, but if you write it down it will be on paper – for ever… continue discussion… Did you want to add something?

C Oh well, what we learned about writing is that it's a lot, but you actually explain instead of us talking to the person, you'll actually write down what you are trying to say to the person so they can understand more.

R OK good. And did you only write or did you also draw some pictures?

C I wrote and I drew some pictures. It was very fun.

Comment [LB35]: SCIENCE KNOWLEDGE

Comment [LB36]: PRACTICAL PROBLEM
SCIENCE KNOWLEDGE

Comment [u37]: insight

Comment [LB38]: SCIENCE KNOWLEDGE

Comment [u39]: insight

Comment [LB40]: PROBLEM SOLVING

Comment [LB41]: TT PSW
COS
Work together is better

Comment [LB42]: SCIENCE VALUE
Not everything has to be perfect

Comment [LB43]: SCIENCE VALUE
Win/loose … FUN

Comment [LB44]: NOTES

Comment [LB45]: Understood instruction and purpose

Comment [LB46]: NOTES = make idea and put together with a friend's idea
COMMUNICATORS/SYMBOL USERS

Comment [LB47]: NOTES = remember
COMMUNICATORS/SYMBOL USERS

Comment [LB48]: NOTES
Hard work (a lot)
Write down instead of talking = understand better
COMMUNICATORS/SYMBOL USERS

Comment [LB49]: Write + DRAW
FUN
COMMUNICATORS/SYMBOL USERS

R It was very fun, aah good!

TYPE OF LEARNING. R Now, how did you feel about this type of learning… like thinking on your own, doing it yourselves…

(Lots of sounds of excitement).

R Oooh, now you are so excited!

C We feeled, uh fun!

R You feeled fun? Okay, good! And you?

C For me it felt exciting and I felt that I was uhm very clever and smart, and I did my own thing that I wanted to do.

R Aah, you felt smart and clever…

C I felt that I wanted to do more of it because it was so fun (chuckles)

R Aah, she wanted to do some more of it because it was so fun. OK

C Uhm…what was the question?

R How did you feel about this type of learning?

C I felt about this type of learning that it was actually nice to do something, uhm using as a group with uhm everyone's ideas, …and uhm that we could accomplished everything that we worked together.

R Ah, thank you so much for that. OK, last one.

C Uhm I learnt about this that when I did this, my first one it … it was amazing to me but my second one we did all together made me feel happier than the first one.

R OK so you felt even happier afterwards…

Children's voice. R Do you think it's important for you to tell adults (now… me, and Miss Mundy and your teacher and your principal and your parents) about your ideas? First think. Do you think it's important for you to tell adults about your ideas, and what you like and not like?

C I think it is because then sometimes when you do it, you feel better.

R Why does it make you feel better?

C Hmm, because teachers, moms and dads can help you in your assignments or something.

R And if you tell them they will know, hey? Why do you think it's important to tell adults how you think and what you think about, and about your ideas?

C I think it's a yes, because, uhm, what Gabriella said if you're doing your assignments you can, uhm, they can also help you and you can get a full mark for that thing that you did.

R Okay, did anyone want to add to that? Why do adults need to know what you think? Not about homework now, about what's important to you?

Comment [LB50]: TYPE OF LEARNING (IBSE)

Comment [u51]: IBSE = fun

Comment [u52]: IBSE = exciting
Clever
Smart
Doing own thing

Comment [u53]: IBSE =
Do more
So fun

Comment [u54]: IBSE
Nice to work as group
Accomplish everything by working together

Comment [u55]: IBSE
Working together = better / happier

Comment [LB56]: LEARNING this way **(CAPACITY EXPANSION)**
We feeled, uh fun!
For me it felt exciting and I felt that I was uhm very clever and smart, and I did my own thing that I wanted to do.
I felt that I wanted to do more of it because it was so fun!
I felt about this type of learning that it was actually nice to do something, uhm using as a group with uhm everyone's ideas, …and uhm that we could accomplished everything that we worked together.
Uhm I learnt about this that when I did this, my first one it … it was amazing to me but my second one we did all together made me feel happier than the first one.

Comment [LB57]: AUDIENCE

Maybe they (adults) could know better than you, but you could also fill in your ideas you think that will make it better.
Some adults do (know better), some adults don't
I also know all the time, because they old and sometimes they forget from their old school from last year.
Sometimes they do, sometimes they don't, because kids are also in school, they also learn stuff, and they get ideas of it

C I think adults need to know that uhm because well, uhm, you, you've been holding it in too much, and you can't … you can't just keep it in any more, and you just get so nervous, uhm like I can't tell, but I have to keep it inside but I have to tell, but uh no, you just get so confused if you wanna tell or not.

R Okay. Do you want to add something? To why it is important for adults to listen to you?

C I think it's important to tell adults because maybe you fail the first time and they can help you to fix your fail.

R Okay, and will they know better than you?

C May…Maybe they could know better than you, but you could also fill in your ideas you think that will make it better.

R But if I listen closely, you think that adults know more than you do. Is that true?

Class (Many voices) No…Yes… Not all the time.

R Aaah, not all the time?

C Some adults do, some adults don't

C I also know all the time, because they old, and sometimes they forget from their old school from last year.

R Do you want to add to that? Do adults always know better?

C Sometimes they do, sometimes they don't, because kids are also in school, they also learn stuff, and they get ideas of it.

Children's views on working scientifically. R OK, last thing… Uhm, I came here today to watch some scientists-in-action. Did you work like scientists?

Class (Many voices) "Yes"

R Yes? Did you convince me now? Did you work like scientists today?

C We did work like scientists today

R Why?

C Because we had to make our own car, and see how it could go, and how straight and how far it could go

R But why do you think scientists work like that?

C Because they want to discover new things that life has not discovered before.

R That's a clever answer! And did you discover new things today?

Class: Yes!

R Aah… okay. And why do you say you worked like scientists today?

C Because we improve, or we used to… because I don't think any of us tried this before, but this time we did, and it doesn't matter if it went far or not far, but at least we tried.

Comment [LB58]: SCIENTISTS
We did work like scientists today.
Because we had to make our own car, and see how it could go, and how straight and how far it could go.
Because they want to discover new things that life has not discovered before.
Because we improve, or we used to… because I don't think any of us tried this before, but this time we did, and it doesn't matter if it went far or not far, but at least we tried.
I think we did kind of worked like scientists today because there was lots of things for us to learn and tell people our answers and all those type of things.
I think we worked like scientists because normally scientists are the ones who invent things and who discover the things that haven't been discovered before.
Well I think we worked like scientists, we improved our skills of cars and then we actually tried our best and it doesn't matter if you failed or succeeded as long as you tried your best, 'cause you try and try and you never succeed but the last time you do it you might succeed.

Comment [u59]: Made a product and tested it

Comment [u60]: Discover new things

Comment [u61]: Tried something new
Improved
Tried (effort)

R At least you tried! Is there another one?

C Uhm, what was the question?

R Did you work like scientists today?

C I think we did kind of worked like scientists today because there was lots of things for us to learn and tell people our answers and all those type of things.

Comment [u62]: Learned new things
Shared information

R Okay.

C I think we worked like scientists because normally scientists are the ones who invent things and who discover the things that haven't been discovered before.

Comment [u63]: Invent
Discover

R And did you do it today?

Class Yes, we did!

R Yes, you did! Last, last one…

C Well I think we worked like scientists, we improved our skills of cars and then we actually tried our best and it doesn't matter if you failed or succeeded as long as you tried your best, 'cause you try and try and you never succeed but the last time you do it you might succeed.

Comment [u64]: Improved skills

Comment [u65]: Tried best

Comment [u66]: doesn't matter if you failed or succeeded - just TRY

R Yes, and that is what scientists do, hey?

R Thank you so much Grade Two's. I came here today to see if I could find any scientists, and I found them in this class.

Focus Group Discussion
School B, Grade 2
Blue Group

Date: 2/9/2015

Opening comments. PPT photo of group (Rian not in picture).

C Why am I lost?

C Probably because you were hiding under the table!

R Leads discussion about being scientists

C We are real scientists.

C (Rian) You guys are, I am not. Because I never wanted to do this.

R Yes but I have a video showing that you were almost most excited about this activity, not true?

C Yes.

R This was almost a week ago. Can you still remember what the problem was (Week later) I'm sure you have forgotten all about it.

C We'd never forgot about it.

Comment [LB1]: Long-term impact

R Why?

C We let it go down and then the whole thing just popped off.

R Can you remember what the problem was you had to solve?

C The problem was that we had to solve is: fix it.

C We had to fix it because the roof came off.

R What was the problem?

C We didn't have the same ideas.

R First problem.

C I know! Someone in BMW didn't know how to make engines.

R …and then… what did he ask you?

C He was late so he asked us to make a BMW for him.

R Ok, but how…

C It had to have wheels, and it had to roll and it had to go far and straight.

Comment [LB2]: Accurate recall of problem

R So that was the problem that you had to solve.

All Yes.

R Did Miss Mundy build the car for you; tell you exactly what to do?

C No, we did it by ourselves.

C No, we had to draw our ideas and then put them together and make a solution.

Comment [LB3]: Put ideas together = solution
SL

R First?

C Draw a picture.

C Draw a picture.

R With whose ideas?

Many children: With everybody's ideas.

Comment [LB4]: Use all ideas

C (Rian) But not mine. They never listened to me even – although I was the manager.

Comment [LB5]: CHALLENGE
Not listen
Group roles (manager)

R We'll talk about that later.

(Video showing children's ideas)

R Did you all have [your own] ideas?

Class: Yes!

R Where do you get your own ideas from?

C Our brains.

Comment [LB6]: Have ideas
Come from bran
(TT)

C From our big heads that uses our brains.

(About writing ideas)

(Children comment on picture: We can't even see C (Rian) ! You can only see my one hand! Etc.)

R After thinking on your own, what was the next thing you had to do?

C We had to mix our ideas together.

Comment [LB7]: Mix ideas
SL = TT

<u>**Video 2**</u> R This one was very interesting to me because… listen to what you were arguing about. (Show video - group roles)

(Lots of chuckles from group)

R have you listened to what this conversation was all about? You had to share your ideas, and then, what did you do?

Class: Uuuhhh…

C We had to draw the picture.

R No this discussion on this video.

C We had to mix our ideas together.

R Yes you had to, but what did you do?

C We listened to our ideas and put it together.

Comment [LB8]: Mix ideas
Put together
SL = TT

(Continue with video 2). R What was that rubber throwing all about?

(Children laughing)

R What did you focus on here?

C The flicking rubber was who would vote on to: "Would I be the manager, would I be the artist…".

C (Rian) I was the first one that flicked and then I said, "Could I be the manager?" Then it just went yes. I have the magiC flick.

R You spent minutes and minutes on this. Why was it so important to you? (i.e. deciding on the roles)

C Because we don't like people arguing and we just wanted to get the arguing done so that we could start with the real fun stuff.

Comment [LB9]: Solution
Social SKILLS

R so now I understand…

Comment [LB10]: CHALLENGE
Group roles
SL

Lots of comments: "I look so silly" ; "I look like a fashion model" ; "Why is there such a big gap between my teeth?" ; "Ben is hiding under the table again". "When I get really mad I do that."

<u>**Video 3.**</u> R What were you doing here?

C We were planning how to build our car.

Comment [LB11]: We were planning
SL GW

R Did you all discuss your ideas here? How did it work for you? Did you share your ideas?

(Interruptions – intercom announcement – kids energetic)

C Because everybody was arguing: "I want to be the manager. No, I don't want to be the manager. No, you can't be the manager, I'm the manager."

Comment [LB12]: CHALLENGE
Group roles
Skills development

C "I wanted to do my own car."

Comment [LB13]: Want to work alone

R How did you feel about sharing your ideas?

C We felt very annoyed because nobody was listening.

C And very crazy!

C And C (Rian) was a little bit cranky.

(Note: Kids took cues from the emoticons on the PPT)

C You wanted everybody to do what you wanted them to do.

C (Rian) Because I am the manager, and that's what managers do. Managers tell everybody what to do.

C Now the big boss comes again.

R Did the group roles make some of you more important than others?

Children (hesitant): …Uuh…ya we do not know.

(Continue with video) (lots of giggling and comments)

R Was sharing in a group easy/difficult/how was it for you?

C Very irritating because people did not listen to me!

C We used some of your silly ideas, and the first time the car smashed.

C It wasn't my silly idea, it was yours.

C No!

C You decided to put more sticky tape on it.

(Arguing, giggling). Children very restless

C No all of them together equals me (C (Rian) referring to the emoticons).

Video 4. Evidence of working together…

R You said it was difficult to share ideas and take decisions, but here you worked well together. How did that work for you?

C That didn't work good.

R Why not?

C Because when we realized that the pipe cleaners did not make the thing roll that was the first part when the whole thing broke into millions of pieces.

C And then after that we made this (pointing to the car).

C That's when we sort of decided to make this and put a…

C No that's where your silly idea never even worked. We had to put that stick in … that's the thing I chose to do and it worked.

R So is that what happened then?

Comment [LB14]: CHALLENGE
EMOTION
Annoyed
Crazy
Cranky

Comment [LB15]: CHALLENGE
EMOTION
Enforce ideas
SL (skills development)

Comment [LB16]: CHALLENGE
Group roles
SL (Skills development)

Comment [LB17]: CHALLENGE
SL
Not listen
Disagreement (we did use your ideas)
Blame for ideas - "silly ideas"

Comment [LB18]: SL = (TT-revision)
Realised – won't work = need to CHANGE PLANS (TT-revision)

Comment [LB19]: SL + TT-revision = PROUD OF PRODUCT

C That's what happened when I came in… to the rescue

R But you still say that working in a group was more difficult than helpful?

C No-one even knew there was holes at the bottom of the thing.

C It was helpful when we realised that the wheels actually worked.

(Lots of excited talk to explain how they worked on their car.)
(Children jump, roll in class to represent their car.)

Video 5. R You had to make some changes + improvements here. Why?

C Because the car smashed… the roof popped off.

R So you tried it on the ramp?

C And we put sticky-, uh cello-tape on, then it worked.

C (Rian) And then we made this beauty (pointing to the car, excited)

C BMW

C And the blue group copied us.

Video 6 R Ok. C (Rian) this is you.

C (Rian) Yes. Did you know what I was trying to do? I was trying to get the wires through the top and try and tie it at the top, so then it can keep the roof together.

R Yes because the roof fell off the first time so you wanted to fix it?

C (Rian) But then after that I tried that but then it slowed it down, but it still crashed.

C Ya, it smashed into millions of pieces.

R Why did it need a roof?

C So the thing wouldn't get sopping wet and all the gears would break and… and when your cellphone is sitting there it wouldn't smash into millions of pieces.

R But it did it make the car go far/straight?

C It made the car go far, because more of the air holes made the steam go through.

R OK, that's interesting.

Video 6 continue: R This was the video where I saw that Rian was very excited.

Comment [LB20]: SL = TT revision

Comment [LB21]: CHALLENGE
EMOTION SL (Skills development)
Argument about ideas
GROUP ROLE = rescue

Comment [LB22]: CHALLENGE
No-one realized (individual)
SL (cooperatively) group ideas = helpful

Comment [LB23]: CHANGES + CONCLUSIONS = justification for actions (fix)

Comment [LB24]: SL – influence on others (mimic)

Comment [LB25]: CONCLUSIONS
Justification for actions

Comment [LB26]: KNOWLEDGE
Not practical / not related to activity

Comment [LB27]: KNOWLEDGE
Not practical / not related to activity

(Notes debating, reasoning)

Video 7 R Rian already explained to me what happened here.

(Children arguing about their participation)

C We were so nervous because we thought it would crash again.

R There you explained everything (video 7). What did you learn from your participation in this activity?

R (reminds them about problem)

C (Rian) Well, we learned about friendship.

C (Rian) Uhm, we learned that we always have to work together.

R Did you really learn that? Because you just told me about the problems you had in your group?

C Yes we did learn about a lot of stuff.

R Be more specific?

C Engines…, fast…

R Did you learn about engines?

C Also, we needed a car that can go far, straight and…What was the other one?

C Just far and straight.

C Oh, far, straight and smooth. I'm very cool. Amen.

R What are these things called? (holding car, pointing to the axels)

C Aah, sticks. You put food on them.

LB: Sticks, yes but in a real car?

C In a real car they have axels.

R But is this like a real car's axels?

C No. It isn't like a real car's axel. It's a stick.

R But what did you need the stick for?

C So that the thing could roll properly and could go straight and far.

R So you needed something like an axel.

C Ya.

Comment [LB28]: EMOTIONS
Nervous about predictions

Comment [LB29]: LEARN
Friendship
To work together

Comment [LB30]: LEARN
Engine
Not accurate

Comment [LB31]: Accurate

Comment [LB32]: LEARN
Axels
Accurate

R And what about the wheels?

C You can make different wheels; big wheels, small wheels.

C All wheels should be the same (follow conversation - clip 23:24)

(C (Rian) making noises that overpower the conversation)

(Hand out written work / science journals to all children.)

R How did you feel about the writing/writing down your ideas?

C (Rian) Horrible.

R Why?

C (Rian) Because I just don't like writing. Yip, that's why. I don't like writing.

R Is that why yours is empty?

C (Rian) Yip, that's why mine is empty. Plus none of them listened to me even though I'm the manager!

R But in this group you were all equals.

C (Rian) Not all of us.

R All of you had ideas that you had to share.

C (Rian) Not all of us.

R Why not?

C Of course, you never even shared yours.

C (Rian) Because none of you will listen to me.

R Ok C (Rian), so you didn't like the writing, but do you think it is important to write down your ideas?

C Yes, otherwise if we don't write it down otherwise we will forget.

R Did you just write/make drawings as well?

C We made drawings as well.

R What worked best for you?

C (Rian) I made only one drawing.

How do you feel about learning this way?

C (Rian) All those funny faces equals the one at the top – and that's me.

Comment [LB33]: NOTES
Horrible
I don't like writing
Did not fill sheet

Comment [LB34]: CHALLENGE
Child's experience of group inhibited participation
(Difficult child)

Comment [LB35]: CHALLENGE
SL No-one listened
Skills development

Comment [LB36]: COMM/SYM
NOTES =
Not forget

C I felt very irritated because nobody listened to me.

R So you never ever want to do this again?

C I do, but it was just a little irritating, and then I felt happy.

Comment [LB37]: IBSE = Irritating but then happy (Frustrations - eventually pleasure in learning)

R Why?

C And then I felt happy because the car actually worked in the second time. And nobody ever listened to me in the first.

Comment [LB38]: IBSE = Happy (Frustrations - eventually pleasure in learning)

(Rian was reprimanded by classroom teacher)

(Rian) What about me? All of you shared ideas but not me.

R So Rian will you do such an activity again, or rather not?

C (Rian) Never!

(Rest of class respond: 'Aag!' and other sounds)

C I'll do it every day if I have to.

Comment [LB39]: IBSE = Do it every day

C I felt irritated, happy, sad, angry, sweating, and very angry.

Comment [LB40]: IBSE = EMOTION

(Note: prompts taken from emoticons on PPT)

R So you felt all the emotions?

C Yes, except for disgust. Ya.

C I felt disgusted, angry, annoyed and kind of happy, and mostly angry.

R Mostly angry? Even if it worked out well?

C I would feel happy. Happy.

R Didn't it work out well for you?

C Not exactly.

C But in the second time I disco-danced on the carpet.

R Ok so then you felt happy?

Comment [LB41]: IBSE = EMOTIONS (Frustrations - eventually pleasure in learning)

(Interrupted by intercom)

<u>Did you work like scientists in this activity? Why did you say so?</u>

R I asked you if you could think like scientists. Rian said no. Never?

C I could think like a scientist because my mother is one.

Comment [LB42]: Scientist IDENTITY My mother is one

R Is your mother one?

C She's a science teacher.

(Rian) I was just kidding. I was just making a joke.

(Rian) (still upset): Because you guys never listened to me.

<u>Should adults listen?</u>

(Rian reprimanded again by teacher)

R Is it important for us to listen to your ideas/what you think?

C Yes ma'am. Because our ideas are very fun. Instead of getting other people's ideas… they're boring.

Comment [LB43]: VOICE Our ideas are fun Other people's ideas are boring

C That is not the solution. The solution is… because everybody has different ideas, so it's actually fine because nobody will actually just think… if there were dividers… nobody would think that this is p this is b this is d. Nobody would think the exact same thing if they were drawing a picture, … maybe.

Comment [LB44]: Everybody has different ideas

R Is it important for us to listen to your ideas? Or should we just tell you what to think?

(Class returns from hymn singing).

"You better hurry up"

(Session ended)

VIDEO: Onsite observation

School B, Grade 2
Orange Group

Date: 27/8/2015

Pseudonyms used for children from focus group
R: researcher

Video (OWN IDEAS) Ben, tell me about your own ideas

Ben Uh, my car is like a very fast car … it's a BMW kind of car. I put like milk jugs on it and those squares are the tinfoil thingies. And there's a (pointing to wire) … that's a wire over there. And the top thing is a lid. And the two things at the bottom is cello tape. And the thing over there is also a lid – for the exhaust.

R And what will you use for wheels?

Ben Uh, sticky tape

R OK, and the wire? What is the wire for?

Ben Uh…, the radio

R OK, one should have a radio in a car, hey? And will the radio make the car go far and straight?

Ben Yes

R How?

Ben Uh…, the radio will do that …, uh… I don't know

(TY's explanation of own idea – not included)

R Let's ask a girl designer

Lyn This is the bottle for the car's top thing. There's the windows with those little sticky things. There's a bit of pipe cleaners stuck to the door for the door handles. That's sticky tape to stick the wheels on it. And the wheels are made out of the round thing on the table. And the pipe cleaner is for the radio just for decoration. This is half a bottle lid and this is the tin thing that you can put like food in, but it's the bit of the car that you like … open the door

VIDEO: Investigation (Ask Lyn to tell what they are doing)

ST interrupts children: Don't worry about decorating your car and making them pretty. Only remember it needs to roll straight and far

Lyn We are putting the wheels and attaching the pipe cleaners so that it can roll like this, and then this thing will be where the people sit. And that

will be the top. Then we're gonna stick little sticky things here for the windows, and … here are the four wheels

(One child trying out the car): It won't roll

(Ben) We told you it won't roll

VIDEO IMPROVE (Child suggests using a skewer)

(Ben) Oh very good idea

Ben (trying it out) Ah! It's gonna roll!

R How did you come up with this solution?

Ben I just did it

Lyn We just decided it

VIDEO TEST and EXPLAIN

ST ask children to test their final design down the ramp and explain the changes they made

Rian explains: The wheels were too close, then we moved them a bit

Ruben And the first time we tried, the whole thing just popped off

Rian And we made a decoration like a star

Interview (Whole class reflection session)
School C, Grade 3 (8-9 years), 15 children

Date: 16/9/2015

C: child
R: researcher

Questions on the PROBLEM/INITIAL SITUATION. R Now, can you remember what the problem was? The activity that you had to do. Can you remember what the problem was that you had to solve?

> **Comment [LB1]:** PROBLEM

C The activity was to build our own BMW car

R OK, to build your own BMW car, and…can you say something more?

C The problem was uhm, we put the wheels too high

R Yes, but before that. What was the problem you had to solve? You had to make a model of a BMW car, and it had to do two things… Can you remember what that was?

(Many excited voices)

C It had to go far…it had to go as far as possible, and as straight as possible

R Do you all agree with that?

Class YES!

R Oh, OK yes, so you had to design a model of a car, and it had to go as far and as straight as possible

> **Comment [LB2]:** PROBLEM
> Accurate recall of problem

R Questions on the think-on-your-own stage. R You can remember very well. Did your student-teacher just give you the answer?

> **Comment [LB3]:** THINK OWN

Class NO!!!

R Not? But why not? What did she ask you to do?

C She wanted us to think for ourselves

> **Comment [LB4]:** Teacher asked us to Think on own

R OK She wanted you to think for yourselves. Nicole, did you want to add something?

C She wanted us to work in a group

R No before that. She already said it… she wanted you to think on your own. So you had to…

Class (MANY VOICES) Think on your own

Class Think for ourselves

R And was it possible for you?

Class YES!

R Is it true?

C_R_p1

Class Yes!

> **Comment [LB5]:** TT
> CHILDREN HAVE THEORIES
> Children confident that they can think on their own

R Where did you get your ideas from?

Class (Majority of the class answers) Our brains!

> **Comment [LB6]:** TT
> IDEAS come form brain

R So do you all have ideas in your brain?

Class Yes!!

R Aah, it seems as if you all agree on that?

(Lots of giggles)
Class Yes!

Questions on sharing-ideas and working in a group

> **Comment [LB7]:** GROUP WORK
> SHARING IDEAS

R So, what was the next thing … Now you've all had wonderful ideas, you drew pretty pictures of the cars you wanted to make…and then, what did she ask you to do?

She wanted us to see … to take materials for our cars.

R Before that…before that… Just after you had to think on your own…Then?

C We had to decide for uhm … with all our cars and uhm design it into one car and then do uhm do, uhm build it

R OK, so after thinking on your own, what was the next thing?

C We had to go and check what materials

R No…

Boy (helping the girl) Before that

R Before that?

C We got a piece, a worksheet that we had to draw what we had to use, and we had to…

R And could you do that design according to you own ideas?

Class Yes!!

R Yes?

Class: No! As a group

R As a group! So you had to share your ideas in a group. Now how did it feel like for you to share your ideas?

> **Comment [LB8]:** SHARING IDEAS?
> quite nice
> disappointed if plans not used
> (Social learning)
> PSW

C It felt … it felt quite nice, but some of us got a… disappointed for most of us not using somebody's plans also

R Yes, because you all had wonderful ideas, and now you had to share them with others. Did you all listen to everyone else's ideas?

Class YES!

C_R_p2

R And was it easy for you to share your ideas with the others?

Class Yes… No…

R Not always, hmm… So how was working in a group for you?

C It was fun and it was nice

> **Comment [LB9]:** WORKING IN GROUP (social learning)
> fun and it was nice
> (social learning)
> PSW

R It was fun and nice. Who wants to add to that?

C I don't think it was a good idea

Class (Others comment) What???

R OK, but now you have to explain why.

Because it feels weird to share ideas.

> **Comment [LB10]:** WORKING IN GROUP (social learning)
> not a good idea
> feels weird to share ideas
> don't like sharing my ideas
> (social learning)
> PSW

R Yes? Why does it feel weird?

C 'Cause, I don't like sharing my ideas with other people

R You don't like sharing your ideas with other people

(Distraction, giggling when tape recorded started playing)

R OK, she said that she didn't like sharing her ideas with other people. Who felt like that as well?

C No me

R Not you? Ok, how did you feel like?

C I felt like uhm people would not choose my idea

(Group members commented - upset) They will. But we did! We used your inflatable tires. We used your spoiler. We used your…
Hey, OK it was not my idea for the spoiler.

(Discussion argument continued)

> **Comment [LB11]:** WORKING IN GROUP (social learning)
> Not using my idea
> (Group members disagree)
> But we did! We used your inflatable tires. We used your spoiler. We used your…

R OK. How did you choose the best option? Because you had to choose one option. Could you choose one of the ideas, or how did you come up with the best solution?

> **Comment [LB12]:** CHOOSING BEST OPTION?

C Because it was a bit like that 'cause also other people are looking at other people's work and it didn't feel comfortable because a lot of people like working alone without people interrupting them

> **Comment [LB13]:** (social learning)
> PSW
> Don't like working together and sharing ideas
> (social learning)
> PSW

R OK so you don't like it when people interrupt you when you work. You want to do everything on your own.

C Not everything. I want some.., I do like people doing the work but most of all I wanted them to listen to my ideas

> **Comment [LB14]:** (social learning)
> PSW
> Wants to work together when they use her ideas
> (social learning)
> PSW

R Yes, all of us want other people to listen to our ideas. What did you want to add to the group work?

C_R_p3

C Uhm, how we made our decision was we said we gonna use from everybody's …so we used one of the person's wheels, the body, and things like that

> **Comment [LB15]:** Social/cooperative learning – used everybody's ideas
> COS
> **CAPABILITY EXPANSION**

R They came up with a wonderful solution

C Well we used my wheels, we used Bhavini's window, your car design, Luke's windows…

> **Comment [LB16]:** Used ideas from all members
> COS (social learning)
> **CAPABILITY EXPANSION**

C Doors…(Luke corrected)

C And you guys didn't even use any of my things!

> **Comment [LB17]:** EMOTION
> Upset that ideas were not used
> However – group disagree
> (social learning)
> PSW
> CHALLENGE

(Oh!...and other comments from group…disagree)

R What was good about the group work?

C It was very good

R Why? You have to say why?

C Ah, because people, because people… we were actually sharing our ideas

> **Comment [LB18]:** GROUPWORK
> (social learning)
> Good
> Sharing ideas
> Chance to tell ideas – reflect if it is good/bad
> They can see your ideas and experience what you like to do
> PSW
> **CAPABILITY EXPANSION**

R You were actually sharing your ideas. And why is that a good thing?

C Ah, we had a chance, uhm uhm to tell everyone about our ideas and then they see if it is good or bad.

R OK, what do you want to add to that?

C It is nice to share our ideas because if you share your ideas then they can uhm see your ideas and then they can experience what you like to do and things like that

C It was creative and we uhm told everyone our ideas because they could know how we did it and added to the cars and things like that.

> **Comment [LB19]:** GROUPWORK
> (social learning)
> Creative
> Told everyone – so they could know how we did it (transfer information)
> PSW
> **CAPABILITY EXPANSION**

R So it was creative as well. Did you want to say something?

C I also liked it because we heard someone else's ideas and then another person's and another person's and then we added it all together and then we had a plan

> **Comment [LB20]:** GROUPWORK
> (social learning)
> I also liked it because we heard someone else's ideas and then another person's and another person's and then we added it all together and then we had a plan
> **CAPABILITY EXPANSION**

R OK…and then you had a plan. You wanted to add something?

C When I tried to, uhm when I tried to say ... uhm tell them a plan…, uh no-one let me say anything (chuckle)

> **Comment [LB21]:** GROUPWORK
> (social learning)
> Tried to tell – but no-one listened
> PSW CHALLENGE

R But in the end, you did work together with the group?

R OK last thing…

C Sometimes they didn't add my ideas to the car…

> **Comment [LB22]:** GROUPWORK
> (social learning)
> Ideas not used
> (Group disagrees)
> PSW CHALLENGE

(Group disagrees) What are you talking about?

R Just finish your sentence? (incomplete)

Questions on the investigation. R OK, now many of you made a car, and then you had to test it… Did your cars work out perfectly?

C_R_p4

Class: Many Yes…No…

R The first time! Did it work out perfectly?

Class: No

R OK, so tell me about that

C We had to test our cars, and not everything worked perfectly, so we had to go back to our desks and fix all the problems there were.

R And how did you feel about that?

C It feels better, because then you can learn how to fix your mistakes

C Like an engineer

R Who wants to add to that one?

C And we and also our uhm our car uh, our car's wheel came out, then we had to uhm go back and fix the wheel because we were uh first the wheels were loose so then we went back and fixed the loose wheel and we tested it again

R And how did you know how to fix the problems with your cars? How did you know how to do that?

C We were thinking like engineers

R You were thinking like engineers?

C Yes because engineers … their first cars don't actually work, then they test it out, then, if it doesn't work they just have to fix it again

R But can they read it in a book?

C Noooooo…, They just fix it by just looking at what…what the problem was

R OK they look at what the problem was and then they fix it? SO who wants to add to that?

C Because when we were fixing our problems, we had to learn from our mistake at first, because it was the only problem was we had to just straighten the wheels because we just hhh pushed the wheels back, So we had to …

R So you learned from your mistakes, and then you had to fix it?

C Yes

LEARN. R asks questions about what did you learn

C We learned to learn from our mistakes and uhm don't give up and keep on trying

R That's beautiful. Ok, so what did you want to say?

C That it must be frustrating to build a real car

R Oh, that must be hard work

C We also learned to work together

Comment [LB23]: Initial plan did not work

Comment [LB24]: TT revision
Test – not work – fix problems
CAPABILITY EXPANSION
(IBSE SKILLS)

Comment [LB25]: TT revision
Feels good to fix mistakes
CAPABILITY EXPANSION
(IBSE SKILLS + ATT)

Comment [LB26]: Justification for need of change and test
TT-revision (fix it)

Comment [LB27]: TT-revision
Thinking like engineers
SCIENTIST IDENTITY

Comment [LB28]: TT-revision
Test – fix – test – fix
SCIENTISTS IDENTITY

Comment [LB29]: TT-revision
They just fix it by just looking at what…what the problem was

Comment [LB30]: TT-revision
Fixing problems = learning from mistakes
Hands-on / mind-on
CAPABILITY EXPANSION

Comment [LB31]: LEARN

Comment [LB32]: LEARN
From mistake
Never give up
SCIENCE ATTITUDE
CAPABILITY EXPANSION

Comment [LB33]: LEARN
Frustrating to build a real car
PRACTICAL SKILLS
CAPABILITY EXPANSION

Comment [LB34]: LEARN
Work together
SCIENCE ATTITUDE
COS
CAPABILITY EXPANSION

R And you learned to work together

C Yes, that is true

C And we learned that it's not easy to make a car, and it's not…well…if you want to make a car you must first get designs and then you can make the car, but you have to see first what the problems could be with the car

R OK, so you had to build a car that could go as far and as straight as possible. So what have you learned about what would make a car go as straight and as far as possible?

(Many children want to answer)

C The engine makes it go far

R Aah, but did you make an engine?

C You must make the car lighter

R OK lighter, why?

C Because the more weight you add to your car it's gonna make your car slower, 'cause if something is heavy, then it can't move that much

I know what we learned.

R Yes?

C It is not very easy making a car out of junk

(Class laughing, making comments)

(Girl, commenting on another group): The Blue group mustn't put too much stuff on their car or it would become too slow and too heavy for the car, and then it would just flip over and nothing would happen

C I learnt that the wheels have to be loose for the car to roll, otherwise it won't go really far, it will just stop in the middle of nowhere

R Yes, and you've learned it from yours hey?

C Uhm, ah we learned that … that the wheels mustn't be like too, they mustn't be like too high and they must be at the bottom of the car and…

(Class discussion)

Documentation and communication / writing and making notes?

C It was quite fun because we got to draw a car, share our ideas, and draw what we had to use so that we won't forget what we had to do

R OK and what was the importance of the writing?

C It was important because we don't have to rethink everything

C It was important because you can't start something without an idea of what you're gonna do

Comment [LB35]: LEARN
Not easy to make a car
Design first
Fix problems
PRACTICAL PROBLEM SOLVING SKILLS / 21ST CS
CAPABILITY EXPANSION

Comment [LB36]: LEARN
Engine makes it go far
TT-revision?

Comment [LB37]: LEARN
Make car lighter
SCIENCE KNOWLEDGE
Practical skills
CAPABILITY EXPANSION

Comment [LB38]: LEARN
Justification for conclusion
SCIENCE SKILLS
CAPABILITY EXPANSION

Comment [LB39]: LEARN
Not easy to make car out of junk
PRACTICAL SKILLS
CAPABILITY EXPANSION

Comment [LB40]: LEARN
NB from other group
COS
CAPABILITY EXPANSION

Comment [LB41]: LEARN
Science knowledge
CAPABILITY EXPANSION

Comment [LB42]: LEARN
Science knowledge
CAPABILITY EXPANSION

Comment [LB43]: COMM/SYM

Comment [LB44]: COMM/SYM
Fun
Share ideas
Draw
Don't forget

Comment [LB45]: COMM/SYM
Not rethink everything

Comment [LB46]: COMM/SYM
NB starting point

R And how does writing or drawing help with that?

C To remember what you did

C Uhm, it's …it's important because it gives you information

R OK it gives you information, and what do you want to do with that information?

C Uuuhhm, … bring it to life

R When you tested your cars, you also needed to tell the others about the problems you had, and how you had to fix it. How did that feel for you? To share your ideas with the other children; to communicate…

C It feels a bit disappointing because nobody likes talking about their problems

R Laughing. OK, but if you tell the others, can't they learn anything from that?

C Yes, but some of them laughed at us.

C Yes

C Because when our car nearly broke down everyone started laughing at us

R Ja, we shouldn't laugh at one another, but sometimes we can just laugh when something is funny, isn't that true?

This type of learning. R OK in this activity you had to do a lot of thinking on your own, working on your own, sharing ideas, trying out, making mistakes, doing it all over again… How do you feel about this type of learning?

(Class is quiet …)

R Should be just never do it with you again?

(Commotion, many excited voices)

C Do it again, every single day

R Do it again every single day?

Class: Yes!

C Learning from our mistakes, and doing it over and over again

(Many children talking at the same time)

R (Quieten the children down; too many excited voices). Repeats question: How do you feel about this type of learning?

C It feels nice and it's very creative and sometimes it's interesting the first time we do it because you learn from your mistakes so that uhm the second time, uhm.., ya, that's it

C It's a very interesting uhm experience

R Yes, why?

C Because, … we get to build something and you get to learn from our mistakes the first time and then fix them

Comment [LB47]: COMM/SYM
Remember

Comment [LB48]: COMM/SYM
Gives information

Comment [LB49]: COMM/SYM
Information – brings it to life

Comment [LB50]: COMMUNICATE
HOW DID IT FEEL?

Comment [LB51]: PSW
Disappointing
nobody likes talking about their problems
CHALLENGE PSW

Comment [LB52]: PSW
Laughing at mistakes makes them feel bad
CHALLENGE

Comment [LB53]: IBSE

Comment [LB54]: IBSE =
Do it again, every single day
POSITIVE

Comment [LB55]: IBSE =
Learn from mistakes
Do it over and over again
POSITIVE

Comment [LB56]: IBSE =
Creative
Interesting
Learn from mistakes
POSITIVE

Comment [LB57]: IBSE =
Interesting
POSITIVE

Comment [LB58]: IBSE =
Learn from mistakes
Fix
POSITIVE

R OK, and you think it's important to learn from your mistakes, and to fix them?

C Uhm, yes, because…because uhm, because you must never give up when…when you do things. You must keep on trying and trying until… until you I…, until you…until you get it corr…correct. And, uhh, and we always have to learn from our mistakes, because it's …, because it teaches us uhm, what…what did you do wrong, and you must fix… and you must do it again

R Ag thank you so much for that. OK

C You don't have to be an engineer to make a model

R You don't have to be an engineer to make a model. Yes, so even children can do that?

C Teamwork is important

R Teamwork is important

C You don't have to be an engineer, because all you have to do is try, and if you get the right bits you can actually make a car

(Another child comment: A car that breaks down…, chuckling)

R asking on children's voice. Do you think it's important for adults to listen to what you have to say?

Class: Yes!

R Oh yes, no uh-uh, I think we should just tell children to keep quiet, do as we say … isn't that true?

Class: Nooo!

R Because we're the bosses

Class Yes/No…No way… rumbling

R OK so, do you think it's important for adults to listen to what you have to say?

Class: Yes

R OK, but then you have to convince me now

C Not all the time, because children should not always get what they want.

R Ya, but this is not about nagging for stuff, it's about you telling us about your ideas (e.g. how to build a model) so that we know how to teach you, the activities we do with you…

C Yes, it is important, because parents also need to know what we have to say

R Why do they need to know that?

C So they can apply it to whatever we're doing, 'cause if children don't get to do something like that, they won't think it's fun

R OK

Comment [LB59]: IBSE =
CAPABILITY EXPANSION
Never give up
Keep trying
Until you get it correct
Learn from mistakes
Fix your problems = learn

Comment [LB60]: IBSE =
YOU can do it
You don't have to be an engineer to make a model
EMPOWERING

Comment [LB61]: IBSE = Teamwork
COS
CAPABILITY EXPANSION

Comment [LB62]: IBSE =
Don't have to be an engineer
Try and try
If you get the right bits – you can actually make a car
EMPOWERING

C It's because if you just leave your child to do nothing then it… then they won't experience what it feels like to do something like this

> **Comment [LB63]:** VOICE/ AUDIENCE
> Information transfer to adults

C And adults also have to listen what children have to say because **what if… uh … a child has something better to say**, so… it makes something interesting and fun for them to do

> **Comment [LB64]:** VOICE / AUDIENCE because **what if… uh … a child has something better to say,**

R Yes what if a child has something better to say, wow!, yes! And do you think it is possible for children to have good things to say?

Class YES!!!

R Ok, last one…

C And you also always have to tell your parents if it's really important or if your teacher says you have to, you have to like bring something, and you don't tell your parents, then the next day when you come, and the teacher asks you where is your thing, then you tell them I forgot to tell my mom, and then,…and then that's all.

> **Comment [LB65]:** VOICE / AUDIENCE
> Information transfer

R And then, that's all.

Scientists. R, OK, Last question: I came to this classroom to see if you can work like scientists, and… can you work like scientists?

> **Comment [LB66]:** SCIENTISTS

Class: YES!!!

R Why do you say so?

(Lots of talk)

C Because we are scientists

> **Comment [LB67]:** SCIENTISTS
> Because we are

C (Girl with pen behind her ear to show she is a scientist).
Because, uhm we can, uhm we can learn … learn how to build things, and…, and create new things.

> **Comment [LB68]:** SCIENTISTS
> Learn how to build things and create new things

R And is that what scientists do?

C (Hesitant) Not really.

R OK Did you think like scientists yesterday?

Class: Yes!!!

R Why, tell me why

C Because we had to build something creative and we had to learn from our mistakes and then…uhm…ya… (chuckles)

> **Comment [LB69]:** SCIENTISTS
> Build something creative
> Learn from mistakes

R Are those things that scientists do?

C Not really, but…

R Not really, why not? Don't you think they ever make mistakes?

C Yes, but they… they build stuff, and…they learn from their mistakes of what they are doing.

R OK, thank you.

C We all worked as a group, and we finally made something that actually works.

> **Comment [LB70]:** SCIENTISTS
> Worked as group and finally made something that worked

R And is that something that scientists would do?

C Yes, we messed around with all of our… our ideas to get something

> **Comment [LB71]:** SCIENTISTS
> Messed around with ideas to get something

R OK, that's a beautiful answer hey? Last one?

C 'Cause also scientists can also do inventions and … which is good 'cause you need to also learn so you can also do good. Also as our ideas grow up you're also gonna tell us that we also need to do a project whe' we invent something that people will need … in the world.

> **Comment [LB72]:** SCIENTISTS
> Inventions
> DO good
> Invent something that people will need in the world

R OK, yes….

R Thank you so much Grade 3s.….

Focus Group Discussion

School C, Grade 3

Date: 16/9/2015

R (Opening discussion - Questions about thinking like scientists)

> **Comment [LB1]:** SCIENTISTS
> We all ask questions every day;
> we do experiments … like growing plants
> we made stuff
> We proved that we could be scientists - By building a car
> It felt like we were very good engineers
> Because every kid can think like a scientist. We ask questions every day, we grow plants, ya
> It felt realistic like … uhm … it felt nice because you were actually doing something on your own
> And as a team

C We all ask questions every day; we do experiments … like growing plants.

C Because we made stuff.

C We proved that we could be scientists.

R How did you prove that?

C By building a car.

C We made stuff.

(Arguments about … why did you put lots of batteries in our car?)

C Because it worked!

C It felt like we were very good engineers.

C Because every kid can think like a scientist. We ask questions every day, we grow plants, ya …

C It felt realistic like … uhm … it felt nice because you were actually doing something on your own.

C And as a team.

R Questions about the PROBLEM

> **Comment [LB2]:** PROBLEM
> Able to articulate accurately – even after 6 days

C Our car had to go far and as straight as possible.

R How can you remember so well? It was so long ago?

C It was only six days ago.

R Questions on THINKING ON YOUR OWN. Where did your ideas come from?

> **Comment [LB3]:** THINK ON OWN
> Figure out yourself
> make our own suggestions
> we had to think of what we gonna do with it.
> TT

C You had to figure it out yourself.

C We all had to make our own suggestions then we had to think of what we gonna do with it.

R Was it easy for you to think on your own?

> **Comment [LB4]:** THINK ON OWN
> TT
> Easy
> Because uhm you thought and you could think of a car like you've seen a car before … you can draw it. So it was kind of easy to draw it and think of it

C Yes

C No

R Why was it easy for you?

C Because uhm you thought and you could think of a car like you've seen a car before … you can draw it. So it was kind of easy to draw it and think of it.

R OK, so it's because you had a picture of a car in your mind?

> **Comment [LB5]:** TT
> Where ideas come from
> Picture in mind

R And why was it difficult for you?

> **Comment [LB6]:** THINK ON OWN
> Difficult
> Because it was very hard to make your own car … and I couldn't decide how to make it
> CHALLENGE

C Because it was very hard to make your own car … and I couldn't decide how to make it.

(PPT Picture of Luke thinking on his own). (NOTE Shonah is not on the picture. She was out of class for an eye test and therefore wasn't present during the think-on-your-own stage)

R: How did you know how to think on your own? Where did your ideas come from?

C From up here (pointing to head)

R So Luke's ideas came from "up there". But you all had ideas. Where did your ideas come from?

C (All) Up here (pointing to head)

R I wonder how they get up there?

C You think of cars.

> **Comment [LB7]:** TT
> Where ideas come from
> Brain

C Actually my idea … I never actually got everything from up here. I got it from the picture on the top (pointing to the picture on the worksheet). It was the only plan I could think of.

> **Comment [LB8]:** TT
> Where ideas come from
> Picture on worksheet

C I've seen cars previously, so I decided to draw some cars from there.

> **Comment [LB9]:** TT
> Where ideas come from
> I've seen cars previously (previous experiences)

R Ok, so you have seen some examples previously and then you got ideas from there?

(PPT Next IBSE phase – sharing ideas)

> **Comment [LB10]:** SHARE IDEAS (Social learning)

C You had to look at the other people's things and then you had to think how to put them and stuff.

> **Comment [LB11]:** Share ideas
> look at the other people's things and then you had to think
> COS PSW

R Ok, so you had to share your ideas in a group?

PPT Watching video – sharing ideas in group). This video showed evidence of how you all shared ideas. How did working in a group work out for you?

C I think it was fine because you could also listen to their ideas, uhm … and uhm … change your car and make it into one car from all five of them.

> **Comment [LB12]:** Social learning
> Fine
> Listen to others' ideas
> Change
> Make into one
> COS PSW

R So you could listen to all the ideas and make it into one thing.

C I didn't actually uhm … My decision was too complicated to work, so I just start with hers 'cause mine look so realistic but…

> **Comment [LB13]:** OWN IDEA
> TT Not practical
> Too complicated
> Looked so realistic, but…
> CHALLENGE

C I just got an idea now.

R Oh, OK that's a good thing!

C That's weird.

C Some people might not like your design or something like that.

R But in the end, were you satisfied with the group's ideas?

C (All) Yes!

R How did you get to deciding on one idea?

C We decided on the easiest model of a car and then we decided like uhm … Josh's wheels, Rea's uhm … windows, Luke's…

> **Comment [LB14]:** BEST OPTION?
> Easiest (Predictive power)
> Used ideas from other members
> (Social learning) COS

(Arguing started)

R OK, so you decided to borrow a bit from everyone's ideas?

(PPT Collecting materials – NOT INCLUDED)

(PPT Video - Working together). R How did working together work for you? Did it help to work as a team or was it difficult or … what do you say?

C It helped because none of us would've gotten the idea of bettering … of making the wheels roll.

> **Comment [LB15]:** Social learning
> Helped
> Improved
> COS PSW

C I'm just saying that it wasn't actually very nice when we were sharing … when we were working together. We could have just … uh …. Actually it would have been nicer uh if uh we just had our own materials and made our own design.

> **Comment [LB16]:** Rather work on own
> (Preference}
> CHALLENGE

R Ok. What do you say Luke?

C (Same child - change of thought) But working together was better.

> **Comment [LB17]:** Social learning
> Better
> COS PSW

> **Comment [LB18]:** Changed mind

R: Now you say it's better. Why?

C It was … It was the worst thing that ever happened to me at first but when we came round, it started out to be better.

> **Comment [LB19]:** Bad – Better
> PSW

R OK … And Luke, what do you say?

C It was fun.

C I say it was nice because uhm … uhm … you can't do anything without your teammates.

> **Comment [LB20]:** Fun
> Working in team
> COS PSW

(PPT Video Test – Oops - Fail). R In the video you say it was an epic fail? So what happened?

C We found out that … Joshua said he knows what the problem was … because … uh … the wheels are too high

> **Comment [LB21]:** Justification
> Conclusion
> TT-revision

C (interrupts by saying) … the bottom was too low.

> **Comment [LB22]:** Social learning
> Team input
> COS PSW

C (child correcting) Ag the bottom was too low, then we cut it but then … when, but then … uhm … the wheels weren't rolling. So then Josh said but I know what the problem was. The wheels are too high, so we just put the wheels lower.

> **Comment [LB23]:** Justification
> conclusion
> TT-revision
> Science knowledge

(PPT Videos testing --- improving) R How did it feel like when you tested out your car and it didn't work so well?

C It felt disappointing.

> **Comment [LB24]:** TT revision
> Disappointing
> CHALLENGE

R It felt disappointing? And did you just want to give up? Just go home?

C No

C No

C Yes

> **Comment [LB25]:** Don't give up vs give up
> CHALLENGE

C No … Try again!

C We took it back to the repair station.

R Oh you took it back repair station …

C … which was our desk

> **Comment [LB26]:** TT revision
> Not give up
> Try again
> Repair station
> **CAPABILITY EXPANSION**

C Because what's the point of giving up … when they're out, you should do something … 'cause you're just kids, you don't know how to do stuff properly yet, and so you can try and try until you get it right.

> **Comment [LB27]:** PSW
> what's the point of giving up
> you should do something …
> 'cause you're just kids, you don't know how to do stuff properly yet,
> and so you can try and try
> until you get it right

> **Comment [LB28]:** Perseverance
> PSW

R Aah, and did it work out for you?

C Yes.

C It also felt bad because some people were laughing … and ya …

> **Comment [LB29]:** Making fun
> EMOTION PSW
> CHALLENGE

R (Discussion about how it feels like when people laugh, and how to deal with it – not included)

(PPT Video: Test, Tell). R: And there the batteries went all over the place.

Rea: You put like eight batteries in our car (laughing, discussion not included)

(PPT Making notes) R How did you feel about all the writing?

> **Comment [LB30]:** NOTES
> COMM/SYM
> felt nice because you could explain what you did and at some place someone else can read it and do the same.
> I loved it because I like to write stories

C It felt nice because you could explain what you did and at some place someone else can read it and do the same.

C I loved it because I like to write stories.

R And this was like a story: It was about a car that crashed and then you fixed it and eventually it worked well.

R Why do you think it's important for you to write down your ideas?

C So that you don't forget your ideas, and uhm …

> **Comment [LB31]:** NOTES
> Value
> don't forget your ideas
> copy
> People can learn from you
> someone else can do this

R: OK, and what do you say Josh?

C Every time you want to make something else, you can just copy what you did ….

C People can learn from you.

C I just said it! Someone else can copy it.

C Sometimes someone else can do this.

(PPT LEARNED?)

> **Comment [LB32]:** LEARNED

C I learned never, that uhm … to give up, keep trying and teamwork is very important.

> **Comment [LB33]:** LEARNED
> Never give up
> Keep trying
> Teamwork NB
> Make anything out of junk

C We learned how to make uh anything out of boxes and junk and … junk and stuff.

C If you ever build a car the wheels have to be loose and they have to be uh lower.

> **Comment [LB34]:** LEARNED
> Science Knowledge
> Wheels = loose / lower

C Another thing is that it's not really easy to build a car.

> **Comment [LB35]:** LEARNED
> Not easy
> (real life problem solving)
> PRACTICAL SKILLS

R It isn't easy, hey?

C Especially with metal.

> **Comment [LB36]:** LEARNED
> Relate to real life
> PRACTICAL

C It was kind of hard to build a car. Now imagine you had to build a real car with an engine and lots of wires …

(Discussion about making a real car – not included)

(PPT LEARNING THIS WAY)

> **Comment [LB37]:** IBSE

C Very good because … uh … very good because … uh … engineers … uh … when they build they just try, try and try again. But if you're going to make a real car out of metal and the engine is going to very complicated.

> **Comment [LB38]:** IBSE =
> Very good
> engineers try, try and try again
> real car will be very complicated

R Yes, but I mean in a classroom?

C I feel like it's better because you can actually do something and it's more creative than just writing on a piece of paper. I'll rather do than say.

> **Comment [LB39]:** IBSE
> actually do something
> more creative
> rather do than say

R You'll rather do than say?

R Shona, how did you feel about working this way?

C Uhm … freaky.

> **Comment [LB40]:** IBSE = freaky

R Freaky? Did you like it or did you not like it?

C I didn't really like it because I didn't do anything to the car. All I did was write on paper.

> **Comment [LB41]:** IBSE =
> didn't like
> Didn't do anything
> Just writing
> (Team differs)

(Rest of group arguing about Shona's involvement)

R: So according to you, we must never do something like this again?

Group (excited): No, do it again! Please! Please!

> **Comment [LB42]:** IBSE
> Do again

C Do it again, we are begging you!

> **Comment [LB43]:** IBSE
> DO again

C We can do it again twice!

> **Comment [LB44]:** IBSE
> Do again

(PPT Children's Voice) R: In this activity we gave you the voice. To tell us your ideas. And how you think. Do you think it's important to tell adults how you think, and what you think?

Group: Yes!

(The conversation was about teachers explaining and parents helping with homework, school tasks or pronouncing words correctly) (Discussion not included … Children need adults' help / Information transfer)

C Never judge children. You can only judge children when it's good.

> **Comment [LB45]:** AUDIENCE

VIDEO: Onsite observation

School C, Grade 3
Focus Group

Date: 15/9/2015

Pseudonyms
R: researcher

VIDEO 56

Robert Guys I think I have an idea so that the wheels can roll. We can stick like a pin or something in there, then we can attach them to the wheels so they can roll

VIDEO 57 R Can you explain to me what is wrong with your wheels?

Keshni: They're not staying on. Every time we roll them, they come off.

VIDEO 58 taking off the wheels and taking out the sticks. R

Keshni We got a different idea now

VIDEO 66 I can see some new things happening here. What have you changed?

Keshni (talking to the team) It just doesn't make sense. Cause you're taking stuff out, then you're putting them back in

Luca: (testing the wheels) Oh, it actually rolls. Ah, it works!

Robert I know!

Keshni: Guys now we go on to phase two. We have to put this on top (picking up tinfoil).

VIDEO 72 While Luca and Jacob are working on the wheels (attaching cello tape), Keshni explains: We're putting the wheels on so when it's moving, the wheels don't come off

R So you have used …

Keshni: cellotape – at the front of the wheels so that they don't come off.

R OK, so we will have to test to see if it works

VIDEO 89 + 90 Testing R You tested yours just now, and what was the problem?

Robert I think the wheels, they're really tight there

Keshni We need to cut these off (pointing to sticks)

Luca That's not gonna help

Jacob: I understand why the car is not working, because the front here is too low, so then it can't roll off…

Team members shout excitedly: Aah, Yay!

Keshni: I was gonna say it!

VIDEO 92: Jacob, you figured out the problem. Can you explain it to me?

Because if the front is too low, the car won't go off things, and it won't be able to go off the ramp

So will you be able to fix that now?

I'm not sure… But we'll try

VIDEO 103 So Luca, what are you planning on doing now?

Robert We're going to cut this part

R And how will it help?

Robert It will help for the car to go straight instead of just crashing

VIDEO 105. While the group tries to fix the bottom part of the car (cutting it), Luca tries the car out on the desk. He comments:

Luca: Guys, this is touching the ground (pointing to the box)

Researcher: What should touch the ground?

Luca… Only the wheels

Researcher: Listen to what Luca is saying – only the wheels

Robert: We should have bigger wheels. But we didn't have bigger wheels.

While the team suggests cutting more off the box, Luca picks up the car, inspects the wheels:
Wo-wo-wo-wo! I found it! Look here! This wheel won't work if we don't do something about it

Keshni: Guys the wheels are too low

Luca (testing the car by moving it to and fro) Look, it's not even working

Robert: We have to cut this (box at the bottom)

Keshni: We have to make the wheels higher

Other children correcting her: Lower!

Researcher So how will you make them lower?

Keshni By moving the sticks

R Will you move the sticks up or down?

Keshni Down

VIDEO 115 working to fix the problem

Luca. Guys, this is gonna work. Now they are super low

R Do you think it will solve your problem?

Robert Yes

R Maybe!

Robert Yes!

R You'll have to test it before you can tell

VIDEO test and tell

Keshni We made the wheels lower, because they were too high and the wheels didn't move

Robert We stuck the sticks lower so that the wheels could be on the ground

ST Let's see if what they did helped

VIDEO Letting car go down the ramp – big improvement

Group shout YAY!!!

Busy writing – ask to explain

We fixed the wheels, then it went really well

Focus Group Discussion : Student teacher participants
Bronwyn-P1, Jean-P2, Monique-P2, Researcher-R

Date: 30 October 2015

PRIOR DISCUSSION
Context: Bronwyn (P1), School A, Grade 1
*Lesson assessed by mentor-lecturer, Ms Annalie Botha

Children grouped according to their Maths-groups; children used to working together in groups.
5 groups – 5 children per group (25)

Why this activity? The theme was Pets.
We decided to make a real life problem where I've got 5 goldfish – one per group and you need to make a tank for it... they were all very excited when we got there with the bucket. They were like swarming the bucket. No but it was … shame it was very cute, and they kept checking if the fish were alive. Because they stopped moving eventually in the packets, but just because they were calm… ya, it was crazy though.
The problem? Uhm well, the fish can't live in the plastic for more than I think three hours … so they're gonna run out of oxygen, and we didn't have any place to put them, and you needed the proper equipment, …
The outcomes? For the fish to be alive …?
Materials – Suggestion by mentor-lecturer: To have random things and then the children had to think how they can use it. So I can't just bring glass containers and pebbles and stuff, because that's too easy …
Collecting materials. To make it equal, I made them pull their names out of a hat. Like which group would go first and then the 1's would come and fetch it … but then a lot of them had the same materials, so then they had to rethink their idea, because I only have like one coke bottle, one of everything. So they all had to come up one at a time, and that took long as well.
What did they learn? I think they learned, well… how to use the material they had, and they learned a lot about fish and what they need to live, because they all wanted to take the fish home, because now they know how to look after a fish, and that you need to acclimatize the water, and put drops in it. And feed them. Ya I think they learnt that they can do it.
Naming fish?: Children came up with the idea, and I just decided to write it on the board

Context: Jean (P2) School B, Grade 2
* Lesson assessed by the classroom teacher

5 groups, 6 children per group (30 children). Tables are grouped, children used to working together

Why this activity? Hands-on activity did in PGCE class; fitted the theme (Transport)
Problem – design a car that can go as far and as straight as possible down an incline
What did they learn? I think they probably learnt maybe the value of trying and trying again, and how to deal with frustration and communicate, because I think they all had their own ideas, and it was difficult for most, you know quite a few of them to actually work together. So I think maybe they learnt that and, ya, not only just the values, but they probably learnt how to critically think and how to test things and, you know, to go back and keep working (more than just science concepts)

Context: Monique (P3), School C, Grade 3

3 groups, 5 children per group (Children not used to working together in a group)

Why this activity?
I was actually thinking we should have done the Saving Fred one for the Grade 3s. It was such a nice lesson. I didn't think it would go so well.
Problem – design a car that can go as far and as straight as possible down an incline. I also used BMW, strangely enough
Think on your own (R They have put a lot of detail in the initial drawings?)
But I think they didn't understand. When they heard BMW, they wanted to make a fancy car…

OK, so uhm… I think most of you said why you chose this activity already. This was part of your theme (P1), that was part of your theme (P2), and you…

P3 I wanted to do something inquiry-based, and then I only thought of that Saving Fred [lesson] afterwards. I didn't have an inquiry-based thing to do.

Comment [LB1]: Didn't have IBSE idea: CHALLENGE

R But that Saving Fred thing would have been a perfect IBSE lesson as well, yes.

P3 Ya, I should have done that one (laughing)

R I loved your car race activity, so…, and it was nice for me to see the difference between the two … uhm so it was valuable for me.

R OK, So in your teaching practice (TP) school, uhm what … you were all in different schools, so what made your school ideal for IBSE?

(Silence)

R Or let's start the other way round, What were not ideal in your schools? Is that easier to answer?

P2 The time constraints. Because I felt like even though there was a time table, my teacher never stuck to the time table. She'd do her maths whenever she wanted to do Afrikaans… I still felt that I was so limited in the time that I had to prepare. Uhm, so that was definitely … definitely a challenge. That wasn't ideal.

Comment [LB2]: Time: CHALLENGE

Comment [LB3]: Limited in time CHALLENGE

Comment [LB4]: Time challenge

P2 (from video discussion before interview) I think if I can just add a comment on is that I found throughout is that … if we had to implement the IBSE it would have to uhm … can't it be slowly introduced? 'Cause at those schools it's so difficult. I mean, I found when I did this, I felt that I was under so much pressure from the teacher and the classroom, because, she's like: it's too noisy, it's too this, it's too that – which was a bit perturbing, because if we had more time, it would've been excellent, I mean … and they enjoyed it.

Comment [LB5]: Introduce IBSE slowly: ST SUGGESTION

Comment [LB6]: Perception of IBSE perturbing: CHALLENGE

Comment [LB7]: Need more time: SUGGESTION

R OK do you think that is at public schools, or …

P2 It's probably, uhm, I don't know about you guys… maybe you guys had the same problem?

P1 Ya, in a private school as well it was very … you know you have to get this done by the end of the week, you have to finish this so … Three hours of letting kids find it out for themselves … it's … almost takes in on other subject's time, so uhm, ya, it's basically a time thing, I think.

Comment [LB8]: CHALLENGE Curr requirements

Comment [LB9]: CHALLENGE Time

R But, don't you think the foundation phase makes it … the flexibility of the programme allows …

P3 Ya, I didn't find that with the time at all… I know maybe also… maybe my mentor-teacher was just the way she was in the class, but… there was no time constraints. I mean if I worked into break, and the kids were happy to stay, then it's fine. Because literally, that's all we did that day … was that lesson. 'Cause then after break they had PE for to an hour, and then they went home.

Comment [LB10]: Contradiction: No time constraints

P2 That's lovely… (and positive comments from P1)

P3 So ya, so ya we were very lucky with that. But I think the school environment is like that as well. Although the planning is done for the week or whatever, but there's no like, if it's not finished by Friday sorry, … So, it was quite nice in that aspect.

Comment [LB11]: Flexible school environment

R So do you think it depends on the school and the classroom teacher and so on?

P3 And also the children. I mean if you did... if their academic level… Obviously if they're struggling, then you don't wanna spend too much time on something that they not nót need, but there is a curriculum to follow at the end of the day.

Comment [LB12]: CHALLENGE Depends on academic level

Comment [LB13]: CHALLENGE (Priority_

Comment [LB14]: Priority

Comment [LB15]: CHALLENGE Curriculum requirements

R But she (referring to Bron) had a three-hour lesson with Grade 1's – which was quite complex. Don't you think it touched on some of the other subjects as well? And the skills that they developed…

P3 All of them

Comment [LB16]: EMPOWERING IBSE covers more

P1 It actually did, ya

Comment [LB17]: EMPOWERING IBSE covers more

P3 I think it is all of them. It was shapes, language, life skills, so it covers everything

Comment [LB18]: EMPOWERING IBSE covers more

P2 I don't think it should have been too much of an issue, but I know afterwards, 'cause I was been assessed there … uhm … I got a decent mark, but not amazing, but then some of the comments she gave me was that it was too noisy; I should have controlled the classroom, but those are exactly the things I didn't want to do. And I felt so stressed while I was doing it because she was like make me run around like "Keep quiet, quiet, quiet", but I didn't want to be that way. And I also found like outside of this lesson … I found that also with some of the activities I gave, the children didn't …, you know some of them didn't want to be too involved 'cause … but "Am I drawing the right thing?, "Am I doing the right thing?" I was so tired of them … not wanting … Like I did my Waldorf-inspired one … they had to write their own summary of *The Tortoise and the Hare*, and draw their own picture … "Is this right?" I mean, it's like, "Don't ask me"… Like, eventually I got to the point where I was telling the learners, don't ask me, think for yourselves, and I think that it's perhaps this idea, … this approach is quite different to what they're expected to do in the classroom.

Comment [LB19]: CHALLENGE Teacher perceptions - Too noisy, etc

Comment [LB20]: Teacher pressure

Comment [LB21]: CHALLENGE Challenge existing practices

Comment [LB22]: CHALLENGE Kids uncertain; not used to doing/thinking on their own

Comment [LB23]: CHALLENGE New expectations

Comment [LB24]: CHALLENGE think for yourselves

P1 (Confirming comments). Yes, they're not used to... Because they're told what to do; they're not, … they're not given the freedom to do like … just do it.

Comment [LB25]: Not expected; not used to

Comment [LB26]: Not used to

Comment [LB27]: CHALLENGE Teacher-directed practice: they're told what to do not given the freedom to do like … just do it

R Are you comfortable with giving children everything they need after your IBSE experience?

P1 Ah, They're more than capable

Comment [LB28]: BENEFIT CAN do; They're more than capable

P3 Ya, and I think it is actually a better way for them to learn than always giving them… I think it is exhausting as well, if you think about it: "Ma'm how do you spell this? Ma'm how do I do this? Eventually I just want to say there is the dictionary do it yourself, just try, you know. Ya, I think it's …

Comment [LB29]: Better way to learn

Comment [LB30]: Do self, try

(Agreement from other participants)

R Have you seen … The science practices in school, have you seen your teacher present something? What that did they do?

P3 That was the first time this year that my class had worked in a group.

Comment [LB31]: CHALLENGE Not used to working collaboratively

R first time …

P3 Uhm. Like proper group work. Like, they get to sit together and maybe play chess and stuff, but not actual work where they had to do something.

Comment [LB32]: No groupwork

R So they sit in groups, but they don't do group work?

P3 Uhm, ya

R O, okay. And other science activities? Have you observed anything?

P2 I hadn't seen … anything, they just … life skills I think for them was integrated into everything … They have the little government things that they'd read together. So transport is this; So trains are transport; Draw your own train. Just the governmental ones. So, … ya, that's why I think I tried to push "sciencecy" things, quite a few of them, because I wanted them to … think.

Comment [LB33]: CHALLENGE NO science in school

Comment [LB34]: Integration life skills I think for them was integrated into everything

Comment [LB35]: They have the little government things that they'd read together

Comment [LB36]: OVERCOME CHALLENGE

P1 (Agreement)

R OK. And what made your school ideal for IBSE? If you have to think about … Yours was a public school with lots of kids in it in a classroom… was there something that could be done? Or will it just be difficult? … too difficult?

P2 Hmm …. (hesitation). I am not sure… Uhm

R Yóú did it?

P2 It wasn't that bad though. There are lots of children, … but I think that was good. I think the children have the advantage of being at a school like that, because there's so many of them, so many ideas. And also different … the genders as well. I mean, they all did the same thing … it was … I think it was an advantage to be at that school.

Comment [LB37]: BENEFIT More children = more ideas

Comment [LB38]: Diversity adds value

R You (referring to P3) had small classes, so it was quite ideal, and yours (referring to P1) was a private school, your teacher was very accommodating.

P1 Yes she was

P2 My class was a little bit rowdy now and then, so I think that's maybe what the teacher was … uhm, maybe concerned about, because they are a big class, and in their groups they can get a bit … much.

Comment [LB39]: CHALLENGE Classroom management Groups a bit rowdy

R In your reflection you (P2) said if there was one thing that you would change, it would be to explain more in the beginning, and your teacher also said that you should have explained more. But is it still IBSE then?

P2 Exactly!

R Isn't it that whole point of the whole thing? That the children figure it out themselves?

P2 Uhm, Uhm… The things that uhm I think she reflected on, she said I should've maybe explained to them the parts of the car, like I… but ya I assumed they should know that.

Comment [LB40]: Perception/ Ignorance of approach

Comment [LB41]: KNWLEDGE OF CHILDREN Assumed prior knowledge

P1 They know the parts of a car… They …

Comment [LB42]: Kids have prior knowledge

P2 Ya, … and how they work, so perhaps … you know we could… I could have explained … I don't know maybe… I didn't, I didn't … at the spur of the moment, I don't know what I was thinking, I just wanted to do the lesson, So ...

Comment [LB43]: Uncertainty of how to …

R No, so, all I wanted to say is, … Please don't change that (Laugh)

R Uhm, You (P1) said "more time" if you had to change anything. And you (P3) said that you could have invited someone from BMW to make it more "real life". So OK, let's talk a little bit about the "real life" … Do you think it is necessary to

create a real life situation like that … in order for IBSE to work? Is it is absolutely necessary; if you think back to your situation … Do you think that a real life challenge is always necessary?

P1 I don't actually think so … I think it makes it exciting for them.

Comment [LB44]: Real life – makes exciting

P3 I think the lesson that they learn must be able to apply to real life in some way, but what they're doing doesn't have to be … real life … if that makes sense. But the lesson they took from each thing, they can use in real life, but that didn't have to do something … real life.

Comment [LB45]: Real life

P1 Like would it still work if they … if no-one from BMW phoned… And you just said, make a car.

P3 See I wouldn't do that to class. If I would have said, BMW phoned, like OK, …

R No, but if you said "We have to build a car..."

P1 Yes

P3 Hmm, ya, then I suppose it would have had the same effect.

Comment [LB46]: Rethink real life

R Would it have been less motivating for them … or …

P3 I don't think so.

R I was just wondering about the "real life" thing - after observing your real life lessons. And your boyfriend had to come back (P2), and you want to invite BMW now (P3), and at your school (P1), the children questioned … they asked me: Was this real or did you make this story up? So I wondered about real life, and I wanted to hear your opinion because you are requested to do that in a class.

P2 I think maybe you should incorporate real life as far as applicable to what's actually happening, because for us like this year to sit and think of, oeh, let's find something that could affect them in the real life - so we can use that - was a little bit contrived, uhm … because sometimes maybe that is not why they don't relate to it - because you make them to fit the themes but, … even then … I mean … Lots of my kids smelled a rat (laugh), like afterwards, they really, they uhm, asked me questions, 'cause the one, … on this … on the letter that David sent to the school - he actually dropped it off at the school as well - he put his name, and by that stage, they had figured out what my boyfriend's name is, because he is always at the school fetching me, and they like: "Does your boyfriend work for BMW?" And I was like "yes", so ja I don't know, I don't think it is always relevant, but if you find something that's actually happening - then use it.

Comment [LB47]: Real life should be natural

(Other participants agree)

P3 When the opportunity comes along, then do it.

Comment [LB48]: Incorporate real life when appropriate

R (Ask participants to complete the Facebook page)

R (Point participants to the Steps of IBSE document). The first step of the IBSE approach is the problem … uhm where you are required to craft a good, productive question. You two (P2 and P3) used the same hands-on activity that we did in class, and you (P1) did something entirely new. So maybe you are the best one to answer this question. Was it easy for you to come up with a problem?

Comment [LB49]: FACILITATION OF PROBLEM

P1 Uhm it was quite easy because there actually was a problem like it was … the actual problem was that the fish were going to die, uhm but … (hesitation)

Comment [LB50]: Easy – there was an actual problem

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R And if you think about other lessons that you presented. Was it easy for you to come up with a problem? One that you could present to the children, and they could just go on with it.

P1 It's been a well thought of problem, uhm.

P3 I found it took very long. It took me like a week to think about that Fred-thing … (Chuckles), Yis, it's hard.

P1 Ya, I didn't take that long with the fish thing just because it's … it was very … it was a basic problem. Uhm, **so they didn't really have to investigate.** Uhm … It was more like, "Solve it". Uhm you just have to think of it, and plan it well so that you can ask the right questions, or give them the right encouragement, I think.

R OK. And then, the outcomes... If you had to search for the science knowledge and skills … those investigation skills …, language and other skills... Was it easy for you to come up with that? You've all done that on your lesson plan. How did you experience selecting the outcomes?

P2 I didn't find that too challenging, because once we have thought out … I think the difficult thing was thinking about the lesson. Once you have the lesson, you could see the parts, … the outcomes that you want to reach … so they need to communicate, they need to work together, they need to think critically, show perseverance, things like that.

R And where did you get the outcomes from? Did you get it from the curriculum?

P1 I … uhm, the framework was in the curriculum, but it was very vague - I thought – but it's … you get it from there, and then I think I added my own outcomes. I like … filled it.

R OK

P2 I looked at your slides as well. You had those science slides, and the values, and outcomes and something. So I got some from there. But also from just … I don't know … thinking, … and going on Google.

R OK so what did you do to engage the children in the activity? Uhm, during engagement they have to become familiar with the phenomenon under studying. So how did you experience facilitation of that part … where you had to engage them?

P3 I found that easier to do that than to stand in front of a class and present a lesson and try and explain something to them, like a maths concept. Because you can only say something so many ways, and a lot of them will say but I still don't understand. It is very difficult then to think … how am I going to do this, whereas there you can say OK, but what do yóú think? Now try and help yourself, instead of saying OK but this is how we do a minus sum where we carry and, …So I found it easier to facilitate learning that way … than to explain.

R One of the trademarks of IBSE is that children's own ideas are taken into consideration. Have you experienced that you used their prior knowledge in this activity?

(Silence)

P2 Ya definitely, I mean they'd learned about cars, and one of the children, Ruben, the one that you actually have a little video of, he one day brought a Top Gear magazine to school, and he was reading about it and he was like look at

Comment [LB51]: CHALLENGE
Took long to formulate problem

Comment [LB52]: Not long to formulate – basic problem

Comment [LB53]: Problem – plan questions + encouragement

Comment [LB54]: OUTCOMES

Comment [LB55]: KNOWLEDGE OF CHILDREN

Comment [LB56]: CHALLENGE
Outcomes from curriculum = vague

Comment [LB57]: OVERCOME CHALLENGE

Comment [LB58]: Outcomes
Teacher education
Internet

Comment [LB59]: FACILITATION OF ENGAGE PHASE

Comment [LB60]: ROLE: FEEL POSITIVE
Easier than to explain

Comment [LB61]: Hand-over to children: OK, but what do yóú think

Comment [LB62]: So I found it easier to facilitate learning that way … than to explain

Comment [LB63]: ROLE: USED CHILDREN'S OWN IDEAS

this new car and it's got this and that engine, and you know … So I think lots of them already have a prior knowledge in some way and they were definitely able to use it.

R So you built, you feel you built on that? And your experience of the "think on your own"-stage... Do you think children were able to do that?

P3 Uhm, I think it takes a little bit of encouragement sometimes, because they don't always want to think. A lot of children just drew an outline of a car for the sake of drawing something. But then they would quite happily take someone else's idea and say OK, that is better than mine, it is fine. Because they not always - well I found - some of them didn't want to … They were just like, agg I'll use someone else's, because we are going to do group work.

P2 Like some of them aren't confident, or they don't ...

P3 Yes, and they rely on other children, yes

P2 They don't like the challenge of having to think. It's like the child I reflected on a lot … He didn't like any sort of challenge, anything that challenged him, wo, I can't do this - and he'd leave it blank. I promise you he wouldn't do anything. So there is just some that … feel that way.

R OK, and "sharing ideas in the group"-stage? How did you experience that?

P1 Uhm, ya I think that's where they have to learn how to work in groups more, or they have to do it more, because they're not used to compromising their own ideas, and they want … like Zia – and … she wanted her idea or like no, and otherwise she's being left out. Even though everyone had a similar idea, but it was hers that they weren't choosing, So, …

P3 Ya, and I think it is difficult for them to take a little bit from everyone and make something new … when they've given up their idea, when it's not being used – that's emotional, … difficult for them.

P2 But you know they're like little adults, … adults are the same way. You have an idea, and you have to work in a group, and you think aah, but what if mine's better. So ya, I saw a bit of that. The one girl as well almost like your Zia-one, she had an idea, and then eventually they shuffled... the group's not listening to me, they're not listening to my idea. Because they had all … agreed - the other five of them - had agreed on a different idea.

P1 In essence, everyone else agreed, … but then she didn't. Ya, so everyone else can agree, but then I think it's just maybe some individuals aren't … good at …

P2 Ya … Also like sometimes I saw in some of the groups there were like … there was a divergence between ideas, so you get three … Originally, that orange group as well, they had one side doing their own one, and the other side doing a different car. And they tried that for … I don't know, 10 to 15 minutes, then, eventually … they ended up working together. Somehow it just flipped completely, and they had all both tried, and then all of a sudden they decided, you know what, let's try actually work together, and it turned out .. I mean, they won. So, ya … (laugh)

R OK, the design and conduct science investigations stage … How did you experience facilitation of that part?

P3 It is hard sometimes to just be like, okay well, struggle along for an hour until you figure it out (chuckle), and not say anything. That I found quite hard … when

Comment [LB64]: Kids have prior knowledge "and they were definitely able to use it"

Comment [LB65]: CHALLENGE
Need encouragement to think

Comment [LB66]: Don't always want to think

Comment [LB67]: Happy to take someone else's idea

Comment [LB68]: CHALLENGE
Aren't confident

Comment [LB69]: CHALLENGE
Rely on others

Comment [LB70]: CHALLENGE
don't like the challenge of having to think

Comment [LB71]: FACILITATION: SHARING IDEAS IN THE GROUP

Comment [LB72]: CHALLENGE
Develop GW skills

Comment [LB73]: CHALLENGE
Not used to compromising ideas

Comment [LB74]: CHALLENGE
To give up idea = emotional/difficult

Comment [LB75]: KNOWLEDGE OF CHILDREN

Comment [LB76]: CHALLENGE
Some feel others are not listening to their idea

Comment [LB77]: CHALLENGE
Some aren't good at sharing ideas (personality / development)

Comment [LB78]: CHALLENGE
Divergence in ideas

Comment [LB79]: OVERCOME CHALLENGES
Found strategies to work together

Comment [LB80]: FACILITATE INVESTIGATION PHASE

Comment [LB81]: CHALLENGE
Hard to facilitate when you see them struggle

they're building theirs – and you can see they're doing it wrong, and then you just like, okay… well … (chuckle)

R Ok and then if you saw that they did something wrong, what did you do then? Because you didn't give them the answers. None of you did.

P2 I asked them questions … Is that gonna work? What's going to happen? Ya, you know … things like that … Just to make them maybe think it through … a little more.

R And did it work? To ask them questions, and so on. They all came up with solutions, so you did something right.

P3 Ya, eventually. I kept reminding them that the problem is the car must go straight and as far as possible. It mustn't look like a BMW; it mustn't have a special injection seat (laugh), and that's the problem – just so that they remembered. Because I found that they drifted off a little bit.

R In your reflection you said (P1), children have not been taught these investigation skills. So, do you think that is something that should be done?

P1 Yes, definitely

P2 Definitely

R And is it possible?

P1 Yes, and from already Grade R. They should be taught that … even earlier.

P2 That school you're at … ya, is quite good. Because, I don't think they have any knowledge of it really. I mean I had asked these Grade twos, what is a scientist, and the one boy has tried "Despicable Me" and "Minions". Ya, so I think they have more of a fantasy kind of Hollywood idea of what a scientist is.

P1 confirming P2's ideas

P1 And it is separated of them. Ya

P2 Yes

R Yes, that was evident in their pictures as well.

All participants confirming, ya, ya

P2 And it would be so nice, because like they really work good with the concepts. I don't know why it is not taught, because I did the one mentor-lecturer assessment - I think it was my second one - on observation, the skill of observation, because they hadn't done it. And they each got given a lavender plant, and I was like okay, I just need you to write down … Well first we discussed observation, and they had to then realise that observation uses your senses to analyse and describe something, and so then they basically, each group had these big lavender plants, and they had to write down what sense they used, and what they see. And it was things like that that they never heard of before. They didn't know what observing was. Ya.

R And they can do it …

P2 They cán do it

P2 And they enjoy it

Comment [LB82]: FACILITATION SKILLS
Asked questions to prompt / make them think

Comment [LB83]: FACILITATION SKILLS
Facilitation strategy – constantly remind about problem

Comment [LB84]: Kids drifted off (Lost sight of the problem)

Comment [LB85]: Definitely TEACH investigation skills

Comment [LB86]: Definitely TEACH investigation skills

Comment [LB87]: KNOWLEDGE OF CHILDREN
Kids CAN from early stage learn inquiry skills

Comment [LB88]: Learn as early as possible

Comment [LB89]: Kids don't know about science

Comment [LB90]: "Fantastical" "Despicable Me" and "Minions"

Comment [LB91]: Fantasy/Hollywood -idea about science

Comment [LB92]: Science separated from self

Comment [LB93]: CHILDREN AS SCIENTISTS
Would be nice

Comment [LB94]: Kids CAN

Comment [LB95]: Why not taught?

Comment [LB96]: Never heard before / Didn't know

Comment [LB97]: Kids CAN

Comment [LB98]: Kids enjoy science

P1 And, it's also like a nice age group where they want to make things, and build things. Like they cán do it, so they should do it at school

R I think in all of the classes I have seen they also wanted to decorate things, they wanted to make it nice for the fish to life in, and even the cars - they wanted it to decorate it

P1 Ya, the one wanted to open the teabags … for sand (laugh). Ya

R OK, and then the "drawing final conclusions"-stage where you had to help them understand what they have learned. How was that phase for you … drawing conclusions? Do you think children learned what you intended them to learn? Did they reach the outcomes? And how did you help them to acquire those concepts/outcomes.

P3 I did like a lesson afterwards, uhm … it was like a day later … uhm, and I asked them, okay, so if we had to build a car, what are we going to do; how are we going to do this, based on what you did yesterday. And a lot of them went straight to the problems that they actually had solved. They said, well the wheels must touch the floor. One group said that, and uhm, what did the other … Oh the one said that the front part of the car must bend and be higher so that when it goes down something it doesn't scrape. Because a lot of them like … So they learned … like they explained that to me, and the shape of the car, and how it mustn't be too heavy, and roll ...

R And that was afterwards even. So they remembered.

P3 Ya, it was the next day. That was the last lesson.

P1 I couldn't check on that though, because my kids were too excited to … like actually then afterwards to sit down and … draw conclusions.

P3 Ya, on that day I was like, that's not gonna happen (laugh)

P1 Ya, I also did one the next day or two days later … then it was easier.

R That's also OK, because IBSE can go over days.

P2 I actually … from the time … I think I have done mine with you at the end of August some time, and then… it was just before I was leaving, you know, one of my last lessons where we did almost like, not a consolidation, but where they had to draw their experience of the race car activity. So it was quite a gap away. But they hadn't forgotten a thing, which was amazing! They had … you know they were able to draw and recall their favourite parts. Like some of them drew the ramp, and … what not, but I think what was … what I did was I linked those scientific things the whole way along. So it wasn't just like OK here is science, … two weeks later another science thing ... I think it was important to constantly link what is a scientist, and you know … what you're doing is scientific. So ya, by the end of it they really had a good concept.

R And then the "communication with other audiences", the last stage … Do you think children are capable? How did you feel about facilitation of that process? To communicate their understanding with other people.

P1 I think they we quite excited to do that. They're excited to share what they've learned, and … uhm …

R And are they able?

Comment [LB99]: CHILDREN AS SCIENTISTS
ECD / Age group
Can, want to, should

Comment [LB100]: creative

Comment [LB101]: FACILITATE DRAW FINAL CONCLUSIONS

Comment [LB102]: Draw conclusions = afterwards

Comment [LB103]: Conclusions based on problems they encountered

Comment [LB104]: Kids too excited to draw conclusions directly afterwards

Comment [LB105]: No drawing conclusions directly after lesson

Comment [LB106]: Draw conclusions later = easier

Comment [LB107]: Time lapse

Comment [LB108]: Remembered

Comment [LB109]: able to draw and recall

Comment [LB110]: Facilitation strategy – linked science

Comment [LB111]: Make aware of science

Comment [LB112]: FACILITATE COMMUNICATION PHASE

Comment [LB113]: Excited to share what they learned

P1 Definitely. They … ya, they want to tell what they have learned, and … show people, and be excited about it.

R And in what way do they do that? Do they talk, or with a poster, or a picture, or … ?

P2 I know we ran out of time in my lesson. It was already going into break, but they were able to stand up there, not really - you know - they weren't concerned that they were explaining … it was just, it was just so … it seemed like comfortable for them, because they were confident. They just done it … this is what worked, this is what didn't, and it was real. They weren't like standing there and reciting, you know knowledge about trees or whatever, they…

R Ya, so you say they were confident about the knowledge that they constructed themselves, and to tell it to others?

P2 Uhm, ya

R I like that one (laugh)

P3 I think it was easier for them communicating something that they learned on their own, because they're not using someone else's words. They've got their … what they saw, what they did, is what they tell you. They not gonna say oh well, we used an axel … No, we used a stick for the wheels. So they use their own words and their own understanding. So they won't forget stuff like that very quickly.

R OK, the recording, the notes, notebook, journal, posters - how do you feel about the facilitation of that process? And how did children respond to that?

P2 I felt at times that I was nagging them to fill it in … because … some of them did it, some of them were just diligent, and you know when I told them, they ding-ding-ding, perfect, beautiful – and they filled it. But some got so excited, they were so intent on building that they wouldn't go back, and, you know, consolidate with the group ideas, or write what work and what didn't. So often times I felt that I was walking around, "Don't forget to do this, don't forget to do this" and almost like a party pooper. I was like just stop having fun and go back and fill this out, so it was a little bit … ya …

R For some easier than for others?

P2 Ya

P1 I think that might work better is if you have a science journal, like that is a normal thing that you do every week, or something … so that they know, after an activity, they write down what worked and what didn't work, because then … it's … then they're reflecting on what just happened. But … because I think it's new to them, so they like … forget about the paper.

P2 That's actually brilliant!

R Ya, uhm, and do you think there is any value in recording ideas - for them?

P3 Yeah, uhm, because a lot of the stuff that they wrote down, they didn't always say afterwards. So like what they remembered at that moment and they wrote, they didn't always – when you tell them about – they're like, Oh yes this and this, but they don't remember it afterwards. So recording it there, I think it is important so they don't forget to mention it …

Comment [LB114]: Able
Want to tell / Want to Show / Want to be excited

Comment [LB115]: Able

Comment [LB116]: Weren't concerned

Comment [LB117]: Confident

Comment [LB118]: Communication based on hands-on involvement

Comment [LB119]: Real

Comment [LB120]: easier to communicate something they learned on their own / active

Comment [LB121]: not using someone else's words

Comment [LB122]: own words and their own understanding

Comment [LB123]: won't forget stuff

Comment [LB124]: NOTES

Comment [LB125]: nagging

Comment [LB126]: some diligent

Comment [LB127]: some got too excited

Comment [LB128]: Absorbed by activity

Comment [LB129]: Facilitation strategy – remind about notes

Comment [LB130]: Have a science journal

Comment [LB131]: Implementation
Introduce science journal as normal thing you do every week

Comment [LB132]: Not used to … Teach IBSE skills

Comment [LB133]: Record = remember

Comment [LB134]: NB record help remember

R It is interesting, I didn't share it here, but uhm, the children felt that it was quite a valuable experience, because they say then you won't forget, and you can share what you know with others on paper. So for them it was quite valuable, even if it was a new experience, and some were a bit lazy and so on.

P2 I think it makes them proud as well of what they've done. Because I mean, I remember at school, when we had little portfolio and things as well, you were so excited to get it back and look through my work and see aah, I did better or you know, see your own growth. So I think for some of the learners that would definitely be a benefit of recording it, … and keeping it.

R OK, your role as facilitator … how did you experience that?

P1 It was nice, but it was also frustrating, because … you can see that it is not gonna work, or you don't … you don't want to kill the vibe, but they have to kind of figure it out by themselves with … your questions and stuff … but it was easier though.

R But if you think of your role as a teacher … Can you see yourselves as a facilitator of learning, or do you prefer to be a transmitter of information?

P1 No rather a facilitator

P2 Definitely, ya

R So more positive than negatives?

P1 Yes

R Refer ST to "I can facilitate IBSE-index" in pack of documents. Ask them to complete, in own time, to rate their facilitation abilities, indicate the IBSE qualities they have and the qualities they still need.

R So, you presented this one activity for me, but did you do some other science activities as well?

P3 Yeah, I did that plant one. I left them, but I have told them that you have cotton wool and a little … you know those things that you put under a pot plant to stop it loosing water, and I gave them sunflower seeds, and I gave them black and white ones - and all of them decided to plant one of each to see which one grows more. So that was quite clever, and I didn't tell them what to do and all of them put the cotton wool and then seed, cotton wool and water and then whatever.

R So if you teach science now, will you be more inclined towards teaching in a IBSE way or…?

P3 Definitely

P1 Ya

P2 Ya. I just think maybe just how I'd start is like doing more science until I feel comfortable presenting the IBSE way properly all the time. Uhm, ya, so I think I was trying that, and now - if I kept that classroom - I would have gradually given them more and more to do completely on their own really. I mean 'cause lots of my lessons had objectives like so that they learn the skill of observation; also that they …, so I wasn't really giving them any answers, but I was kind of leading them towards learning that skill in a specific way. So I think … I definitely want to implement it more, but … gradually.

Comment [LB135]: Record = proud

Comment [LB136]: Record = benefit

Comment [LB137]: FACILITATION
Nice

Comment [LB138]: Facilitation = Frustrating

Comment [LB139]: Allow child-centeredness

Comment [LB140]: Facilitation = easier

Comment [LB141]: rather a facilitator

Comment [LB142]: CHILD CENTRED LEARNING
Allowed child-centred learning

Comment [LB143]: Facilitated child-centred learning

Comment [LB144]: Develop self-efficacy / competence to teach IBSE

Comment [LB145]: Gradually introduce IBSE / Build IBSE skills

Comment [LB146]: Definitely implement IBSE, but gradually

R But if you have your own classroom, you can gradually build those skills.

P3 But I think not only in science. I think there's a lot of concepts you can do in language and maths as well through … like 3D shapes. You could give them stuff and say OK, you need to make a container for this … and see if they can figure out, you know, how to fold a paper in such a way to make a box or …

R So you can transfer it to other subjects as well? OK.

R Regarding planning, classroom organization, management – the planning of the activity, was it easy, was it difficult, … what were the challenges of planning an activity like this?

P1 Yes, you have to plan it very well, and you have to think about what the children are gonna think of … so that you have the materials that they might want, … or need.

P2 And think of the order you're doing things, and how long you can spend on each … uhm part. 'Cause I found that in some places I just felt like I spent way too much time, and then it was taking away from the time they would have to work … on their own.

R But I think that would also come with experience, because you don't know yet how long it will take.

R Uhm, and the organization of classroom according of the IBSE principles … how did you feel about that? So the physical environment, setting up the groups, but also the classroom culture of inquiry.

P3 I think it should be set like, almost like a gallery walk-style, so that they can go from one place to another without everyone all over the classroom. Like with yours or for ours, we could have had like the groups sitting, then the materials, then here's where you test, then you go back this way to try again kind of thing. Just so that there was like … and also guides them, OK now that didn't work, now I cannot run back and grab another material and fix it here, I have to go back to my desk and then go there kind of thing.

R Was it easy for you to set up a classroom in that way or, or was there …

P3 I think if it was you own classroom it's a lot easier, because you can go and say I'm gonna move all my stuff and do it like this, because this is my class, but you don't always want to be like … take your PC (laugh) and move it around.

R OK, preparing resources, especially because it is a hands-on, minds-on type of activity, planning for resources - how did you experience that?

P3 I think if you collect stuff, you also have to plan well in advance. You can't say OK I'm going to do … building something tomorrow for a lesson when you don't have stuff… You have to …

R And is it enough to get all of the stuff, the fishes, the wheels (laugh), the boyfriends …

P2 I thought it was you know … was easy enough. I have a supportive boyfriend, so he was more than happy or to call and pretend to be someone and … you know, to type things up. Also with the resources I had a lot of … mostly help from you, and then also … my boyfriend's dad does recycling, so he does it I think once a week, or once every two weeks, so out in the back, they just have, you know, there's the plastics, and there's this and this. So I just went there and was like … I like that bottle, and I like that bottle … , so I think that really, really helped

Comment [LB147]: IBSE applied to other subjects

Comment [LB148]: Plan well

Comment [LB149]: Plan for what kids might want/need + materials

Comment [LB150]: Order

Comment [LB151]: Pacing

Comment [LB152]: CLASSROOM ORGANISATION

Comment [LB153]: Organise classroom for easy access + flow

Comment [LB154]: own classroom it's a lot easier

Comment [LB155]: RESOURCES

Comment [LB156]: Plan resources well in advance

Comment [LB157]: Resources easy enough

me. So, I think as teachers – potential teachers – it's probably good to recycle, … and be organised.

P3 Ya, that's one thing I started

R You have to think about,… you'll look twice before you throw something out!

R OK, then classroom management. You (referring to P1) used 1-2-3, look-at-me. It was quite effective – I am sure they were used to that. But how was classroom management for you - the noisiness, you know, those busy bodies…?

P3 I didn't mind it when they were doing that, like when they're busy doing that, I don't mind at all. Like they can carry on, I've got no problem. But it's obviously when you're trying to say something important, then they just needed to stop, in the beginning, they must just wait for everyone to just … focus.

R I didn't think your children were so noisy. I didn't think they were ever out of hand. I think they were constructively busy, so …

P2 I think the teacher was just sitting very close to the yellow group, and they were the group I had to often personally go to, rather than shout to the whole class, I could see they were struggling to work together, so I'd go to them and I'd tell them, "Listen, where is the peace keeper, where is this person …", uhm, because there was fighting and yanking things, and … Not all the time, but now and then, so I actually had to go and speak to them and try and manage them. But the rest of the class, I didn't have too much problems with them. I didn't really need to shout over them and say anything. There were only a few things, like uhm when we … when I wanted them to start working on their posters, their final posters …, because they were so overwhelmed with testing the car and retesting it, and building and whatever, that when you know time was running out, and I was like OK they must make their posters now. I think I did … I maybe had to shout over them or do something. But … I don't mind them making a noise and doing their own thing. I just think if there was a nice method to regain all their attention at once … it would be helpful

R Ya, you'll find strategies when you're a teacher in your own classroom.

P3 Ya, they've got quite a nice one at SPARKS, and the stuff they do there, it's quite cool.

P2 Ya, hmm

P1 I think I've kind of lost the plot towards like the end of the three hours. Like they were just too … they were like overwhelming me, and they were like … they were in charge. Not that I wasn't ever in charge, but … I had to eventually tell them that uhm, you guys are stressing out the fish, 'cause they we like … and I was like … look at the fish, everyone has to keep quite now, and then they kept quiet and the fish like calmed down, so I was just like ooh, zen yourself … (laugh)

R OK, We have already spoken about children's engagement in IBSE. So this is a new experience for them, and according to my observations, they coped quite well with it. But, do you think children in ECD and foundation phase can engage in the cycle of IBSE?

P2 Definitely, 100 per cent

R Definitely, 100%. OK, and child-centred learning. How did children respond to this type of learning … where they took responsibility for learning?

Comment [LB158]: CLASSROOM MANAGEMENT

Comment [LB159]: Didn't mind moving, talking

Comment [LB160]: Need strategy to get attention

Comment [LB161]: To focus attention

Comment [LB162]: Some struggle to work together – need guidance

Comment [LB163]: Remind about rules

Comment [LB164]: Most

Comment [LB165]: Absorbed by activity

Comment [LB166]: Need "nice method to regain all their attention at once"

Comment [LB167]: Kids overwhelmed – Need strategy to calm

Comment [LB168]: ECD/FP Science

Comment [LB169]: 100% able

P1 I think it meant more to them. It was more important for them to do it properly, because it's their own ideas, … they're doing it physically.

R So the motivation comes from within more than from …

P3 And I think they also build confidence if you allow them to do something like … as a silly example, but there was a fire very near one of the school fences and there was a lot of smoke, and then the kids went crazy at break. They really thought there was like … the fire was coming, and the children were asking us to phone the fire brigade, because they're going to die … And then like the one teacher said OK, so now what are we gonna do? And the one little Grade 1 was like Let's go hide under our desks, and then they all you know went and solved the little … So if you just leave them to try, I think they, … they figure it out their own … even if it's not realistic, they just … solve their own problems

R (Refer to key principles of IBSE highlighted by ST based on own experiences. Ask ST to highlight the ones they experienced in their classrooms or add new ones). To be completed in own time.

R OK, then I have asked the children whether they think they were scientist and they were really adamant that they were. So, do yóú think they are natural scientist?

P1 Yes

R Why do you say so?

P1 They just have that uhm, like inborn inquisitive sense of …

P3 … natural curiosity

P1 Yes

P2 Ya, They're doing scientific things and they don't even know it. I mean … because we did a science lesson and I haven't even told them really about science, and then they did the science lesson, and then I asked them afterwards in a different … you know what is science? Then I made them think, and I was like but you did all of that stuff on Monday, and then they like ohhhh… then the penny drops. So I think they just do, and they don't know it's natural. Ya.

R I also experienced they are really natural scientist. So they can do it. It's just the adults, … we that struggle to teach science. And all of you have special qualities, but the teachers in your classrooms … you haven't even observed any science lessons that they presented. So the children can, but the adults feel that they can't. I am wondering about that?

R So what were the main challenges that you experienced? P3 you said Grade 1s' egocentrism, the emotional immaturity, lack of social skills, time. P2 you said time, some learners found it difficult to work in a group, and you (P3) said they came up with fancy instead of practical solutions. But what were the main challenges you experienced with presenting IBSE?

(silence)

P3 I think it's like preparing for the unexpected. Like, you're never fully prepared for what's gonna happen. Like I also was worried about how am I going to thingy if they got this idea to use that box, and there is only one, … what am I going to do? So like … It's just like preparing for all the things you can't actually prepare for. I found that quite difficult. 'Cause it's like well … "sorry there's no other box, so you'll have to … (laugh) change your plan", so ya it's just like …

Comment [LB170]: it meant more to them
Comment [LB171]: more important for them to do it properly
Comment [LB172]: because it's their own ideas
Comment [LB173]: confidence
Comment [LB174]: just leave them to try – they will figure it out themselves
Comment [LB175]: inborn inquisitive sense
Comment [LB176]: natural curiosity
Comment [LB177]: They're doing scientific things and they don't even know it
Comment [LB178]: they just do, and they don't know it's natural
Comment [LB179]: CHALLENGES
Comment [LB180]: preparing for the unexpected

R If you think about the approach, the school factors, the classroom factors, teachers, way of teaching, learners, way of learning, the curriculum, what were the main things …?

P2 I think that the teachers and the school uhm wasn't limiting. But I think that's something that a teacher should do in their own capacity, … uhm with like-minded teachers. Like, being a student-teacher in someone else's class where you see that science isn't … there aren't any science lessons and … you know … they put pressure on you while you're doing your science lessons, was … disheartening. So I definitely think that those were the factors. And, also the curriculum. There is so much pressure on the Maths and the English and … then they were doing the ANAs, I think, they were going to do the ANAs, and then they were cancelled. It's just … the school and all of the staff, they were so focused on … they need to do this maths, and then you do this, and you need to write the ANAs. There was no thinking more of learning in the broader sense of you know learning sciences, learning skills – it was just very … focused on those two.

P1 Ya, I think everyone is very conditioned, like everyone's conditioned, … and there's no time to, or … it's either too much effort or there's no time to branch out and actually spend time on the details of the little things, and … to spend time on something that is not really in the curriculum. But it is … it can be. .. I don't know.

R It is a little bit limited in the curriculum I experienced, but it is there. But you have to search hard and long for it. (Refer to challenges-poster, and ask participants to complete).

R OK, So you three don't necessarily have a science background. You have a BA degree, uhm with no science - necessarily. Does it take a specific type of person to do IBSE? I know Bern, you love science, and you have a good background knowledge and …

P2 Ya, I did a year of BSc, but then I changed.

R O, OK, so you have the science behind you! Both of you are naturally talented and born facilitators, and I think you like teaching science stuff. But does it take a specific person, or can anyone do it?

P3 I don't think anyone can do it. Like I don't think you can just go and be like OK! I think there is a certain amount of research … You do have to know what is going on. Like P1 couldn't just go in there, and like hope and pray that they don't ask her a question about the fish. Like you do have to do a little bit of … prep and you know … you have to be prepared.

P1 (Confirmation)

P2 And interest. I think the teacher or facilitator has to be interested in what's going on, because I mean, everyone remembers teachers or people who were just so boring and bland. They came there and now I have to teach you … this or that. So I think if a teacher has, … you know … they should have a certain passion towards it, or interest. Then it will help. Then it doesn't matter what science lesson you want to do.

R But do you think teachers know the importance of teaching science for this age group?

All participants: No

R And, can't they see that children are natural scientist?

Comment [LB181]: Like-minded teachers
Comment [LB182]: Teacher's response to IBSE = disheartening
Comment [LB183]: pressure on Maths and English
Comment [LB184]: focused on national assessments
Comment [LB185]: no thinking more of learning in the broader sense
Comment [LB186]: everyone is very conditioned (old habits)
Comment [LB187]: no time
Comment [LB188]: not curriculum priority
Comment [LB189]: it is … it can be
Comment [LB190]: Science BACKGROUND
Comment [LB191]: P2 some background
Comment [LB192]: I don't think anyone can do it
Comment [LB193]: research
Comment [LB194]: be prepared
Comment [LB195]: interest
Comment [LB196]: passion
Comment [LB197]: Teachers 'knowledge of importance?
Comment [LB198]: No

P1 I think they don't give them the opportunity … to practice being a scientist.

P3 Especially in the Grade R phase I found as well, I thought I would see it more there, because it's not such a rigid curriculum that you have to follow, and I found that there wasn't really … You couldn't really leave the children to try something and do something, when they can, so …

R So we will create the awareness?

P3 I hope so

P2 Ya there need to be [an awareness]. Because I think even some of the teachers maybe, … I don't know whether it's a thing between the different sectors, but maybe science or scientist are a bit of oooh untouchable … NASA, you know, whatever. So maybe the teachers feel a bit like it's not in their job description, … if that make sense.

Confirmation from other participants

P3 And I think it's also intimidating. Like if you think about the general workload of a teacher, … that certain people are expecting you to do all of this work, especially the admin for example. Now you have to go and research something you would like to teach. It is a little bit of a … difficult situation to be… Like I find it takes a lot of time, it not just walk in there and … okay, let's try…

P2 Because the teacher does have to meet specific outcomes, and it's nowhere stipulated that you need to … you know … make sure the learners are equipped with these scientific skills. There is no priority placed on it, so to add that on to a typical average teacher who, perhaps isn't that interested wouldn't be beneficial, I don't think.

R OK, and the last thing… How prepared do you feel to implement IBSE? You had one year to prepare as generalists, and you had to do a whole lot of different kinds of lessons, so - how prepared do you feel?

P1 I would definitely want to implement is next year, I think. I am doing four year olds next year, … I'm teaching four year olds, so I think if you start as young as that, and specifically with the science journal. So they can write down what they find interesting, or … that will be uhm like the first step I think, uhm is to get them used to writing down and observing, and learning all those skills then they can carry it through … rather.

R So do you feel prepared enough to try it out on four year olds? (laugh)

P1 Ya, I think they have their own ideas of how everything is made and stuff, so … it will be interesting to see that and … ya, I don't know …

R And you P2, do you feel prepared enough to do IBSE next year in your school?

P2 I think so … Definitely, I am going to try it.

R And you P3?

P3 Ya, I'm doing English next year only - from grade four to seven. But I have already spoken to the head of department about a few different ways to do some of the concepts, and not just say well this is a conjunction, this is what it does and let's do a worksheet. It must be like a different way to … just let them figure some stuff out for themselves. So it's not science, but it's at least inquiry in some way.

R Ya, inquiry can work for different kinds of lessons.

Comment [LB199]: no opportunity to practice being a scientist
Comment [LB200]: No science in Grade R
Comment [LB201]: Hope to create awareness
Comment [LB202]: Science = untouchable
Comment [LB203]: Not in job description
Comment [LB204]: intimidating
Comment [LB205]: general workload / admin
Comment [LB206]: Adds burden
Comment [LB207]: Curriculum priorities
Comment [LB208]: No curriculum priority
Comment [LB209]: Not a priority to make sure the learners are equipped with scientific skills
Comment [LB210]: There is no priority placed
Comment [LB211]: Additional burden
Comment [LB212]: Definitely teach IBSE
Comment [LB213]: Start young
Comment [LB214]: Teach IBSE skills gradually
Comment [LB215]: Kids CAN
Comment [LB216]: Definitely try IBSE
Comment [LB217]: Definitely teach IBSE.. but it's at least inquiry in some way

(Refer to Preparedness Index. Ask to complete in own time).

R Anything that you feel you had to tell me?

P1 It's a very fun way of teaching … of doing things. I enjoyed it as much as the kids did as well.

R Is it? Not too much work, and too stressful?

P1 Ya the kids are a lot, but it's … It was just fun. I enjoyed it a lot. Like you feel like you have accomplished something … by them accomplishing something on their own. If that makes sense.

P3 I think it also covers a whole lot more than what you think it will in that lessons. So the extra prep … and planning and that, covers so much more than just what you did there. So it is not just all for one lesson, I mean there's so much that they gain from it.

(Thank participants and discuss the way forward)

Comment [LB218]: Fun way of teaching / feel good experience
Comment [LB219]: Enjoyed it as much as the kids
Comment [LB220]: Feel good experience
Comment [LB221]: Sense of accomplishment
Comment [LB222]: IBSE covers a whole lot more

Appendix E: Research Journal

RESEARCH JOURNAL

SCHOOL A
GRADE 1

REFLECTING ON IBSE LESSON IDEA & INITIAL PLANNING BY MEANS OF AN E-MAIL TO IBSE TRAINERS	
Le **18/08/2015** 13:46, Linda Bosman a écrit:	
Dear Anne and Albine	
My first student participant invited me to her lesson on Friday 21/8/2015. The theme is PETS (for Grade 1: 7 years old). I went to the school today so that she can discuss her plans with me. She will be working on FISH as pets on Thursday, and on Friday when I come, she will ask children to build a fish tank to keep the fish save until they can be released into a proper fish tank again. Her idea is to bring 5 fish in plastic bags to school and ask learners to design and make tanks for the fish with a variety of suitable and non-suitable materials she will have available in the class.	IBSE LESSON IDEA: STUDENT INITIATIVE
Her idea is to develop and reinforce concepts of living and of suitable conditions for fish as pets (habitat in captivity...). And to explore materials that will be suitable for a fish tank.	OUTCOMES
I'm not sure if the activity is perfectly suitable as IBSE activity. I'm concerned about the investigation possibilities of the lesson. But the student took initiative, and went through a lot of trouble preparing for this lesson. I don't want to be too prescriptive. I want students to design their own lessons according to the principles of IBSE. The aim of my study is to investigate the implementability of IBSE in the Foundation Phase classroom - and thus also to note the things that make implementation difficult.	CONCERN: IBSE-focused?
I will really appreciate your input on the fish lesson!	

REFLECTING ON LESSON (POST OBSERVATION) BY MEANS OF AN E-MAIL TO IBSE TRAINERS	
On SATURDAY AUGUST 22, Linda wrote:	
Dear Anne and Albine	
I was in the classroom yesterday from 8:30 and I left at 13:30 – and we are not even done yet! The learners had to complete the consent letters first (that took a while), and then we started with the lesson just after break time (so that they could be refreshed before the lesson). The lesson started at 10:00. There was a lot of joy and excitement in the class! The student and I were really exhausted later, but the learners still had lots of energy to keep going.	DURATION OF ACTIVITY JOYFUL LEARNING
The student wanted to create a "real life situation" (we call it the "transcendental" paradigm, and in this context it means that the student creates a real problem that needs to be solved urgently). So she asked me to enter the class with 5 (different kinds of) fish in small plastic bags (that should preferably	IBSE PROBLEM MOTIVATED PARTICIPATION

be transferred to better conditions within a few hours). She asked them to help with a plan. The student then showed them the fish – and they Googled (on the white board) what type they were. They had to look at the fish in the bag, and then find the corresponding fish on the Internet. Then she had a discussion with them about living/non-living - and what a living being needs to stay alive (she wrote down their ideas for further discussion later).	KNOWLEDGE TRANSMISSION
Thereafter she asked them to build a tank in which the fish could be released. The learners first needed to think on their own. It took a lot of time for Grade 1's to write and draw (Many of them filled their paper with an entire aquarium – as they have them at home).	FOLLOWING STEPS OF IBSE INTRODUCED IBSE PROBLEM L INEXPERIENCED ITO IBSE?
The student provided them with a lot of suitable and unsuitable materials (she planned it like that - e.g. a coke bottle stuffed with paper, a glass jar with tea bags, a water jug, a container with plastic blocks, some pebbles, plastic aquarium plants, etc.). She told the learners that, as this was an unexpected situation, she could only find a few things in her car – she displayed it on a table. She wanted them to think creatively about what they could use.	ST FACILITATION ROLE
I don't think there was a very clear objective and not really an "investigable" problem (I suppose in the end it was to design a fish tank that can hold water – but without the testing it with water to see if it worked). She called one child per group to collect one item, so if another group planned to use it, they had to quickly re-think and re-design. One group for instance decided to use plastic blocks to build their tank. When they realized that the gaps would leak water, they got sticky tape to try make it waterproof. In the end they realised that it might not work at all, so they emptied all the blocks, and used the block container instead (which then worked quite well).	CONCERN: IBSE-FOCUSED PROBLEM? ST INEXPERIENCE L INNOVATIVE THINKING!
All the groups spent some time decorating their tanks (so some integration of Art). When they were done, the fish were released into the tanks. The kids were very proud of their tanks and even gave the fish names! When it was break time, some of the learners stayed behind to observe the fish, and later a few more came back to join them. I am going back on Monday for the conclusion, and to do a short interview with two of the groups - maybe they will tell me what they've learned.	INTEGRATION OF SUBJECTS L MOTIVATION AND JOY IN LEARNING
On the student's planning I could see some errors, but all I did was to remind her about the IBSE principles and to follow the guidelines. I didn't want to give too much input - because one of my aims is to see if students can plan and present IBSE lessons on their own. I will have a focus group discussion with my student participants at a later stage to hear their views.	ST PLANNING CHALLENGES
With my training we had some hands-on sessions, watched IBSE videos, studied the principles, frameworks and guidelines, watched videos of last year's students presenting IBSE to learners, and had a final session where students worked in groups to design their own lessons for Grade 1/2/3 based on CAPS and "inquirised" according to IBSE principles. When students presented their lessons in class, it seemed as if they understood. But seeing them in action – on their own... I can see facilitation is complex. The sad thing is that in most teacher training programmes, we don't have more time for IBSE training, and at this stage, there will be no further professional development when these student become teachers. So, this is it! For a start, I think it would be better to have some "standardised" lessons based on the CAPS themes for Grades 1/2/3 – with the question/problem, a list of resources they will need, and almost like	TEACHER TRAINING MORE GUIDELINES AND RESOURCES NEEDED?

step-by-step "instructions" to follow.	
What I have already realized so far is that - for learners - it is natural to think and work in this way. The student teacher is a natural facilitator! But IBSE facilitation seems complex.	L NATURAL SCIENTISTS IBSE FACILITATION COMPLEX?
Well, that was my first case. Next week Thursday will be the car race activity for Grade 2. This was one of the hands-on sessions we had in the class – so I am eager to see how the student will transfer a session that she experienced herself to the kids.	

REFLECTING ON THE LESSON AFTER WATCHING VIDEOS SEVERAL TIMES AND WORKING THROUGH ALL THE DATA: **October 2015**	
The problem was not a typical scientifically-oriented problem as proposed by LAMAP IBSE in the sense that learners had to conduct a scientific investigation to gather data and test their predictions to generate knowledge. The learners were required to build a fish tank with the materials available, but not required to test it (for instance, to see if it holds water, etc.). However, the problem was open-ended, providing learners with opportunities to use a variety of thinking and problem-solving skills and to work cooperatively towards achieving a common goal to build a fish tank for a living fish.	
NB: What I realised again is that regardless of what and how we teach, learners will learn. There wasn't a clearly formulated investigation in this lesson, but it was evident that learners learned a lot – from one another, but also from self-initiated investigations. Anna, for instance, "tested" the blocks of their original design by pulling them (the columns) apart. She realised that the material they used might not be suitable for a fish tank – and that they might need to consider another plan.	EFFECT OF ACTIVE LEARNING
Regardless of the fact that the problem was not IBSE-focused, and that important science concepts were not consolidated by the student teacher, children drew conclusions based on the evidence presented to them by the problem solving activity and their hands-on, minds-on effort to solve it.	

MY OBSERVATIONS AND REFLECTIONS: GRADE 1 WHOLE CLASS REFLECTION SESSION **24 AUGUST, 2015**	
The whole class reflection session was after break, just before home time. The learners were excited to see me, but they were quite restless after break time. There was also a lot of noise going on outside (lawnmower, just outside the window). But that was the time I had for this discussion – and I had to make do.	TIME FOR SESSION NOT IDEAL
I asked the student teacher to act as scribe and to write down learners' ideas on posters, but I didn't give her the questions beforehand. So I don't know yet if the summaries will be very helpful. I'll have to listen to the recordings carefully to see how the ideas on the video correspond with the poster. It was difficult to hear some of the softer voices.	LIMITATION IN METHOD

The "What did you learn"-question confirmed my suspicions. Just as I suspected, the learners were not very clear about what they have learned. This confirms my suspicion that the objective and initial problem was not so clearly articulated. To me, the initial question/question is one of the most important decisions, but also the most difficult.	EFFECT OF NON-IBSE FOCUSED OUTCOME ON L KNOWLEDGE ACQUISITION
On children's voice… It is not so easy to give learners voice, especially not in a group setting. There are learners that can freely express their opinions. I hear the voices of the learners that do speak up, and that are well-articulated more clearly than the quieter ones; the ones that don't express themselves so easily. So, some learners remain voiceless…are overpowered by the situation? I suspect that many good ideas were not spoken. Did I really create a platform for giving children a voice? How can I change this?	CHALLENGE: CHILD PARTICIPATION IN FORMAL SCHOOL CONTEXT LIMITATION
NOTE: In future, give a recording device to learners to use as "microphone" when they give an answer.	ADAPT METHOD TO CAPTURE VOICE MORE EFFICIENTLY

Observation and reflection notes: Grade 1 focus group discussion **25 AUGUST 2015**	
I prepared to interview two groups (Group 1 & Group 4), although I need one group only. I decided on these two groups as I could get rich information from both. I carefully went through all the video footage, and scrutinised the learners' notes – of all individuals in each group. I made a PPT for each group with photos of their work (notes, products, etc.), and video clippings of their participation. Also some screen grabs. I based my questions on the pictures and videos I captured.	METHOD USED FOR FOCUS GROUP DISCUSSION
I arrived just before 8:30, as the teacher said I could get the first group at 8:30 (while they are still fresh). She suggested that we sit in the foyer of the hall – where there will be peace and quiet. I decided to take Group 1 first. We took cushions to sit on the floor of the foyer.	IDEAL TIME; FAMILIAR ENVIRONMENT
Disaster!!! Two of the group (of 5) were absent due to illness, and the one boy had an earache. I nonetheless continued. Disaster upon disaster! I couldn't get my recording equipment to work properly. The learners were much more interested in my digital media, and wanted to play with the equipment. The sick child didn't feel like participating and rather wanted to lie on the cushion. Due to the risk of potential harm (the sick child worried me), I stopped the exercise and took them back to class. I felt despondent … and didn't have much hope when I collected the next group (Group 4).	CHALLENGES AND LIMITATIONS IN RESEARCH SKILLS
Well, the unexpected happened. I got the recorder going again, and the group were ready and eager to participate, and loved watching their work and their participation. I also feel happy about the information I got from this group.	FLEXIBILITY IN QUALITATIVE RESEARCH

SCHOOL B
GRADE 2

REFLECTING ON IBSE LESSON IDEA & INITIAL PLANNING **THURSDAY 27 AUGUST 2015**	
Care Race activity	LESSON PREPARATION ACCORDING TO LAMAP
Yesterday when I popped in at School B to finalise the last preparation, Jean indicated that she was ready. It sounded as if she consulted the LAMAP guidelines carefully and discussed her ideas for the science journal with me. She asked me to bring a ramp/incline for the car activity.	
Her mentor-teacher will also be present to assess the lesson.	MENTOR-TEACHER INVOLVEMENT

OBSERVATION NOTES AND REFLECTION ON IBSE LESSON PRESENTATION FRIDAY 28 AUGUST 2015	
I arrived at 10:00 to explain the research project and for the kids to fill in the assent letters before break time.	ASSENT SESISON
When I entered the class, the desks were grouped into 5 groups of 6 learners. I didn't see any prepared materials and was a bit worried about the availability of resources. This lesson was one of the hands-on activities that the students participated in during their training. They also watched videos in class of the 2014 PGCE-students presenting this activity to learners (with a reflection discussion on the strengths and areas for improvement). I also put my lesson guidelines as well as the lessons of the 2014 students on the student online system. So there was a wealth of support for this activity to be well executed.	SETING UP THE CLASSROOM
During break time I checked out the best spots to place my cameras. I felt nervous that the cameras and recorders will fail me. It seems as if a PhD-project depends on the effective of use of technological equipment …	RESEARCH METHODS
After break the learners returned, and we started with the activity at 10:30. The student introduced the activity with a telephone call from "BMW" requesting the kids to design a car that can go as far and as straight as possible (exactly like the 2014 student). Thereafter she had a discussion with the kids on what we need in order to make a car, and elicited a discussion on wheels, etc.	INTRODUCED IBSE PROBLEM FACILITATE ENGAGEMENT
Jean's questioning seemed to focus on guiding learners to think on their own. Did questions guide learners to reach outcomes of the activity? Questions and feedback on learners' comments might not stimulate deep thinking or lead learners to search for answers. What knowledge were learners supposed to acquire in this lesson? (I'll have to check the objectives in her lesson planning).	FACILITATE INVESTIGAITON AND CONCLUSIONS
The student introduced the group roles somewhere during the lesson. She should have done this PRIOR to commencement. This caused learners to lose track of the task. The Orange Group spent a lot of time (most?) arguing about who will take what role, and eventually started flipping a rubber to make decisions. I reminded them a few times to stay on track and to focus on the PROBLEM…, but it was as if the matter of group roles was just much more urgent at that time. Well, I was quite impressed by how they solved that problem	GROUP ROLES CHALLENGE! L INNOVATIVE WAY OF

(and by coming up with the rubber flipping solution to help them make decisions. Some creative ways of solving interpersonal challenges evident there! But I was disappointed in the time they lost on focusing on the problem.	OVERCOMING SOCIAL LEARNING CHALLENGES
Although the activity went very well, I wanted to see a perfect IBSE lesson here. But I need to realise that this approach is NEW to everyone … the student, the learners as well as the teacher. Although the student participated in this activity herself, there are no guarantees that she would just know how to facilitate it perfectly. I think mentor-teachers can be of assistance here. But then they need to be knowledgeable about the approach.	ROLE OF MENTOR-TEACHER

OBSERVATION AND REFLECTION NOTES: GRADE 2 WHOLE CLASS REFLECTION SESSION **27/08/2015 (After break, about 12:30)**	
Quick notes on session: Sit in groups 1-6 (at tables/carpet). Remind learners about the activity they participated in. Hand out the "microphone". Tell learners that it is a quiet game (only whispering allowed), and only the child holding the microphone is allowed to speak.	APPLY ADAPTED RESEARCH METHOD TO ELICIT CHILDREN'S VOICE
Quick reflection afterwards: The whole class reflection session went so well! I was concerned when the teacher suggested that we do the session directly after break time, rather than coming back the next day. I felt a bit unprepared…, but I didn't want to be pushy. The learners worked hard during the activity, and I was concerned that they would too tired to reflect on their learning. Break time however fuelled their energy, and they rocked!	CONCERN ABOUT TIME FOR SESSION
I was so surprised by their voices… True experts and knowers, competent and skilful communicators. Out of the book responses. (And the "microphone strategy" worked perfectly!)	CHILDREN'S VOICE

OBSERVATION AND REFLECTION NOTES POST IBSE ACTIVITY **FRIDAY 28/08/2015**	
What knowledge did the learners acquire? Now that I have worked through the Blue Group's work and videos, I wonder again what they have learned through participation in the activity. Their car didn't work perfectly from the start, and didn't improve a lot for the second and final try. I could see that their answers were non-specific – and it made me realise that things need to work out in order for learners to learn something. The one thing this group learned is that their car is not going far nor straight, regardless of the improvements they made. So did they learn anything from making mistakes? I think this group needed more time to test and try and make more adaptations to actually gain knowledge about what would make the car go straight and far. They could learn from what the other groups discussed, but I doubt if they were so interested in what others had to say.	CONCERN ABOUT KNOWLEDGE ACQUISITION
So to learn, to discover knowledge in such a situation, requires that the initial situation should be investigable, and that the learners should get some kind of a result in order to reach conclusions. It is also important here for the teacher to	REQUIREMENTS FOR KNWOWLEDGE

link the learners' ideas to scientific facts, meaning that the teacher should be knowledgeable about the subject and the specific topic – and be able to help them all to gain the same knowledge.	CONSTRUCTION
In the section where they had to write their conclusions, one child in the group wrote: "We don't have to be perfect". A good life lesson, but is it enough? Does it justify the inclusion of IBSE activities?	

OBSERVATION AND REFLECTION NOTES: GRADE 2 FOCUS GROUP DISCUSSION ON 2/9/2015	
THURSDAY 3 SEPTEMBER 2015	
By Wednesday (2 September) I was getting worried about the time lapse between the activity and my focus group follow-up. I messaged the student to remind her to ask the teacher for an appropriate time for me to do the focus group interview with one of the groups. The student called me at 12:00 to say that the teacher said 13:00 will be a good time (she forgot to let me know the previous day). I finished my preparation for two groups (Blue and Orange), and was still somewhat indecisive…	CHALLENGES INVOLVING CHILDREN IN RESEARCH: TIMES
After careful consideration, I decided that the learners in the Blue Group could give me the richest information. The Orange Group had some interesting events (e.g. quarrelling about group roles) – but it made me wonder about how they would participate in a focus group…? I decided to focus on the Blue Group instead. The Blue Group had a good gender and racial mixture – so perfect!	FLEXIBILTIY IN QUALITATIVE RESEARCH SELECTION CRITERIA
When I got to the school, two members of the Blue Group were absent, and the decision was made for me. The expected unexpected events of qualitative research are truly unexpected!	
I was disappointed because I was forced in a way to involve this group, and in the first few minutes I could see why my gut feeling could be trusted. (We had 30 minutes before home time). They were like kids high on sugar. Circumstances made it difficult for me to have a good focus group discussion.	CHALLENGES INVOLVING CHILDREN IN RESEARCH

REFLECTION NOTES: GRADE 2 FOCUS GROUP DISCUSSION **SUNDAY 06/09**	
I downloaded the videos and sound recordings of the focus group discussion today. I watched and listened… It will be extremely hard to transcribe. There are many voices, all speaking at the same time. I decided to only partially transcribe this discussion. Only the parts that actually help me to clarify some of the events and contribute to answering the research questions.	CHALLENGES INVOLVING CHILDREN IN RESEARCH: DIFFICULT TO TRANSCRIBE AND MAKE SENSE OF DATA

REFLECTING ON IBSE LESSON POST OBSERVATION BY MEANS OF AN E-MAIL:	
4 SEPTEMBER 2015, Linda wrote:	

Dear Anne and Albine	
I am now done with data collection at the second school: It was the car race activity with Grade 2's, and although not a flawless lesson, I think I got some good data. (We did this activity in class, and I also showed this year's students some videos and preparation of the 2014 students when they did this activity with kids).	
From what I see, it is very difficult for students not to give too much information. It is also difficult to manage time so that the activity runs smoothly. I sometimes had to step in to remind her about the next steps (e.g. share ideas in the group). What I missed from this student was the questioning to encourage learners to think and reason about the problem. What bothers me is what learners actually learn from these activities? Without proper guidance, I'm concerned that the kids don't really acquire the scientific concepts. When I asked learners what the most important things were they learned from the activity, many answered: to work in a group, or to try harder when you failed. Only a few had answers about the placement of the wheels, etc. I know IBSE is good for developing a variety of skills and competencies, but should the scientific knowledge not be most important?	FACILITATION CHALLENGE IMPACT ON LEARNERS' KNOWLEDGE ACQUISITION
Class management is also still very difficult for the students. The kids are extremely noisy (very excited, but very productive), but in the South African situation teachers need kids to sit still and listen. Group work for the learners seems like a bit of a challenge. Although the desks in this class are arranged in groups, I don't think the kids really work together as a group towards a common purpose. The student had the kids in their groups for the think on your own part, but when they had to share their ideas, she said they must now first decide on their group roles (the manager, scribe, artist, communicator, etc.). That caused the whole lesson to derail. One group spent about 15 minutes just arguing about who should be the manager and who should be the artist and so on. They were so absorbed by this, that they couldn't focus on the task (Personally, I don't agree with this group role approach at all. I think the dynamics in a group should come naturally). What happened in this particular group was that the one child was so upset because the group didn't want to take his ideas – because he was the "manager", and the manager tells the others what to do, that he almost didn't' want to participate. I had a focus group discussion with this group a few days later, and when I asked them about the group role incident, they said that they wanted to sort out the roles first so that they could focus on the activity. I don't think it happened, because even during the focus group discussion almost a week later, they still wanted to argue about the roles!	CHALLENGE: CLASSROOM MANAGEMENT CHILDREN PREFER TO WORK IN NON-THREATENING ENVIRONMENT AND DEVISE STRATEGIES TO MANAGE BEHAVIOUR
The kids also don't keep up with the writing, and not enough time is spent on communicating their findings, and linking their conclusions with scientific facts. The activities take a bit long, but I assume that things can run more smoothly when everyone (kids and teachers) are more experienced in the approach.	FACILITATION CHALLENGE: MINDS-ON PHASES
The classroom teacher didn't seem impressed with this lesson at all. She didn't seem to approve of the noisiness and energy-levels of the children. Her suggestions to the student teacher were also not supporting IBSE principles.	IMPACT OF MENTOR-TEACHER SUPPORT

SCHOOL C
GRADE 3

REFLECTION ON MEETING WITH STUDENT PRIOR TO IBSE ACTIVITY AND OBSERVATION **FRIDAY 11 SEPTEMBER 2015**	
Today I had a meeting with Monique at School C. Last case. So, I'm a bit concerned… This one can't go wrong …	
When I requested permission for my research at this school a few weeks back, the principal replied promptly, and sounded excited to be included in my project. He scanned and e-mailed the consent letter to me immediately. When I got there today, it felt as if everyone was excited. The student seemed to have all her plans ready. She started collecting materials a while ago, and she even explained how she and her grandfather had been making plans for the ramp. The classroom teacher seemed so friendly and accommodating, and assured me that they will do their best to make sure that everything goes well. She is excited about the new approach.	SCHOOL ENVIRONMENT: FLEXIBLE ACCOMMODATE NEW APPROACHES

OBSERVATION AND REFLECTION NOTES: PRESENTATION OF IBSE ACTIVITY **15 SEPTEMBER 2015**	
9:30: Classroom set up and assent session	ASSENT SESSION
Monique seemed 100% in charge. Her resources were all set out on the counters at the back of the class. I was so impressed with the variety of resources she collected.	ROLE AS PLANNER
Monique involved the vice-principal to introduce the activity. The student is a natural. She is a comfortable facilitator. She constantly reminded the learners to write their idea in the prepared science journals. She was very adamant that learners had to keep up with recording.	FACILITATION ACCORDING TO IBSE PHASES
It was much easier for me to observe and interact with three groups of learners. I could move in-between all the groups and have conversations and make videos about the important events quite easily. Maybe I was more experienced at this by now, but it felt as if I could keep track of each groups' progress.	

OBSERVATION NOTES: GRADE 3 WHOLE CLASS REFLECTION SESSION **WEDNESDAY 16 September 2015, 12:30**	
The teacher indicated that I could come at 12:30 for the whole class reflection session. I was disappointed as I have learned from experience that the time after break is not a good time to get good data…. But I am tied to the times available to me. Questions ready.	CHALLENGES INVOLVING CHILDREN IN RESEARCH: TIMES

REFLECTION NOTES: GRADE 3 WHOLE CLASS REFLECTION SESSION **THURSDAY 17 SEPTEMBER**	
What a relief that it went so well! I loved seeing the kids, and they were excited	

to see me! I felt as if I were the person they associate with having a fun learning experience… Once I arrived at school, I decided to have the learners sit on the carpet in front of me. 15 learners are easy to handle, and it is nice and intimate. I knew how to use the voice recorders, and felt more relaxed about my technology abilities. The learners were not rowdy, and we could have a good session.	RESEARCH METHOD
One little girl put a pen behind her ear while we had the session. When I asked her about the pen, she said that she was a scientist.	CHILDREN'S VOICE

OBSERVATION AND REFLECTION NOTES: GRADE 3 FOCUS GROUP DISCUSSION (Blue Group) **MONDAY 21 September (11:00)**	
I could go with any group this time. There was so much richness in each and every group. But I decided to go with the blue group. Apart from the important events, they were really a mixed group (almost one child from each of the racial groups in South Africa).	SELECTION CRITERIA
The students were not at the school any more (back on campus), but I was going to see the kids. I felt so sad on my way to the school. This is the last visit to the last school. I've grown so attached to the kids. And I loved working with them in this way.	
I spoke to the classroom teacher about my feelings, and that I appreciated that they allowed us to try out new approached in practice. She noted that it is important for us to have this connection with practice. And I agree. As lecturers we so often advocate approaches, without seeing the implementation in practice. I taught IBSE. I advocated the approach. I observed its implementation in a real classroom situation. It works…	INFLUENCE OF SCHOOLS AND MENTOR-TEACHERS IN STUDENT TEACHERS' PROFESSIONAL DEVELOPMENT

REFLECTION ON FACILITATION CHALLENGE OBSERVED IN ALL THREE CASES (March 2016)	
What I noticed in all classrooms (during observation and after watching the videos several times) is that, while student teachers provided learners with the opportunity to record their own thinking at the onset of the activity, their guidance throughout the activity was more general in terms of encouraging learners to think on their own … However … it is not sufficient merely to allow time and space for learners to explore and express their ideas. Learners need to experience physically and be aware of whether, why and how their initial ideas changed. I did not observe this kind of support from the student teachers, which may imply that they need clearer guidance in this regard.	FACILITATION CHALLENGE

REFLECTION ON THE RESEARCH PROJECT BY MEANS OF AN E-MAIL TO PROF PIERRE LÉNA (CO-FOUNDER OF LAMAP) **31 OCTOBER 2015**	
Dear Prof Léna	

I was in the fortunate position to have been selected to participate in the 6th international *La main à la pâte* seminar in June this year. It was the event of a lifetime, one that will have a lifelong impact. I am truly grateful for the wonderful opportunity I had. It came at just the right time for me.	OWN TRAINING
I was first introduced to *La main à la pâte* when Prof Billy Fraser at the University of Pretoria (where I work in the department of Early Childhood Education) invited me to attend the LAMAP launch in South Africa in 2012. (He was aware of my interest in early childhood science education). After the opening, I asked if I could participate in the training that was presented by Anne Goube and Albine Courdent – and thereafter I was hooked for life.	
I have to admit that I am not a scientist. I actually view myself as a non-scientist, and not even particularly scientifically literate. Being an early childhood expert I never viewed science as one of my strong points. I now often ask myself how I got myself into this science-business, as I always supported the "I hate science!" team. So what changed my mind? I attended the first training session in 2012, being well aware that I was the only person in the venue without any science background. So I was seriously nervous when Anne and Albine presented the first hands-on problem. I even got more nervous when they asked us to think on our own and to write down our own idea. I didn't have any ideas…, so I was relieved when they said it was fine if we left the space blank. And that is exactly how I felt – blank, and very unhappy about it. Actually I did have a few ideas, but I didn't feel confident enough to write them down. When we had to share our ideas with our team… I was too shy to share mine. As I listened to my team's ideas (all real scientists), they were the same ones I had, but didn't have the confidence to write down. Their ideas were also not so great, and far from solving the problem… and it made me feel a bit better about myself (and my scientific abilities). In the end I was the one that came up with the solution (best feeling ever!!!). My team, being aware that I am not a scientist, stared at me in disbelief ("How did she…????"). Then one of my team members commented: "Maybe it is because you can think like a child".	EARLY CHILDHOOD GENERALIST - CHALLENGE: LIMITED SCIENCE BACKGROUND KNOWLEDGE PERSONAL EXPERIENCES PARTICIPATING IN IBSE (EMPOWERMENT) IBSE MAKES SCIENCE ACCESSIBLE TO ALL
Well, I didn't know if that was meant as an insult or a compliment … but there I realized that this type of approach makes science accessible to all. And in South Africa, we owe it to all those young "natural" scientists to give them access to science. I guess that is why I got myself into this science-business: I represent early childhood, the area in which most people working with young learners are not so scientifically-oriented. Yet, as educators in this field, it remains our responsibility to unlock our young learners' scientific potential.	PERSONAL TRAINING EXPERIENCES
Having completed the training in 2012, I became part of the team of trainers in 2013, training the Grade 4 teachers of the pilot project. And, once-again, I felt uncomfortable in my role as trainer of IBSE. I felt uncomfortable with both the subject (science), as well as the phase of schooling (intermediate phase, grades 4-6). But I was "in love" with the approach, and decided to stick with it regardless of my own fears. I then decided to expose my own student teachers (specializing in early childhood and Foundation Phase) to the LAMAP IBSE approach.	IMPACT OF APPLYING IBSE ON STUDENT TEACHER SKILLS
The 2014 students were however so positive about IBSE, and some of them – after the little training I provided – were so good at presenting IBSE during their teaching practice. I was so surprised by the students' responses to this approach after trying it out in practice, and also by the learners' responses (from my classroom observations), that I was dedicated to continue this year,	EFFECT OF NETWORK OF SUPPORT

and to use what I have learned (from my initial training, my involvement in the pilot project and attendance of the international seminar) with greater confidence. I know that I still have a lot to learn, but I hope that slowly and surely I will become more proficient, and refine my own practice over time. I must say, I depend heavily on Anne and Albine for their input in whatever I plan to do – and they are always so willing and generous with their help!	
My 2015 students got a good dose of LAMAP IBSE this year. I realize the training I offer is not ideal (far from the suggested 80 hours or three years!), but it is all we have. We focus heavily on child-centred learning, and I teach students that science should be taught through inquiry as far as possible.	TEACHER TRAINING
Well of course, I wouldn't claim that the lessons the students presented were without difficulties (and I didn't expect to see any "perfect" lessons). I merely wanted to see the possibilities and the challenges involved in its implementation, so that I can report on it. Regardless of the difficulties, from my observations I can honestly say that our young South African learners are absolutely ready to reason, and to think scientifically! And the learners' response to this approach was astounding!	SOUTH AFRICAN CHILDREN CAN PARTICIPATE IN IBSE
We just need to get the teachers excited about this too!	RAISE AWARENESS AMONGST TEACHERS
On the 30th of October 2015, I had a focus group discussion with my three student participants – to hear their experiences of presenting IBSE during their teaching practice time. I have not had the time to go through the data I collected in detail, but I had a warm feeling after the session. Although students pointed out the challenges they faced, they felt very positive about the implementability of IBSE in Foundation Phase classrooms. It seems as if they whole-heartedly adopted this approach – not only when they presented science, but they even followed an inquiry-approach when they taught other subjects like mathematics and language. They said that they enjoyed presenting IBSE just as much as the learners enjoyed participating in it. They could see the inherent curiosity, the natural scientists within the learners in the classrooms. And they could see the benefits for learners participating in IBSE. One of my participants said: "IBSE should be implemented in all schools as it is a great way to improve the learners' cognitive and practical skills and it will be beneficial to the learners in all aspects."	IMPACT OF IBSE IMPLEMENTATION ON STUDENT TEACHERS' PROFESSIONAL DEVELOPMENT
All three the student participants already got teaching positions for next year – and they will definitely teach science the IBSE way in their own classrooms. They said that they felt privileged to be part of my research project, and would love to make other educators aware of IBSE, and of learners' abilities to do science. So, the "hands in the dough"-idea will hopefully spread when my students carry the message into their new school environment as real teachers. We have planted the seeds!	INFLUENCE ON FUTURE TEACHING PRACTICE
On your last presentation at the seminar in France ("Transmitting science to a changing youth"), I eventually started understanding your rationale for driving the LAMAP IBSE approach internationally… because you care about the planet. And because you want the world to educate a reasoning youth that can take care of earth for the sake of future generations. So although I will never be a scientist, that ideal is something I can live with and promote.	AIM OF IBSE

Appendix F: Field Notes

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

School: A Grade 1
Teacher: Student-teacher (ST) Bronwyn
Class: Grade 1 (6-7 years)

	1a T asks questions requiring Chn to give their existing ideas	T's questions include open questions (requiring more than a one word answer) which probe what Chn are thinking not only at the start but at other times in the activity; e.g. What do you think is the reason?' rather than 'what is the reason?'	x			Children were requested to think on their own, and to write or draw their own ideas on their notes page. She used the interactive white board for instructions on the format for recoding their own ideas / group ideas / change of plans / final ideas
	1b T helps Chn to formulate their ideas clearly	T asks Chn to explain their ideas so that others can understand, if necessary asking 'Is this what you mean?', giving them some time, perhaps in small groups, to discuss and clarify what they think.		x		ST gave opportunity to express ideas, but did not ask children to explain in order to help them articulate accurately. She moved between groups to listen to ideas and ask questions. (Children's own ideas were influenced by the group). T helps Chn to formulate their ideas clearly
	1c T provides Chn with positive feedback on how to review or take their ideas further	T responds to Chn's ideas such as by suggesting how they could be investigated in the current activity or later, or by referring to the Chn's ideas at some stage during the investigation asking 'do you still think that...?'	x			She interacted with individual children, groups and class as a whole to stimulate discussion. Encouraged to think on their own and figure it out. Did not give answers
2. Supporting investigations						**NOTE: Questioning more general than IBSE-problem-specific. IOW supporting thinking, but not towards reaching inquiry-based outcomes. The children needed more problem-focussed guidance**
	2a T encourages Chn to ask questions	T asks, for example, 'What would you like to know about ...?' or has a 'question box' or board where Chn can put questions which are read and taken into account in later discussion.			x	Not observed
	2b T helps Chn to formulate productive (investigable) questions	This might be through discussing with Chn the kinds of questions that can lead to investigation and the need to clarify the meaning of words such as 'best' in a question such as 'which is the best shape for a paper aeroplane?'			x	Not observed
	2c T encourages Chn to make predictions	T asks Chn to give their ideas about what they think might happen in the investigation and why, for instance 'What do you think will happen if we ... or when ...? Why do you think that?"	x			She fostered their curiosity by asking questions, and guiding their participation.
	2d T involves Chn in planning investigations	T makes sure that Chn take part in planning the investigation by providing some structure for making decisions about what they will do. Chn are not expected to plan without help but the plan is not decided entirely by the teacher.	x			ST encouraged groups to make their own plans, and to collaborate in solving the problem. She provided opportunities for children to take the lead. Through her questioning prompted them to identify potential problems, and to come up with solutions. She encouraged them to communicate and reflect on their observations and ideas
	2e T encourages Chn to include fair testing in their planning	In investigations where comparisons are being made or changes are being investigated, T encourages Chn to think about and ensure that some things are kept the same so that only the variables under investigation change.		x		Real life problem solving activity.The children were required to build a fish tank with the materials available, but not required to test it (for instance, to see if it holds water, etc.). As Bronwyn explained: " ... so they didn't really have to investigate... It was more like, solve it". However, the problem was a real life problem, and open-ended, providing children with opportunities to use a variety of thinking and problem-solving skills and to work cooperatively towards achieving a common goal (to build a fish tank for a living fish).
	2f T encourages Chn to check their results	T asks Chn to be sure to check their results by repeating observations or measurements where possible and ensuring accuracy, for instance in reading measurement scales carefully.			x	NA to this activity. Not IBSE-focused problem (with investigation that will lead to results)
	2g T helps Chn to keep notes and record results systematically	This might be through providing a framework or headings or a checklist of things to record and where relevant helping them to organise their data in a table.	x			Childre were required to take notes and record their process in four blocks (Own thinking / group / Changed ideas / Final ideas). It was children's first encounter with IBSE, and their first experience with recording their scientific thinking. Final ideas were not IBSE-specific (IBSE conclusion)
Guiding analysis and conclusions						**NOTE: Facilitation not directed towards guiding analysis and conclusions**
	3a T asks Chn to state their conclusions	T makes it explicit that they should bring their results together in a statement of what they mean, not simply record data collected.	x			YES, BUT needs improvement. Not IBSE-outcome. Lesson had too many new aspects for inexperienced children. Children were required to verbally explain the process of their thinking and doing, but not the CONCLUSIONS they reached.
	3b T asks Chn to check that their conclusions fit with their results	T asks Chn to check that all their observations or results are consistent with their overall conclusions.		x		Needs improvement. Lesson outcomes, problem and guidance need to be IBSE-specific.
	3c T asks Chn to compare their conclusions with their predictions	T asks Chn to recall what they predicted and to compare it with what they found.		x		Verbal discussion (whole class) of the PROCESS and END PRODUCT. Not comparison between predictions and conclusions. Not IBSE-focused
	3d T asks pupils to give reasons or explanations for what they found	T asks Chn to explain and not merely describe what they found, helping them to use ideas that also can explain other situations. 'What could be the reason for ...?'		x		ST encouraged them to communicate and DESCRIBE their process and end product. Did not require reasoned justification of conclusions. Not sufficient reflection
	3e T helps Chn identify possible sources of error	T asks Chn to consider what aspects of how they carried out the investigation could have made a difference to their results, such as by asking if they would get exactly the same result if the investigation was repeated.		x		Not observed
	3f T helps Chn identify new or remaining questions	This could be by asking Chn what else they would like to know about the topic of their investigation and discussing other questions that have arisen.		x		Not observed
	3g T encourages Chn to reflect on what they have done and found	This might be by asking Chn 'do you think this was the best way to investigate ...?' 'What would you change if you were doing it again?'		x		Not observed
	SUMMARY ANALYSIS					
	Capabilities	Knowledge of child-centred pedagogy				
		Facilitation is directed towards guiding child-centred action				
	Challenges	Building inquiry-focused ideas				
		Supporting IBSE-focused investigations				
		Guiding children towards inquiry-focused analysis and conclusions				

	A	B	C	D	E	F	G	H
1	**IBSE OBSERVATION NOTES**							
2	Date: 27/8/2015							
3	School: B							
4	Student-teacher : Jean							
5	Class: Grade 2 (7-8 years)							
6	Session: Transport: Car race							
7	OBSERVATION: Children's activities			YES	NO	N/A	Complementary evidence	
8	4. Carry out investigations							
9		4a Chn pursue questions which they have identified as their own, even if introduced by the T	Their ownership of the questions is shown by Chn being able to explain in their own words what they are trying to do or find out.	x			Explain accurately in own words.Problem relevant, meaningful to their current situation. Children driven by "real life"problem	
10		4b Chn make predictions based on their ideas	They give a reason for what they predict, even if it is inaccurate, showing that is it not just a guess.	x			Able to explain own ideas, and give reasons for suggestions. However, ideas are often unpractical, not focused on IBSE problem, and difficult to excecute with recyclable material. NOTE: Think on own should involve a prediction (suggestion) to solve the IBSE problem: i.e. car that can go straight/far down an incline - and should therefore include aspects like position of wheels/axle/etc - directly related to the problem. Most draw fancy/BMW car.	
11		4c Chn take part in planning an investigation	Chn suggest what to do in general terms and discuss details within the structure provided by the teacher. The plan may not be created entirely by Chn but is understood and agreed by them.	x			Enegetic discussion, suggesting plans. Children given agency to explore materials and come up with their own plans. Not prescribed by teacher.	
12		4d Chn include "fair testing" in their plan if appropriate	In investigations where it is necessary to ensure fair comparisons, children's plans include decisions about which variables to change and which to keep the same.	x			Investigation offered many opportunities for fair testing. Children constantly "tested" elements of their prototype (e.g tested to see if wheels could roll/not role, or tested its performance down the ramp to see if car meets requirements: go far/straight)	
13		4e Chn carry out their own investigations	Children are active in collecting and using evidence themselves (directly from objects studied or using secondary sources), not observing someone else doing this. If this is NO then 4f is also recorded as NO.	x			Most children actively involved in collecting and using evidence themselves. Evidence presented by direct involvement in hands-on activity (using materials to build prototype). Some children (e.g. Rian) have difficulty participating due to personality traits, but get drawn in by the excitement created by the activity	
14		4f Chn gather data using methods and sources appropriate to their inquiry question	The appropriate data may be observations, measurements, or information from secondary sources such as books, posters or websites. For observations and measurements, relevant equipment and instruments such as rulers, balances or lenses are used.	x			No science equipment needed for this activity. Children used available materials and tools to create their prototype.	
15		4g The data gathered enables Chn to test their predictions	The nature of the data collected by observations, measurement, or from secondary sources enables them to test their predictions and answer their inquiry questions.	x			Children use data drawn from their observations and hands-on participation (e.g. wheels won't rol /car broke into pieces) as evidence to modify plans	

	A	B	C	D	E	F	G	H
16		4h Chn consider their results in relation to the inquiry question	This refers to group or whole class discussion (the written account is considered separately) of how the results of the investigation help to answer the inquiry question	x			YES, BUT ... Discussion of results relate to problems they themselves encountered during the investigation and does not relate directly to the inquiry question	
17		4i Chn propose explanations for their results	Chn discuss in groups or the whole class possible reasons for what they found or how the results can be explained.	x			YES, BUT ... again - relating to their problems, e.g. didn't roll - move wheels away so that it can roll. But not sufficiently focusing on far/straight	
18	5. Working with others							
19		5a Chn collaborate when working in groups	Chn work together, agreeing on tasks and sharing them, not working individually although seated in a group.	x			Challenging personal interactions (arguments about group roles dominated group dynamics). However, all members (including "difficult child") were driven (absorbed) by the problem solving nature of the activity, as well as other groups' energetic actions and interactions	
20		5b Chn engage in discussions of their investigations and explanations	During group work Chn discuss what they are doing and how to explain what they find.	x			Dialogic interactions - lively, energetic, noisy. Eager to voice opinions. Criticise "silly" ideas, but also complement "good" ideas. Hear, but not focussed attention on listening. PRACTISE needed to participate in scientific discussions: to share, listen, respect others' opinions.	
21		5c Chn report their work to the class	This can be by direct oral reporting from one or more groups to the whole class, or to another group, or groups displaying their work in the classroom for all to look at.	x			Able, willing and excited to show/tell. Elementary, brief verbal explanations - focussed on personal encounters	
22		5d Chn listen to each other during reporting	The indications of paying attention include looking at the person speaking, not speaking themselves and responding, if asked, to what was reported.		x		Too absorbed / excited about own prototype to pay focussed attention to other groups' explanation. NEED PRACTICE and more time to get enough of own experience so that they can focus on learning from others as well	
23		5e Chn respond to each other during reporting	Responding may imply asking questions to better understand their classmates' presentation or agreeing or disagreeing with what is being reported.		x		Groups experienced the show/tell more as competition to see which one wins/loses than to focus on learning about the aspects that made the car go far/straight or not.	
24	OBSERVATION: Children's records							
25	6. Records children make of their work							
26		6a Chn make some record of what they did and found	This can be an individual or group record, in the form of a drawing and/or written account, as appropriate to the age group. If there is no tangible record, responses to all items in section 7 ("Chn's written records") will be N/A	x			Prescribed format provided, children filled in. Variety of signs, symbols used to represent their thinking.	
27	7. Written records							
28		7a Records clearly state the problem or question being investigated	In most written records, whether individual or group, there is a title or statement that describes what question the investigation was designed to answer.			x	Question verbally introduced. Not provided on science journal	
29		7b Records indicate what data were collected and how	Most written records (individual or group) include a brief statement of what was observed or measured and how this was done. E.g. that the length of the shadow of a stick was measured using a ruler.	x			Children kept record according to the prescribeed format, and indicated own ideas, group ideas, materials used, observations after test 1, improvement made, observations after test 2 and what they learned. Children's descriptions of their observations were described using own everyday language in terms of failure or success. Clearly lacked vocbulary and skills to describe observations and improvements scientifically	
30		7c Observations and data are recorded in a systematic way	Most records (individual or group) include a table or organised list of data collected or a drawing showing their result.		x		Filled according to a prescribed format. Results do not contain evidence-based conclusions.	
31		7d Records indicate whether or not results agreed with predictions	Most written records state whether what Chn found agreed with what they predicted.		x		Clear difference between own/original idea and final idea. (i.e. Theory Revision). However original idea was often impractical and not a successful attempt to predict a possible solution. Therefore	
32		7e Records indicate what the conclusions were	Most written reports (individual or group) included discussion or a general statement of what the observations or measurements meant overall.		x		No general statement (evidence-based conclusion). End product or skills / virtues / practical (no SCIENCE outcomes related to IBSE problem)	
33		7f Chn take some personal notes during their work	This refers to informal notes that Chn may have made during the investigation, jotting down ideas or data, not the formal written or oral record compiled at the end.	x			Prescribed format, but filled according to own preferance (write/draw) and contianed children's personal notes	

OBSERVATION CHECKLIST

School: C Grade 3

Student-teacher: Monique

DATE: 15/9/2015

ST: student teacher

L: learner

ST-LEARNER-INTERACTIONS

	Items	Explanations	YES	NO	N/A	Complementary evidence
1. Building ideas						
	1a ST asks questions requiring L to give their existing ideas	T's questions include open questions (requiring more than a one word answer) which probe what L are thinking not only at the start but at other times in the activity; e.g. What do you think is the reason?' rather than 'what is the reason?'	x			Learners were requested to think on their own, and to write or draw their own ideas on their notes page. She had science journals for learners to record g their own ideas. She used questioning throughout, prompting learners to think, rather than giving them the answer.
	1b ST helps L to formulate their ideas clearly	T asks L to explain their ideas so that others can understand, if necessary asking 'Is this what you mean?', giving them some time, perhaps in small groups, to discuss and clarify what they think.	x			She interacted with individual learners, groups and class as a whole to stimulate discussion, prompting to think. Not much attention to helping learners clarify their formulation.
	1c ST provides L with positive feedback on how to review or take their ideas further	T responds to L 's ideas such as by suggesting how they could be investigated in the current activity or later, or by referring to the L 's ideas at some stage during the investigation asking 'do you still think that...?'		x		Encouraged L to think on their own and figure out themselves. Did not give answers. Support not inquiry-question-focused. More focused on general thinking than on concept acquisition.
2. Supporting investigations						
	2a ST encourages L to ask questions	T asks, for example, 'What would you like to know about ...?' or has a 'question box' or board where L can put questions which are read and taken into account in later discussion.		x		Not observed
	2b ST helps L to formulate productive (investigable) questions	This might be through discussing with L the kinds of questions that can lead to investigation and the need to clarify the meaning of words such as 'best' in a question such as 'which is the best shape for a paper aeroplane?'		x		Not observed
	2c ST encourages L to make predictions	T asks L to give their ideas about what they think might happen in the investigation and why, for instance 'What do you think will happen if we ... or when ...? Why do you think that?"	x			Partially
	2d ST involves L in planning investigations	T makes sure that L take part in planning the investigation by providing some structure for making decisions about what they will do. L are not expected to plan without help but the plan is not decided entirely by the teacher.	x			ST provided guidance by guiding L systematically through the steps of IBSE. She provided a structure for recording all steps, and gave time to plan, make, test, record, modify, test, record, communicate. Encouraged the groups to make their own plans, and to collaborate in solving the problem. Encouraged and prompted L through questioning to think and figure things out for themselves.
	2e ST encourages L to include fair testing in their planning	In investigations where comparisons are being made or changes are being investigated, ST encourages L to think about and ensure that some things are kept the same so that only the variables under investigation change.	x			Gave opportunity for testing, but not sufficient guidance towards solving the IBSE problem
	2f ST encourages L to check their results	T asks L to be sure to check their results by repeating observations or measurements where possible and ensuring accuracy, for instance in reading measurement scales carefully.		x		Not done
	2g ST helps L to keep notes and record results systematically	This might be through providing a framework or headings or a checklist of things to record and where relevant helping them to organise their data in a table.	x			ST provided age appropriate framework and guidance. L were required to record their process in 9 blocks (1) own idea; (2) group idea; (3) Materials; (4) First model; (5) Test 1: What works/What doesn't work (6) Changes; (8) Test 2 observations; and (9) What did I learn. This was learners' first encounter with IBSE, and their first experience with recording their scientific thinking
	3a ST asks L to state their conclusions	T makes it explicit that they should bring their results together in a statement of what they mean, not simply record data collected.		x		Learners verbally stated conclusions. Recorded data relevant to their investigation, but not necessarily focused on the inquiry question . Needs improvement.

	3b ST asks L to check that their conclusions fit with their results	T asks L to check that all their observations or results are consistent with their overall conclusions.		x		Not focused on inquiry-question. Needs improvement, and more time to practise.
	3c ST asks L to compare their conclusions with their predictions	T asks L to recall what they predicted and to compare it with what they found.		x		Not sufficiently done. Learners reach their own conclusions, and it is accepted by the ST
	3d ST asks pupils to give reasons or explanations for what they found	T asks L to explain and not merely describe what they found, helping them to use ideas that also can explain other situations. 'What could be the reason for ...?'		x		Learners merely describe what they found. Not prompted to justify conclusions.
	3e ST helps L identify possible sources of error	T asks L to consider what aspects of how they carried out the investigation could have made a difference to their results, such as by asking if they would get exactly the same result if the investigation was repeated.			x	Not observed
	3f ST helps L identify new or remaining questions	This could be by asking L what else they would like to know about the topic of their investigation and discussing other questions that have arisen.			x	Not observed
	3g ST encourages L to reflect on what they have done and found	This might be by asking L 'do you think this was the best way to investigate ...?' 'What would you change if you were doing it again?'		x		Not sufficiently. Given opportunity to share, but not to reflect and consolidate their conclusions.

IBSE: OBSERVATION NOTES					**Date: 15/9/2015**
School C					
Class: Grade 3 (8 - 9 years)					
Student-teacher: Monique					ST: student teacher
Session: Car race					L: learners
OBSERVATION: Learners' activities		YES	NO	N/A	Complementary evidence
4. Carry out investigations					
4a L pursue questions which they have identified as their own, even if introduced by the T	Their ownership of the questions is shown by L being able to explain in their own words what they are trying to do or find out.	x			Explain accurately in own words. Problem relevant, meaningful to their current situation. learners driven by "real life" problem introduced by vice-principal
4b L make predictions based on their ideas	They give a reason for what they predict, even if it is inaccurate, showing that is it not just a guess.	x			Able to explain own ideas, and give reasons for suggestions. Ideas in journals - too much detail. Ideas are often unpractical, not focused on IBSE problem, and difficult to execute with recyclable material. Many draw fancy/BMW car.
4c L take part in planning an investigation	L suggest what to do in general terms and discuss details within the structure provided by the teacher. The plan may not be created entirely by L but is understood and agreed by them.	x			Energetic discussion, suggesting plans. Learners given agency to explore materials and come up with their own plans. Not prescribed by teacher.
4d L include "fair testing" in their plan if appropriate	In investigations where it is necessary to ensure fair comparisons, learners' plans include decisions about which variables to change and which to keep the same.	x			Investigation offered many opportunities for fair testing. Learners constantly "tested" elements of their prototype (e.g. tested to see if wheels could roll/not role, or tested its performance down the ramp to see if car meets requirements: go far/straight)

4e L carry out their own investigations	**Learners are active in collecting and using evidence themselves (directly from objects studied or using secondary sources), not observing someone else doing this. If this is NO then 4f is also recorded as NO.**	x			Most learners actively involved in collecting and using evidence themselves. Evidence presented by direct involvement in hands-on activity (using materials to build prototype).
4f L gather data using methods and sources appropriate to their inquiry question	**The appropriate data may be observations, measurements, or information from secondary sources such as books, posters or websites. For observations and measurements, relevant equipment and instruments such as rulers, balances or lenses are used.**	x			No science equipment needed for this activity. Learners used available materials and tools to create their prototype.
4g The data gathered enables L to test their predictions	**The nature of the data collected by observations, measurement, or from secondary sources enables them to test their predictions and answer their inquiry questions.**	x			Learners use data drawn from their observations and hands-on participation as evidence to modify plans
4h L consider their results in relation to the inquiry question	**This refers to group or whole class discussion (the written account is considered separately) of how the results of the investigation help to answer the inquiry question**	x			Discussion of results relates to problems they themselves encountered during the investigation. (Not sufficiently inquiry question focused)
4i L propose explanations for their results	**L discuss in groups or the whole class possible reasons for what they found or how the results can be explained.**	x			YES, BUT ... again - relating to their problems, e.g. didn't roll - move wheels away so that it can roll. Not sufficiently focusing on how/why the car could go far/straight
5. Working with others					
5a L collaborate when working in groups	**L work together, agreeing on tasks and sharing them, not working individually although seated in a group.**	x			Although not experienced in working collaboratively, L work well together.
5b L engage in discussions of their investigations and explanations	**During group work, L discuss what they are doing and how to explain what they find.**	x			Dialogic interactions - lively, energetic, noisy. Eager to voice opinions, share, listen, respect others' opinions.
5c L report their work to the class	**This can be by direct oral reporting from one or more groups to the whole class, or to another group, or groups displaying their work in the classroom for all to look at.**	x			Able, willing and excited to show/tell. Elementary, brief verbal explanations - focused on personal encounters.
5d L listen to each other during reporting	**The indications of paying attention include looking at the person speaking, not speaking themselves and responding, if asked, to what was reported.**		x		Sufficient time provided for learners to share their conclusions. Grade 3 learners listened to other groups' explanations, and learned from others.
5e L respond to each other during reporting	**Responding may imply asking questions to better understand their classmates' presentation or agreeing or disagreeing with what is being reported.**		x		ST managed classroom so that L had time to pay attention to other groups' explanations. L had to record in their journals what they learned from other groups.
OBSERVATION: Learners' records					
6. Records learners make of their work					

6a L make some record of what they did and found	**This can be an individual or group record, in the form of a drawing and/or written account, as appropriate to the age group. If there is no tangible record, responses to all items in section 7 ("L 's written records") will be N/A**	x			Prescribed format provided, learners filled in. Variety of signs, symbols used to represent their thinking.
7. Written records					
7a Records clearly state the problem or question being investigated	**In most written records, whether individual or group, there is a title or statement that describes what question the investigation was designed to answer.**			x	Problem verbally introduced and provided on page 1 of science journal
7b Records indicate what data were collected and how	**Most written records (individual or group) include a brief statement of what was observed or measured and how this was done. E.g. that the length of the shadow of a stick was measured using a ruler.**	x			L kept record according to the prescribed format. Descriptions of their observations were described using own everyday language. Lacked vocabulary and skills to describe observations and improvements scientifically .
7c Observations and data are recorded in a systematic way	**Most records (individual or group) include a table or organised list of data collected or a drawing showing their result.**		x		Filled according to a prescribed format. Results do not sufficiently contain evidence-based conclusions.
7d Records indicate whether or not results agreed with predictions	**Most written records state whether what L found agreed with what they predicted.**		x		Clear difference between own/original idea and final idea. (i.e. Theory Revision). However original idea was often impractical and not a successful attempt to predict a possible solution. L not guided to reflect on initial idea.
7e Records indicate what the conclusions were	**Most written reports (individual or group) included discussion or a general statement of what the observations or measurements meant overall.**		x		Conclusions stated, but not sufficiently focused on science outcomes planned for activity.
7f L take some personal notes during their work	**This refers to informal notes that L may have made during the investigation, jotting down ideas or data, not the formal written or oral record compiled at the end.**	x			Mostly used prescribed format for making notes. ST often reminds learners to record thinking.

Appendix G: Thematic Data Analysis

THEMATIC DATA ANALYSIS

STUDENT TEACHER PARTICIPANTS

Data from focus group discussion; lesson plans; post-lesson reflections and other reflection documents

SCHOOL A: Grade 1	(blue)
SCHOOL B: Grade 2	(red)
SCHOOL C: Grade 3	(green)

CHALLENGES EXPERIENCED WHEN IMPLEMENTING IBSE

SCIENCE NOT CURRICULUM PRIORITY (TIME AND CURRICULUM PRESSURE)

The time constraints. Because I felt like even though there was a time table, my teacher never stuck to the time table. She'd do her maths whenever she wanted to, do Afrikaans…	B_ST_FG_p1L22-23
[Regardless of curriculum flexibility] I still felt that I was so limited in the time that I had to prepare. Uhm, so that was definitely … definitely a challenge. That wasn't ideal	B_ST_FG_p1L24-25
… if we had more time, it would've been excellent…	B_ST_FG_p1L32-33
Ya, in a private school as well it was very … you know you have to get this done by the end of the week , you have to finish this so … Three hours of letting kids find it out for themselves … it's … almost takes in on other subject's time , so uhm, ya, it's basically a time thing, I think	A_ST_FG_p1L40-43
And, also the curriculum... There is so much pressure on the Maths and the English	B_ST_FG_p14L790
…then they were doing the ANAs … It's just … the school and all of the staff, they were so focused on … they need to do this maths, and then you do this, and you need to write the ANAs.	B_ST_FG_p14L791-794
There was no thinking more of learning in the broader sense of you know learning sciences, learning skills– it was just very … focused on those two	B_ST_FG_p14L794-795
Ya, I think everyone is very conditioned , like everyone's conditioned, … and there's no time to, or … it's either too much effort or there's no time to branch out and actually spend time on the details of the little things, and … to spend time on something that is not really in the curriculum . But it is … it can be … I don't know	A_ST_FG_p14L797-800
And also the children. I mean if you did... if their academic level … Obviously if they're struggling, then you don't wanna spend too much time on something that they not nót need , but there is a curriculum to follow at the end of the day	C_ST_FG_p2L64-66
Because the teacher does have to meet specific outcomes, and it's nowhere stipulated that you need to … you know … make sure the learners are equipped with these scientific skills. There is no priority placed on it, so to add that on to a typical average teacher who, perhaps isn't that interested wouldn't be beneficial, I don't think.	B_ST_FG_p15L864-868

Contradiction: Flexibility

Ya, I didn't find that with the time at all… I know maybe also… maybe my mentor-teacher was just the way she was in the class, but… there was no time constraint. I mean if I worked into break, and the kids were happy to stay, then it's fine. Because literally, that's all we did that day … was that lesson.	C_ST_FG_p1L48-51

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SCIENCE PRACTICE FOLLOWED IN SCHOOLS

I hadn't seen … anything, they just … Life Skills [subject] I think for them was integrated into everything … They have the little government things that they'd read together. So transport is this; So trains are transport; Draw your own train. Just the governmental ones.	Bp3L126-129
[Learners are seen as] Empty vessels – fed knowledge. Education isn't for them, it is to pass all the curriculum	A_R8
[School context] Strict worksheet based regime. Preplanned to get all worksheets done.	A_R8
Focus on Maths and English	A_R8
[classroom context] Layout. Desks. Rigid. Facing teacher.	A_R8
Teacher-directed instruction	A_R8
Teachers struggle to let go of control	A_R8
Guidelines aren't focused on Science in Gr0-3. Not enough emphasis on it	A_R8
CAPS – more the workload of what is expected, and there's hardly any science	A_R8
[IBSE] should be [implemented in school] but it is very 'strict'/limited concerning time	A_R8
CAPS: don't really allocate anything for IBSE	C_R8
IBSE not really implemented	C_R8
Ya there need to be [an awareness]. Because I think even some of the teachers maybe, … I don't know whether it's a thing between the different sectors, but maybe science or scientist are a bit of oooh untouchable … NASA, you know, whatever. So maybe the teachers feel a bit like it's not in their job description, … if that make sense.	B_ST_FG_p15L850-854
All participants agree that teachers are unaware of children's scientific abilities and the importance of science education	ST_FG_p14
I think they don't give them the opportunity … to practice being a scientist.	A_ST_FG_p15L839
And I think it's also intimidating. Like if you think about the general workload of a teacher, … that certain people are expecting you to do all of this work, especially the admin for example. Now you have to go and research something you would like to teach. It is a little bit of a … difficult situation to be… Like I find it takes a lot of time, it not just walk in there and … okay, let's try…	C_ST_FG_p15L858-862

IGNORANCE OF IBSE APPROACH

Cause at those schools it's so difficult. I mean, I found when I did this, I felt that I was under so much pressure from the teacher and the classroom, because, she's like: it's too noisy, it's too this, it's too that – which was a bit perturbing…	B_p1L2032
…some of the comments she (teacher) gave me was that it was too noisy; I should have controlled the classroom, but those are exactly the things I didn't want to do. And I felt so stressed while I was doing it because she was like make me run around like "Keep quiet, quiet, quiet", but I didn't want to be that way	B_ST_FG_p2L81-84
My class was a little bit rowdy now and then, so I think that's maybe what the teacher was … uhm, maybe concerned about, because they are a big class, and in their groups they can get a bit … much	B_ST_FG_p3L153-155
… being a student-teacher in someone else's class where you see that science isn't … there aren't any science lessons and … you know … they put pressure on you while you're doing your science lessons, was … disheartening	B_ST_FG_p14L795-789

INSUFFICIENT GUIDELINES (CAPS/SCIENCE/IBSE)

I didn't have an inquiry-based thing to do	C_ST_FG_p1L5
[selecting outcomes] the framework was in the curriculum , but it was very vague - I thought – but it's … you get it from there, and then I think I added my own outcomes. I like … filled it	A_ST_FG_p5269-271

2

I looked at your slides as well. You had those science slides, and the values, and outcomes and something. So I got some from there. But also from just … I don't know … thinking, … and going on Google	B_ST_FG_p5L275-277
I know how they learn but the nature of scientific inquiry might need more explanation. (I do not come from a scientific background)	A_R9
More prior/subject knowledge on experiments	(A_R4)
More ideas (science experiments that are easy/quick and cheap resources)	(A_R4)
Not enough information on it	A_R8
Too little information on IBSE & Questioning techniques	A_R1

IDENTITY AS IBSE FACILITATOR

CHARACTERISTICS/QUALITIES

"I do not come from a scientific background"	(A_R9)
"It comes quite naturally for me as I am an introvert and I prefer being out of the spot light and listening to others" "It's easier for me to let learners think on their own"	(A_R4)
View self more as a facilitator of learning, than a transmiter of information	(A_ST_FG_p10L561)
"…this [facilitation] might be my best attribute"	(A_R9)
I did a year of BSc , but then I changed	B_ST_FG_p14L811
I love science. I always have been interested in science … I fee like I have the background and knowledge to be a successful teacher. By using the talents I already have, combined with what I am learning in the ECD course, I can understand my role as facilitator and not a teacher.	B_ST_LR_p1-2
"I plan well and get everything ready prior to the lesson to ensure it runs smoothly"	(A_R4).
I am patient and ask guiding questions	C_ST_R9
I am able to stand back and let learners be involved and take learning into their own hands. I can guide with thinking questions and not get frustrated when trial and error takes very long	C_ST_R4
Creative & Innovative; Guide thinking with questions; Ability to encourage learners to keep trying	C_ST_R4
[I am] creative and innovative, thus I am able to use creative ideas to implement IBSE	C_R1
I am with all my lessons to let the learners do the thinking- the learners need to come up with solutions without me having to give them direct answers.	B_ST_LR_p2
I also know that the learners need to be in control on their learning in this type of lesson and I must just guide	B_ST_LR_p2
Patience	C_R4
Ability to stand back and observe	C_R4
Thinking on your feet	C_R4

VIEWS ON / ATTITUDES TOWARDS IBSE FACILITATION

SHAPED PROFESSIONAL IDENTITY AS IBSE TEACHER

"Fulfilling as a facilitator"	(A_R1)
Ya the kids are a lot, but it's … it was just fun. I enjoyed it a lot. Like you feel like you have accomplished something … by them accomplishing something on their own. If that makes sense.	A_ST_FG_p16L908-910

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It's a very fun way of teaching … of doing things. I enjoyed it as much as the kids did as well.	A_ST_FG_p16L903-904
[IBSE made me feel] Rewarded for all the hard work and proud of the learners' abilities	C_R1
Exciting and a new way of doing things	C_R1
I got to see children interact and think differently to everyday classroom activities. The enthusiasm was contagious	C_ST_R1
[Special moment] when the one group finally realised they need to lower the wheels for the car to be able to move	C_R1
IBSE teaches the facilitator as much as the children learn and allows one to be reflective and see things differently	C_R1
The first was the excitement and the belief that I had it in my students to create a solution to the problem. This was so rewarding and they found the solutions all on their own	A_ST_LRp6
I then sat down in the middle of 7 year old excitement on the carpet	A_ST_LRp5
I am proud of how I conducted myself …	B_ST_LRp2
Emotionally drained … extremely worth it	A_ST_LRp6
The actual lesson was so much fun for me as facilitator and for the learners	A_ST_LRp2
I was extremely excited when one girl got the correct answer	A_ST_LRp4
The best moment for me …	A_ST_LRp5
It is a learning experience to stand back and watch how children learn	C_R2

FACILITATION ROLES

PLANNER

Yes, you have to plan it very well, and you have to think about what the children are gonna think of … so that you have the materials that they might want, … or need	A_ST_p11L613-615
And think of the order you're doing things, and how long you can spend on each … uhm part. 'Cause I found that in some places I just felt like I spent way too much time, and then it was taking away from the time they would have to work … on their own.	B_ST_p11L617-620
I think if you collect stuff, you also have to plan well in advance. You can't say OK I'm going to do … building something tomorrow for a lesson when you don't have stuff…	C_ST_p11L646-648
I think it's like preparing for the unexpected. Like, you're never fully prepared for what's gonna happen. Like I also was worried about how am I going to thingy if they got this idea to use that box, and there is only one, … what am I going to do? So like … It's just like preparing for all the things you can't actually prepare for. I found that quite difficult. 'Cause it's like well … "sorry there's no other box, so you'll have to … (laugh) change your plan", so ya it's just like …	C_ST_p13L773-769
ST-A regards thorough planning as a prerequisite for successful implementation of IBSE	(A_ST_FG_p11L613; A_ST_Rp1, 2)

FACILITATE CHILD-CENTRED LEARNING; GUIDE LEARNERS TO THINK

So, … ya, that's why I think I tried to push "science'y" things, quite a few of them, because I wanted them to … think	Cp3L129-130
"… the role of the teacher is merely to facilitate and guide, using leading questions in order for the learners to figure out the best solution and not told what to do"	(A_ST_LRp7)
… and I facilitated the discussion about the problem without giving any solutions or information away	A_ST_Rp2
I found that easier to do that than to stand in front of a class and present a lesson and try and explain something to them, like a maths concept. Because you can only say something so many ways, and a lot of them will say but I still don't understand. It is very	Cp5L284-290

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difficult then to think … how am I going to do this, whereas there you can say OK, but what do yóú think ? Now try and help yourself, instead of saying OK but this is how we do a minus sum where we carry and, …So I found it easier to facilitate learning that way … than to explain	
… and plan it well so that you can ask the right questions, or give them the right encouragement	A_ST_FG_p5L252-253
Ya, eventually [they figured out the problem]. I kept reminding them that the problem is the car must go straight and as far as possible. It mustn't look like a BMW; it mustn't have a special injection seat (laugh), and that's the problem – just so that they remembered. Because I found that they drifted off a little bit.	Cp7L374
"With the learners being in the centre of the lesson being a facilitator allows as much learner autonomy as possible with guidance"	(A_R4).
The investigation was very much learner-led. The learners initiated and planned the building of their prototype cars. I really feel like I encouraged the learners to think freely and promoted a culture of inquiry. I wanted the learners to ask questions and to find out the answers on their own. When I found some learners were struggling, I encouraged them to redesign or change something and not give up. When learners would ask me questions, I would answer with "I'm not sure, why don't you find out and tell me?"	B_ST_LRp3
This was very effective as most of the learners were immediately excited …	B_ST_Rp2
I am really proud of how I conducted myself during the engagement phase as my materials table was on display and I facilitated the discussion about the problem without giving any solutions or information away (p2)	B_ST_Rp2
I do think I posed a good question for the learners that lead to the investigation but feel like I could have facilitated a discussion a bit more in guiding them towards coming up with their own ideas	B_ST_Rp3

FACILITATE DRAWING CONCLUSIONS

I did like a lesson afterwards, uhm … it was like a day later … uhm, and I asked them, okay, so if we had to build a car, what are we going to do; how are we going to do this, based on what you did yesterday. And a lot of them went straight to the problems that they actually had solved. They said, well the wheels must touch the floor. One group said that, and uhm, what did the other … Oh the one said that the front part of the car must bend and be higher so that when it goes down something it doesn't scrape. Because a lot of them like … So they learned … like they explained that to me, and the shape of the car, and how it mustn't be too heavy, and roll ...	C_ST_R_p8L437-445
Ya, on that day I was like, that's not gonna happen (laugh)	C_ST_R_p8L437-454
I actually … it was just before I was leaving, you know, one of my last lessons where we did almost like, not a consolidation, but where they had to draw their experience of the race car activity. So it was quite a gap away. But they hadn't forgotten a thing, which was amazing! They had … you know they were able to draw and recall their favourite parts. Like some of them drew the ramp, and … what not, but I think what was … what I did was I linked those scientific things the whole way along. So it wasn't just like OK here is science, … two weeks later another science thing ... I think it was important to constantly link what is a scientist, and you know … what you're doing is scientific. So ya, by the end of it they really had a good concept.	B_ST_R_p8L460-470
I needed to remind them of this and also engage in a conclusion session to consolidate all the concepts..	C_R2
I found that I was scrabbling for time by this stage of the lesson. The groups had made posters but they were not very detailed as there was not much time for this. I had to stop people testing their cars and instruct them to make posters as groups otherwise I would never have gotten any posters! It was difficult to pull the learners out of the investigation stage and to ask them to compare their findings to their ideas, as some were incomplete.	B_ST_LRp3

FACILITATE COMMUNICATION

I encouraged this amongst the groups and sometimes mediated discussions a bit by asking certain learners a question, in the group, to evoke equal participation	C_R2
We were able to reach the communicate with other audiences stage but didn't have much time as we were already eating into the second brake time. This was very rushed and a bit disorganised as I called all groups to the carpet with their prototypes. Each group came up, one at a time, tested their car and explained what they changed, what worked and gave a summary of their journals. The learners were able to do this well, but I found that due to the excitement and disorder, many learners did not listen to their peers' presentations and this made for disruptive classroom management.	B_ST_Rp4-5
I think they we quite excited to do that. They're excited to share what they've learned, and … uhm …	A_ST_R_p8L476-477
Definitely (able to communicate findings). They … ya, they want to tell what they have learned, and … show people, and be excited about it.	A_ST_R_p9L481-482
I know we ran out of time in my lesson. It was already going into break, but they were able to stand up there, not really - you know - they weren't concerned that they were explaining … it was just, it was just so … it seemed like comfortable for them, because they were confident. They just done it … this is what worked, this is what didn't, and it was real. They weren't like standing there and reciting, you know knowledge about trees or whatever, they…	B_ST_R_p9L501-506
I think it was easier for them communicating something that they learned on their own, because they're not using someone else's words. They've got their … what they saw, what they did, is what they tell you. They not gonna say oh well, we used an axel … No, we used a stick for the wheels. So they use their own words and their own understanding. So they won't forget stuff like that very quickly.	C_ST_R_p9L487-492

FACILITATE RECORDING THINKING IN SCIENCE JOURNALS

I felt at times that I was nagging them to fill it in … because … some of them did it, some of them were just diligent, and you know when I told them, they ding-ding-ding, perfect, beautiful – and they filled it. But some got so excited, they were so intent on building that they wouldn't go back, and, you know, consolidate with the group ideas, or write what work and what didn't. So often times I felt that I was walking around, "Don't forget to do this, don't forget to do this" and almost like a party pooper. I was like just stop having fun and go back and fill this out, so it was a little bit … ya …	B_ST_R_p9L511-518
I think that might work better is if you have a science journal, like that is a normal thing that you do every week, or something … so that they know, after an activity, they write down what worked and what didn't work, because then … it's … then they're reflecting on what just happened. But … because I think it's new to them, so they like … forget about the paperwork.	A_ST_R_p9L524-528
Yeah, uhm, because a lot of the stuff that they wrote down, they didn't always say afterwards. So like what they remembered at that moment and they wrote, they didn't always – when you tell them about – they're like, Oh yes this and this, but they don't remember it afterwards. So recording it there, I think it is important so they don't forget to mention it …	C_ST_R_p9L534-538
I think it makes them proud as well of what they've done. Because I mean, I remember at school, when we had little portfolio and things as well, you were so excited to get it back and look through my work and see aah, I did better or you know, see your own growth. So I think for some of the learners that would definitely be a benefit of recording it, … and keeping it.	B_ST_R_p9L545-549
Encourage learners to constantly record their findings	A_R2
Use science journal and poster … but maybe do it on a time limit (E.g. 20 min for trial & error, 10 min …)	A_R2
I reminded the learners constantly and felt as though I was nagging them to fill these in	C_R2
I had to remind the learners to keep recording their steps and to write down their best solution.	B_ST_Rp3

A problem was the learners recording their steps scientifically. Many learners neglected to fill in their journals as they were consumed with the idea of building the car and testing it! I then had the extra task of running around and making sure that the learners filled these in.	B_ST_Rp5
Need to work on enforcing the journal as priority	(A_R4)
Guiding students to record their progress and findings	A_R9
Make science journal fun or exciting. Maybe make it digital or draw pictures. Or record it / watch video again and then discuss it in a group	A_R8

FACILITATION CHALLENGES

GUIDING LEARNERS TO THINK

Like, eventually I got to the point where I was telling the learners, don't ask me, think for yourselves	Bp2L90-92
I think it is exhausting as well, if you think about it: "Ma'm how do you spell this? Ma'm how do I do this? Eventually I just want to say there is the dictionary do it yourself, just try, you know.	Cp2L104-106
…the constant facilitation to guide learners to get to a correct answer was tiring compared to just telling the learners the answer or what to do	A_ST_Rp4
It is hard sometimes to just be like, okay well, struggle along for an hour until you figure it out (chuckle), and not say anything. That I found quite hard … when they're building theirs – and you can see they're doing it wrong, and then you just like, okay… well … (chuckle)	Cp6-7L359-362
… neglected emotional support	A_ST_Rp6
It (facilitation) was nice, but it was also frustrating, because … you can see that it is not gonna work, or you don't … you don't want to kill the vibe, but they have to kind of figure it out by themselves with … your questions and stuff … but it was easier though.	B

CLASSROOM MANAGEMENT

I think I've kind of lost the plot towards like the end of the three hours. Like they were just too … they were like overwhelming me, and they were like … they were in charge. Not that I wasn't ever in charge, but …	A_ST_FG_p12_L702-704
The class was also difficult to manage as the learners were super excited and energetic.	B_ST_Rp3
I did walk between the groups to listen to their solutions, to ask questions and to stimulate further thinking, however some groups were not working well together. I found that a lot of time was spent reiterating what the learners need to do in their groups.	B_ST_Rp3
I could see they were struggling to work together, so I'd go to them and I'd tell them, "Listen, where is the peace keeper, where is this person …", uhm, because there was fighting and yanking things, and … Not all the time, but now and then, so I actually had to go and speak to them and try and manage them. But the rest of the class, I didn't have too much problems with them. I didn't really need to shout over them and say anything.	B_ST_FG_p12L681-686
With regards to the groups and group discussions, I found it difficult to facilitate in some groups and not in others. For example the Yellow group could not work together. They tried, and I tried to facilitate, but they were totally incompatible! Whereas in the Orange group, it was difficult at first because of over excitement and the inability to decide on one best solution. What ended up happening is that the Orange group had 2 prototypes at one stage. However, something changed and the learners ended up working together very successfully … They were so successful at resolving their issues and working together that their car actually won the race!	B_ST_LRp4
Also, when implementing IBSE in the Foundation Phase, I found that it can be difficult for learners to work together. This is not true for all learners though, as some groups worked really well together!	B_ST_Rp4,5

I feel like I should have been more clear in my instructions. I should have spent more time discussing how the learners must work together and what rules they need to follow. I do feel like I was rushed for time and maybe neglected these aspects unintentionally.	B_ST_LRp3

NEED ATTENTION FOCUSING STRATEGY

I didn't mind it when they were doing that, like when they're busy doing that, I don't mind at all. Like they can carry on, I've got no problem. But it's obviously when you're trying to say something important, then they just needed to stop, in the beginning, they must just wait for everyone to just … focus.	C_ST_p11L671-673
There were only a few things, like uhm when we … when I wanted them to start working on their posters, their final posters …, because they were so overwhelmed with testing the car and retesting it, and building and whatever, that when you know time was running out, and I was like OK they must make their posters now. I think I did … I maybe had to shout over them or do something. But … I don't mind them making a noise and doing their own thing. I just think if there was a nice method to regain all their attention at once … it would be helpful	B_ST_L686-693

VIEWS ON CHILDREN'S CAPABILITIES AS SCIENTISTS

NATURAL/INHERENT ABILITIES

They just have that uhm, like inborn inquisitive sense of …	A_ST_FG_p13L746
… natural curiosity	C_ST_FG_p13L748
So I think they just do, and they don't know it's natural. Ya.	B_ST_FG_p13L757
So I think lots of them already have a prior knowledge in some way and they were definitely able to use it.	Bp6L301-303
Children can do so much on their own	C_ST_R1
They're more than capable	A_ST_FG_p2L101
Learners all managed with hardly any prompting	A_R1
They cán do it	B_ST_FG_p7L418
Definitely, 100 per cent	C_ST_FG_p12L714
Ya, They're doing scientific things and they don't even know it. I mean … because we did a science lesson and I haven't even told them really about science, and then they did the science lesson, and then I asked them afterwards in a different … you know what is science? Then I made them think, and I was like but you did all of that stuff on Monday, and then they like ohhhh… then the penny drops. So I think they just do, and they don't know it's natural. Ya.	B_ST_FG_p13L752-757
And, it's also like a nice age group where they want to make things, and build things. Like they cán do it, so they should do it at school	Ap8L422-423

POSITIVE INFLUENCE ON LEARNERS' MOTIVATION

… and they enjoyed it	A_ST_FG_p1L33
And they enjoy it	B_ST_FG_p7L420
… super excited and energetic	B_ST_LRp3

POSITIVE INFLUENCE ON SOCIAL LEARNING

It wasn't that bad though. There are lots of children, … but I think that was good. I think the children have the advantage of being at a school like that, because there's so many of them, so many ideas. And also different … the genders as well. I mean, they all did the	B_ST_FG_p3L142-148

same thing … it was … I think it was an advantage to be at that school.	
Ya … Also like sometimes I saw in some of the groups there were like … there was a divergence between ideas, so you get three … Originally, that orange group as well, they had one side doing their own one, and the other side doing a different car. And they tried that for … I don't know, 10 to 15 minutes, then, eventually … they ended up working together. Somehow it just flipped completely, and they had all both tried, and then all of a sudden they decided, you know what, let's try actually work together, and it turned out … I mean, they won. So, ya … (laugh)	B_ST_FG_p6L347-354
… learnt to work better in groups	A_ST_Rp3
But you know they're like little adults, … adults are the same way. You have an idea, and you have to work in a group, and you think aah, but what if mine's better	Bp6L336-338

POSITIVE INFLUENCE ON LEARNERS' THINKING ABILITY

"IBSE aims at developing of cognitive skills and higher order thinking as well as teaching the learners to use specific scientific skills such as questioning, reasoning, experimenting and checking hypothesis"	A_ST_LRp7
Ya, and I think it is actually a better way for them to learn than always giving them…	C_ST_FG_p2L103
I believe it is crucial for learners to question things, to test knowledge and to come to conclusions on their own	B_ST_LRp2
[IBSE makes kids feel] Important, 'heard', in charge, capable	A_ST_R1
I think it meant more to them. It was more important for them to do it properly, because it's their own ideas, … they're doing it physically	A_ST_FG_p13L719-720
And I think they also build confidence if you allow them to do something	C_ST_FG_p13L724
[IBSE made the kids feel] Independent and confident	C_ST_R1
… children changed their minds without any prompting	A_ST_Rp6
Great at challenging learners. Increase scientific thinking	A_ST_R1
So if you just leave them to try , I think they, … they figure it out their own … even if it's not realistic, they just … solve their own problems	C_ST_p13L731-732
Some of the benefits I could see for learners would be that IBSE encourages critical, creative and independent thinking. Further to this, it makes learners want to ask questions! I believe it is crucial for learners to question things, to test knowledge and to come to conclusions on their own	B_ST_LR_p2
Children figured out by themselves and modified accordingly	A_ST_Rp4
… improve learners' cognitive and practical skills	A_ST_Rp7
IBSE allows learners to truly experience learning	A_ST_R1
… beneficial to the learners in all aspects	A_ST_Rp7
I actually … from the time … I think I have done mine with you at the end of August some time, and then… it was just before I was leaving, you know, one of my last lessons where we did almost like, not a consolidation, but where they had to draw their experience of the race car activity. So it was quite a gap away . But they hadn't forgotten a thing, which was amazing! They had … you know they were able to draw and recall their favourite parts. Like some of them drew the ramp, and … what not, but I think what was … what I did was I linked those scientific things the whole way along . So it wasn't just like OK here is science, … two weeks later another science thing … I think it was important to constantly link what is a scientist, and you know … what you're doing is scientific. So ya, by the end of it they really had a good concept.	B_ST_FG_p8L460-470

CROSS-CURRICULAR LEARNING/INTEGRATION

I think it is all of them. It was shapes, language, life skills, so it covers everything	C_ST_FG_p2L76-77
But I think not only in science. I think there's a lot of concepts you can do in language and maths as well …	C_ST_p11L602-603
I think it also covers a whole lot more than what you think it will in that lessons. So the extra prep … and planning and that, covers so much more than just what you did there. So it is not just all for one lesson, I mean there's so much that they gain from it.	C_ST_FG_p16L912-915
The learners in my class have not been taught these skills before but even with this being said the learners were more than capable of understanding and doing what was required of them. The learners also develop linguistic skills through communication of ideas and group work. The learners have to work together and therefore discuss which idea is the best and if it will work with reasons backing up their discussions	(A_ST_LRp7
I think they learned well how to use the material they had, and they learned a lot about fish and what they need to live, because they all wanted to take the fish home, because now they know how to look after a fish, and that you need to acclimatize the water, and put drops in it. And feed them. Ya I think they learnt that they cán do it.	A_ST
I think they probably learnt maybe the value of trying and trying again, and how to deal with frustration and communicate, because I think they all had their own ideas, and it was difficult for most, you know quite a few of them to actually work together. So I think maybe they learnt that and, ya, not only just the values, but they probably learnt how to critically think and how to test things and, you know, to go back and keep working. So, more than just science concepts.	B_ST

VIEWS ON CHILDREN'S IBSE SKILLS

LACK OF IBSE SKILLS

Learners aren't used to this approach	C_ST_R8
Learners seemed very rushed as all they wanted to do was get their hands on the materials and start building, even though they first needed to work together.	B_ST_Rp3
I think that it's perhaps this idea, … this approach is quite different to what they're expected to do in the classroom	B_ST_FG_p2L92-93
Yes, they're not used to ... Because they're told what to do; they're not, … they're not given the freedom to do like … just do it	A_ST_FG_p2L95-96
I found that also with some of the activities I gave, the children didn't …, you know some of them didn't want to be too involved 'cause … but "Am I drawing the right thing?, "Am I doing the right thing?" I was so tired of them … not wanting … (to think)	B_ST_FG_p2L85-88
I think it takes a little bit of encouragement sometimes, because they don't always want to think. A lot of children just drew an outline of a car for the sake of drawing something. But then they would quite happily take someone else's idea and say OK, that is better than mine, it is fine. Because they not always - well I found - some of them didn't want to … They were just like, aag I'll use someone else's, because we are going to do group work	C_ST_FG_p6L308-313
Like some of them aren't confident (to think on their own)	B_ST_FG_p6L315
They don't like the challenge of having to think	B_ST_FG_p6L319
Because, I don't think they have any knowledge of it really. I mean I had asked these Grade twos, what is a scientist, and the one boy has tried "Despicable Me" and "Minions" . Ya, so I think they have more of a fantasy kind of Hollywood idea of what a scientist is	Bp7L390-393
And it (science) is separated of them (CONFIRMATION FROM B & C)	Ap7L397
And it would be so nice, because like they really work good with the concepts. I don't know why it is not taught, because I did the one mentor-lecturer assessment - I think it was my second one - on observation, the skill of observation, because they hadn't done it. And they each got given a lavender plant, and I was like okay, I just need you to write down … Well first we discussed observation, and they had to then realise that observation uses your senses to analyse and describe something, and so then they basically, each	Bp7L405-414

group had these big lavender plants, and they had to write down what sense they used, and what they see. And it was things like that that they never heard of before. They didn't know what observing was. Ya	

SOCIAL LEARNING SKILLS

That was the first time this year that my class had worked in a group… Like proper group work. Like, they get to sit together and maybe play chess and stuff, but not actual work where they had to do something	C_ST_FGp2L113-118
Yes, and they rely on other children	Cp6L317
Uhm, ya I think that's where they have to learn how to work in groups more, or they have to do it more, because they're not used to compromising their own ideas	A_ST_FG_p6L326-330
Ya, and I think it is difficult for them to take a little bit from everyone and make something new … when they've given up their idea, when it's not being used – that's emotional, … difficult for them	C_ST_FG_p6L332-334
The one girl as well, almost like your (child-name), she had an idea, and then eventually she scuffled… the group's not listening to me, they're not listening to my idea. Because they had all … agreed - the other five of them - had agreed on a different idea	B_ST_FG_p6L338-341
In essence, everyone else agreed, … but then she didn't. Ya, so everyone else can agree, but then I think it's just maybe some individuals aren't … good at …	A_ST_FG_p6L343-344
Egocentrism played a big role in children's lack of group work skills	A_ST_Rp3-4
(social learning challenge) … upset when not using their ideas	A_ST_Rp3
(social learning challenge) … some don't like working in groups (see excerpt)	A_ST_Rp3
(social learning challenge) some are incompatible regardless of efforts from both facilitator and children	B_ST_Rp4

SUGGESTIONS FOR IBSE IMPLEMETATION

POSITIVE EFFECT OF IBSE/CHILD-FOCUSED PEDAGOGY

IMPLEMENT IBSE. Definitely worth trying – so much to learn from the experience.	(C_R1)
Any subject can implement inquiry based learning	(C_R1)
"IBSE should be implemented in all schools as it is a great way to improve the learners' cognitive and practical skills and it will be beneficial to the learners in all aspects"	A_ST_LRp7
[IBSE can work] Yes! Would definitely work. It just needs to be focused on	A_R1
Let learners lead	A_R1
I'd tell anyone who is listening that this is the way forward in creating independent learners	A_R1
Create opportunities to do more IBSE with different concepts / new way of doing things	C_R8
Expose learners to this more often and encourage the process of inquiry based learning, e.g. recording in a journal will be more natural	C_R8
Bring IBSE into classrooms, make it regular practice and encourage learners to think on their own	C_R1
Do more independent activities. 1/week or day for learners to research or out of curiosity	A_R8
Ask learners what they want to learn about	A_R8
Need to make education for them!	A_R8
[Give learners] Choice of what to do in specific themes	A_R8
[allow] autonomy in how they want to complete something	A_R8

Do more science based activities, introduce Science every Friday, even if you YouTube experiments to broaden prior knowledge	A_R8

SUGGESTIONS FOR INTRODUCING IBSE

…if we had to implement the IBSE it would have to uhm … can't it be slowly introduced?	B_ST_FG_p1L28-29
I just think maybe just how I'd start is like doing more science until I feel comfortable presenting the IBSE way properly all the time. Uhm, ya, so I think I was trying that, and now - if I kept that classroom - I would have gradually given them more and more to do completely on their own really. I mean 'cause lots of my lessons had objectives like so that they learn the skill of observation; also that they …, so I wasn't really giving them any answers, but I was kind of leading them towards learning that skill in a specific way. So I think … I definitely want to implement it more, but … gradually.	B_ST_p10L591-598
I really think that this lesson should have been done over a few days and not in one day. If I could do it over, I would do t over a few days, explain the instructions more clearly and facilitate more. I feel like due to time constraints, this lesson was rushed and perhaps not executed as best it could have been	B_ST_Rp4
This could have been resolved had I managed the lesson more effectively or had we done the lesson over more than 1 day.	B_ST_Rp4

SPECIALISED TRAINING

I don't think anyone can do it. Like I don't think you can just go and be like OK! I think there is a certain amount of research … You do have to know what is going on. Like ST_A couldn't just go in there, and like hope and pray that they don't ask her a question about the fish. Like you do have to do a little bit of … prep and you know … you have to be prepared	C_ST_FG_p14L817-821
And interest. I think the teacher or facilitator has to be interested in what's going on, because I mean, everyone remembers teachers or people who were just so boring and bland. They came there and now I have to teach you … this or that. So I think if a teacher has, … you know … they should have a certain passion towards it, or interest. Then it will help. Then it doesn't matter what science lesson you want to do	B_ST_FG_p14L825-830

SCHOOL ENVIRONMENT SHOULD ACCOMMODATE (FLEXIBILITY)

But I think the school environment is like that as well [flexible]. Although the planning is done for the week or whatever, but there's no like, if it's not finished by Friday sorry, … So, it was quite nice in that aspect.	Cp1L56-59
I think it should be set like, almost like a gallery walk-style, so that they can go from one place to another without everyone all over the classroom. Like with yours or for ours, we could have had like the groups sitting, then the materials, then here's where you test, then you go back this way to try again kind of thing. Just so that there was like … and also guides them, OK now that didn't work, now I cannot run back and grab another material and fix it here, I have to go back to my desk and then go there kind of thing	C_ST_p11L629-635
Change environment (classroom layout, corners, etc.)	A_ST_R8

EXPAND CURRICULUM GUIDELINES

Expand on Curriculum. Even if it doesn't change make it your own to add a holistic viewpoint to the classroom. Add scientific depth to NS	A_ST_R8
Use CAPS as a guideline, particularly themes and create own IBSE opportunities	C_ST_R8

CREATE AWARENESS AND NETWORK OF SUPPORT

But I think that's something that a teacher should do in their own capacity, … uhm with like-minded teachers	B_ST_FG_p14L785-786

Parents, principals and HOD members should be included to create awareness, research and implementation of IBSE	C_R1
Also government entities to include IBSE in curriculum	C_R1
[create awareness among] SGB, HOD's, Teachers & Parents to make it work	A_R1

CHILD PARTICIPANTS

Data from whole class reflection session; focus group discussion

SCHOOL A: Grade 1	(blue)
SCHOOL B: Grade 2	(red)
SCHOOL C: Grade 3	(green)

SHAPING IDENTITY

CHARACTERISTICS AS SCIENTISTS

We did work like scientists today	B_L_R_p7L389
Because we are scientists	C_L_R_p9L502
Because we're clever	A_L_R_p1L10
Oh because they think of clever things	A_L_R_p1L15
We thinked!	A_L_R_p1L28
We all ask questions every day; we do experiments … like growing plants	C_L_FG_p1L3-4
Because every kid can think like a scientist. We ask questions every day, we grow plants, ya…	C_L_FG_p1L22-23

SCIENTIFIC SKILLS AND VIRTUES

Because we had to make our own car, and see how it could go, and how straight and how far it could go	B_L_R_p7L393-394
Yes, but they… they build stuff, and…they learn from their mistakes of what they are doing	C_L_R_p9L527-528
Because we made stuff.	C_L_FG_p1L6
We proved that we could be scientists. By building a car.	C_L_FG_p1L8,12
Well I think we worked like scientists, we improved our skills of cars and then we actually tried our best and it doesn't matter if you failed or succeeded as long as you tried your best, 'cause you try and try and you never succeed, but the last time you do it you might succeed	B_L_R_p8L430-433
Because we improve, or we used to… because I don't think any of us tried this before, but this time we did, and it doesn't matter if it went far or not far, but at least we tried	B_L_R_p7L406-408

NATURAL SCIENTISTS / INVENTORS / DISCOVERS

Because, uhm we can, uhm we can learn … learn how to build things, and…, and create new things	C_L_R_p9L518-519
Because they want to discover new things that life has not discovered before	B_L_R_p7L398
I think we worked like scientists because normally scientists are the ones who invent things and who discover the things that haven't been discovered before	B_L_R_p8L421-422

WE KNOW THE BENEFITS OF SCIENCE FOR SOCIETY

I think we did kind of worked like scientists today because there was lots of things for us to learn and tell people our answers and all those type of things	B_L_R_p8L416-417

'Cause also scientists can also do inventions, and … which is good 'cause you need to also learn so you can also do good. Also as our ideas grow up you're also gonna tell us that we also need to do a project whe' we invent something that people will need … in the world.	C_L_R_p10L540-543

SCIENTISTS WORKING TOGETHER (SCIENCE AS COOPERATIVE ENDEAVOUR)

And we put all of our ideas together	A_L_R_p1L32
We all worked as a group, and we finally made something that actually works	C_L_R_p9L532
Yes, we messed around with all of our… our ideas to get something	C_L_R_p10L536
And as a team	C_L_FG_p1L28

OUT OF SCHOOL EXPERIENCES / SCIENCE EXPERIENCES SEPARATED FROM SCHOOL/SELF

(Referring to activities at home): I like scientists because I practise being a scientist	A_L_R_p5L292
I know already how to be a scientist because I just got science stuff in my room (R: And in class?) Now I'll try and be	A_L_R_p5L294-295 A_L_R_p5L299
I have a science book at my house	A_L_R_p6L301
I could think like a scientist because my mother is one	B_L_FG_p8L430

NOTE Children also mentioned TV programmes they watch

EMPOWERING POTENTIAL OF PARTICIPATION IN IBSE

MOTIVATION

[Class shouting] Good…Good…Good!	A_L_R_p5L249
We feeled … fun !	B_L_R_p6L299
I felt that I wanted to do more of it because it was so fun	B_L_R_p6L308
I'll do it every day if I have to	B_L_FG_p 8L400
Do it again, every single day!	C_L_R_p7L390
No, do it again! Please! Please!	C_L_FG_p6L284
Do it again, we are begging you!	C_L_FG_p6L286
We can do it again twice!	C_L_FG_p6L288

AUTONOMY + SELF-EFFICACY

For me it felt exciting and I felt that I was uhm very clever and smart, and I did my own thing that I wanted to do	B_L_p6L303-304
It felt realistic like … uhm … it felt nice because you were actually doing something on your own.	C_L_FG_p1L25-26
It felt like we were very good engineers.	C_L_FG_p1L20
You don't have to be an engineer to make a model	C_L_R_p8L422
You don't have to be an engineer, because all you have to do is try, and if you get the right bits you can actually make a car	C_L_R_p8L431-432

DEEP LEARNING / LEARNING THROUGH PROCESS / LEARNING BY DOING

I feel like it's better because you can actually do something and it's more creative than just writing on a piece of paper. I'll rather do than say.	C_L_FG_p5L268-267
It's a very interesting uhm experience. Because, … we get to build something and you get to learn from our mistakes the first time and then fix them	C_L_R_p7L405, 409-410
It feels nice and it's very creative and sometimes it's interesting the first time we do it because you learn from your mistakes so that uhm the second time, uhm .., ya, that's it	C_L_R_p7L401-403

WHAT DID YOU LEARN FROM THE ACTIVITY?

VIRTUES AND RESPONSIBILITIES

To save God's creatures	A_L_FG_p6L344
To look after animals	A_L_FG_p6L346
To put them back in their home	A_L_FG_p6L348
That you don't have to be perfect. You can… you mus' just try your hardest	B_L_R_p4L217
We learnt about the car that it doesn't matter if your car is not the best…it might still win, and that not everything has to be uhm perfect and stuff	B_L_R_p5L256-257
It doesn't matter if you win, it just matters how you have fun	B_L_R_p5L259

LEARN FROM MISTAKES

We learned to learn from our mistakes and uhm don't give up and keep on trying	C_L_R_p5L281-282
I learned never, that uhm … to give up, keep trying	C_L_FG_p5L240
Learning from our mistakes, and doing it over and over again	C_L_R_p7L394
Uhm, yes, because…because uhm, because you must never give up when…when you do things. You must keep on trying and trying until… until you get it correct. And, … and we always have to learn from our mistakes, because it's …, because it teaches us uhm, what…what did you do wrong, and you must fix… and you must do it again	C_L_R_p7-8L414-418

SOCIAL LEARNING

How to share	A_L_FG_p6L353
To work as groups	A_L_R_p4L191
Well, we learned about friendship	B_L_FG_p6L282
Uhm, we learned that we always have to work together	B_L_FG_p6L284
Yes, that when you try and do your own things and try and shout and scream at each other, you realise the next design where you do it all together makes it perfect	B_L_R_p5L250-252
We also learned to work together	C_L_R_p5L90
… and teamwork is very important	C_L_FG_p5L241
Teamwork is important	C_L_R_p8L427
Uhm I learnt about this that when I did this, my first one it … it was amazing to me but my second one we did all together made me feel happier than the first one.	B_L_p6L322-324

I felt about this type of learning that it was actually nice to do something, uhm using as a group with uhm everyone's ideas, …and uhm that we could accomplished everything that we worked together	B_L_p6L316-318

REAL LIFE PROBLEM SOLVING / PRACTICAL SKILLS / SCIENCE IN REAL WORLD

It is not that easy to make (a fish tank)	A_L_Rp4L198
That you had to use different materials, and not everything has to be the same	A_L_FG_p6L357
(some materials are) difficult to use	A_L_FG_p6L362
And that you didn't have to use the material that you wanted to use	A_L_FG_p6L364
That it must be frustrating to build a real car	C_L_C_R_p5L286
And we learned that it's not easy to make a car, and it's not…well…if you want to make a car you must first get designs and then you can make the car, but you have to see first what the problems could be with the car	C_L_R_p6L296-298
It is not very easy making a car out of junk	C_L_R_p6321
We learned how to make uh anything out of boxes and junk and … stuff	C_L_FG_p5L43-44
Another thing is that it's not really easy to build a car. Especially with metal	C_L_FG_p5L249, 253
It was kind of hard to build a car. Now imagine you had to build a real car with an engine and lots of wires …	C_L_FG_p5L255-256

SCIENCE KNOWLEDGE

We learned that they need food and a big place to swim	A_L_FG2_p1L32
They must be empty, and you fill it up with water	A_L_R_p4L202
I think it would have looked nicer if you could use glass - then you could see through. But glass, glass can break easily.	A_L_FG_p5L281-282, 288
Uhm we learnt that sometimes the wheels uhm also need to be a little out than close, 'cause if the wheels are too close to the car, the wheels won't roll because the wheels are too stuck to the car because the car can make the …, the parts of the car can make the wheels stop because the wheels don't have any space to uhm roll	B_L_R_p4L227-231
I learned that …the problem was that we had too much paper, …pipe cleaners on … and prestik on the wheels so it couldn't roll and was too close to the tinfoil and the side	B_L_R_p5L235-237
(You need a stick/axel)… So that the thing could roll properly and could go straight and far	B_L_FG_p6L318
We realised that the wire at the bottom made the car slow down, but we thought that it would work because the wire actually didn't touch the ground. Then we just took the wire off and then we realised that the car was perfect.	B_L_R_p5L241-246
You must make the car lighter. Because the more weight you add to your car it's gonna make your car slower, 'cause if something is heavy, then it can't move that much	C_L_R_p6L310, 314-315
I learnt that the wheels have to be loose for the car to roll, otherwise it won't go really far, it will just stop in the middle of nowhere	C_L_R_p6L329-330
We learned that the wheels mustn't be like too, they mustn't be like too high and they must be at the bottom of the car	C_L_R_p6L334-335
If you ever build a car the wheels have to be loose and they have to be uh lower	C_L_FG_p5L46-47
The Blue group mustn't put too much stuff on their car or it would become too slow and too heavy for the car, and then it would just flip over and nothing would happen	C_L_R_p6325-327

NON-IBSE

The engine makes it go far	C_L_R_p6L306

SOCIAL LEARNING/COMMUNITY OF SCIENTISTS (Sharing ideas / Working in a group)	

SOCIAL LEARNING BENEFITS

[working in a group feels] "Good". "Fine"	B_L_R_p2L90
It was fun and it was nice	C_L_Rp3L119
(Teamwork feels) Good … Because we working together	A_R_p1-2L54, 58
It was fun	C_L_FG_p3L156
Because all of us are friends and (handing the microphone over to her friend…) we love working together and we like deciding everything together because we all best friends.	B_L_R_p3L137-139
We had to draw our ideas and then put them together and make a solution	B_L_FG_p2L57-58
It helped because none of us would've gotten the idea of bettering … of making the wheels roll.	C_L_FG_p3L137-138
I say it was nice because uhm … uhm … you can't do anything without your teammates.	C_L_FG_p3L158-159
I also liked it because we heard someone else's ideas and then another person's and another person's and then we added it all together and then we had a plan	C_L_R_p4L209-211
Yes, Uhm we worked as a group. We tested it but it didn't work, but … but we worked together, so ours uhm could go faster and not skew all the time. So we…[It was helpful to work as a group. L133]	B_L_R_p3L128-129
[Good things about working in a group …] It was very good. Ah, because people, because people… we were actually sharing our ideas. Ah, we had a chance, uhm … to tell everyone about our ideas and then they see if it is good or bad	C_L_R_p4L187, 191, 195-196
It is nice to share our ideas because if you share your ideas then they can uhm see your ideas and then they can experience what you like to do and things like that	C_L_R_p4L200-202
I think it was fine because you could also listen to their ideas, uhm … and uhm … change your car and make it into one car from all five of them.	C_L_FG_p2L103-104
It was creative and we uhm told everyone our ideas because they could know how we did it and added to the cars and things like that	C_L_R_p4L204-205
Because then life will go easy… easier …more not difficult anymore	A_R_p2L62
Because then like, then you don't have to do it all by yourself and it becomes boring	A_R_p2L66-67
Sometimes, hm sometimes you have to because it's going to take long to do it. So you have to have somebody to use it, then, then you going to do it very late and you're going to get tired	A_R_p2L71-73
Well, the last one of ours, yes…uhm…it's better to work in a group than work just by yourself, 'cause if you work in a group you have more people to help you, but if you work by yourself, you just have you.	B_L_R_p4L175-177

SOCIAL LEARNING CHALLENGES

Not choosing my idea / feeling overpowered

Everyone thought of different ideas and it was hard to choose one of them	A_R_p2L80
Hard. Because… It was hard because we didn't know what we should do, and we didn't want to do the same thing as the other one that wanted to do the other thing.	B_L_R_p2L92, 101-102
I couldn't really understand why no-one took any one of my ideas	A_L_R_p2L94
Learners explained that they made a solution "With everybody's ideas"	B_L_FG_p2L68

But not mine. They never listened to me even – although I was the manager	B_L_FG_p2L70-71
When I tried to, uhm when I tried to say ... uhm tell them a plan…, uh no-one let me say anything (chuckle)	C_L_Rp4L215-216
I felt like uhm people would not choose my idea [Group members commented – upset] They will. But we did! We used your inflatable tires. We used your spoiler. We used your… Hey, OK it was not my idea for the spoiler	C_L_Rp3L146 C_L_Rp3L148-150
Sometimes they didn't add my ideas to the car (Group disagrees) What are you talking about?	C_L_Rp4L222, 224
And you guys didn't even use any of my things! [Group disagrees]	C_L_Rp4L181 C_L_Rp4L183

Dealing with frustrations

Good. Sometimes it feels bad because they don't use your idea and then you feel really really really mad, then you can't be like really mad, because it's actually mean to be mad	A_C_BG_p1L28-30
It felt … it felt quite nice, but some of us got … disappointed for most of us not using somebody's plans also	C_L_Rp2L105,106
We felt very annoyed because nobody was listening.	B_L_FG_p3L156
I felt irritated, happy, sad, angry, sweating, and very angry.	B_L_FG_p8L402
I felt disgusted, angry, annoyed and kind of happy, and mostly angry. But in the second time I disco-danced on the carpet.	B_L_FG_p 8L410, 420
What makes working in a group difficult uhm, let's say that you have a problem and one of…and one of the person in your group decided to make it worse, the uhm, it's hard so that the other kids can make a more beautiful car than us.	B_L_R_p3L147-149

Personality (ambivalence)

I don't think it was a good idea. Because it feels weird to share ideas. 'Cause, I don't like sharing my ideas with other people	C_L_Rp3L123,129,133
Because it was a bit like that 'cause also other people are looking at other people's work and it didn't feel comfortable because a lot of people like working alone without people interrupting them	C_L_Rp3L158-160
[R question: Do you always prefer to work alone?] Not everything. I want some.., I do like people doing the work,but most of all I wanted them to listen to my ideas	C_L_Rp3L165-166

Preference to work on own

I'm just saying that it wasn't actually very nice when we were sharing … when we were working together. We could have just … uh …. Actually it would have been nicer uh if … we just had our own materials and made our own design.	C_L_FG_p3L140-143
[same child, change of thought] But working together was better. It was … It was the worst thing that ever happened to me at first, but when we came round, it started out to be better	C_L_FG_p3L147, 151-152
I felt very irritated because nobody listened to me. [So you never ever want to do this again?] I do, but it was just a little irritating, and then I felt happy…. because the car actually worked in the second time. And nobody ever listened to me in the first.	B_L_FG_p7-8L379-388

SOCIAL LEARNING STRATEGIES

Merging ideas

It was hard, but we also got used to it and then we realised that both of our ideas were good, so we mixed all of our ideas together.	B_L_R_p2L107-108
And you should … include other people's ideas	B_L_R_p3L160
And you could also make your own idea and you could make that all of the ideas into one idea	B_L_R_p3L164-165
We made up one. We made a whole new one that the whole group decided	A_R_p2L86, 90
Uhm, how we made our decision was we said we gonna use from everybody's …so we used one of the person's wheels, the body, and things like that	C_L_Rp3L171-172
Well we used my wheels, we used Keshni's window, your car design, Luca's windows…(Luca corrected: "doors")	C_L_Rp4L176-177, 179
Maybe we can make two tanks and attach them together!	A_L_R_p2L104

Teamwork skills

We must all listen to everyone's ideas	A_L_R_p2L100
We should work together and work properly, and not shouting at other children.	B_L_R_p3L155-156
And we should also be kind to one another and always respect one another	B_L_R_p3L171

THEORY REVISION

Intuitive theories

Mine didn't look exactly like how I planned it	A_L_R_p3L144
No, we put our things together and then we realised that it actually didn't look the same than our pictures. It looked completely different but it's still, it's still … we add some of the stuff that we did put in our one that we thought would look like but it looked actually different.	B_L_R_p4L192-195
We had to test our cars, and not everything worked perfectly, so we had to go back to our desks and fix all the problems there were	C_L_Rp5L239-240
My decision was too complicated to work, so I just start with hers 'cause mine look so realistic but…	C_L_FG_p2L108-109

Theory-revision emotions

"Hmm, sort of nice" (showing sort of with hand)	A_L_R_p3L118
A little bit nice and a little bit not nice	A_R_p3L124
(Feels) A little bit good and a little bit sad	A_L_R_p3L162
Because if you really wanted that …that part that you wanted … Then you make up with a new idea and then you feel happy	A_L_R_p3L166, 170
Good. We made up with an idea and then we happy, feel happy	A_L_R_p5L245
It feels better, because then you can learn how to fix your mistakes	C_L_R_p5L244
Because what's the point of giving up … when they're out, you should do something … 'cause you're just kids, you don't know how to do stuff properly yet, and so you can try and try until you get it right.	C_L_FGp4L193-195

Theory revision strategies

We had to make new ideas	A_L_R_p2L114

We had to change it	A_L_R_p3L156
We had to make a new plan	A_L_R_p3L158
We decided on the easiest model of a car and then we decided like uhm … Jacob's wheels, Robert's windows, Luca's…	C_L_FG_p2L125-126
Like an engineer	C_L_Rp5L246
We were thinking like engineers	C_L_Rp5L257
Yes because engineers … their first cars don't actually work, then they test it out, then, if it doesn't work they just have to fix it again	C_L_Rp5L261-262
Noooooo…. They just fix it by just looking at what…what the problem was	C_L_Rp5L266
Because when we were fixing our problems, we had to learn from our mistake at first, because it was the only problem was we had to just straighten the wheels because we just … pushed the wheels back. So we had to …	C_L_Rp5L271-273

Social learning during theory revision

We listened to everyone's ideas and put it all together	A_L_R_p3L128
And do teamwork	A_L_R_p3L132
And you also mustn't throw a tantrum if they .. if they also… if they take your idea… and they come up with a new idea, you mustn't throw a tantrum	A_L_R_p3L136-137
We put all of our ideas together and we just, we just thought of other things	B_L_R_p4L199
We felt like we will never pass, but we did because we worked together as a team and we helped each other so that's what made our…our car go faster and better	B_L_R_p4L208-210
And we and also our uhm our car uh, our car's wheel came out, then we had to uhm go back and fix the wheel because we were uh first the wheels were loose so then we went back and fixed the loose wheel and we tested it again	C_L_Rp5L246

RECORDING THINKING IN SCIENCE JOURNAL

Experiences

We learnt about the writing that we must always write our stuff that we made with our car.	B_L_R_p5L264-265
I love writing	A_L_FGp6L312
I also like writing	A_L_FGp6L314
I don't like writing	A_L_FGp6L316
Yes I like drawing, but I don't like writing.	A_L_FGp6L321
It felt good	A_L_R_p4L210
It was a little hard	A_L_R_p4L212
Cause you had to design still and you had to do a lot of working	A_L_R_p4L214
I wrote ánd I drew some pictures. It was very fun .	B_L_R_p5L288
I loved it because I like to write stories	C_L_FG_p5L218
Horrible. [Why?] Because I just don't like writing. Yip, that's why. I don't like writing. [Is that why yours is empty?] Yip, that's why mine is empty.	B_L_FG_p7L336, 340, 345
It was quite fun because we got to draw a car, share our ideas, and draw what we had to use so that we won't forget what we had to do	C_L_R_p6L341-342

Benefits

Because … you could write what you were thinking of and see if you made any changes or not for the real one	A_L_R_p4L226-227
(writing helped) … to think of it	A_L_R_p4L231
I kind of know because then, then you can actually see what you're wanting to make. Then you know what you're wanting to make.	A_L_FG_p6L329-330
Oh well, what we learned about writing is that it's a lot, but you actually explain instead of us talking to the person, you'll actually write down what you are trying to say to the person so they can understand more.	B_L_R_p5L282-284
Because then when you write down everything it makes an idea and then you can put that idea together with your friend's idea.	B_L_R_p5L270-271
[if you don't write it down] Then you'll forget it	B_L_R_p5L277
It was important because we don't have to rethink everything	C_L_R_p6L346
It was important because you can't start something without an idea of what you're gonna do [and writing helps] To remember what you did	C_L_R_p6L348-349, 353
Uhm, it's …it's important because it gives you information	C_L_R_p6L355
[And the information will be used to?] Uuuhhm, … bring it to life	C_L_R_p7L359
It felt nice because you could explain what you did and at some place someone else can read it and do the same	C_L_FG_p5L215-216
So that you don't forget your ideas , and uhm …	C_L_FG_p5L223
Every time you want to make something else, you can just copy what you did ….	C_L_FG_p5L227-228
People can learn from you.	C_L_FG_p5L230
I just said it! Someone else can copy it. Sometimes someone else can do this	C_L_FG_p5L232, 234

AUDIENCE

Children's voice

Because it's good	A_L_R_p5L273
Because we might … we might have better ideas than what you do	A_L_FGp8L427
Because our ideas are very fun. Instead of getting other people's ideas… they're boring	B_L_FG_p9L446-447
And adults also have to listen what children have to say because **what if… uh … a child has something better to say**, so… it makes something interesting and fun for them to do	C_L_R_p9L474-476
It's because if you just leave your child to do nothing then it… then they won't experience what it feels like to do something like this	C_L_R_p8L471-472
Yes, it is important, because parents also need to know what we have to say. So they can apply it to whatever we're doing, 'cause if children don't get to do something like that, they won't think it's fun	C_L_R_p8L462, 466-467

Adult power over children

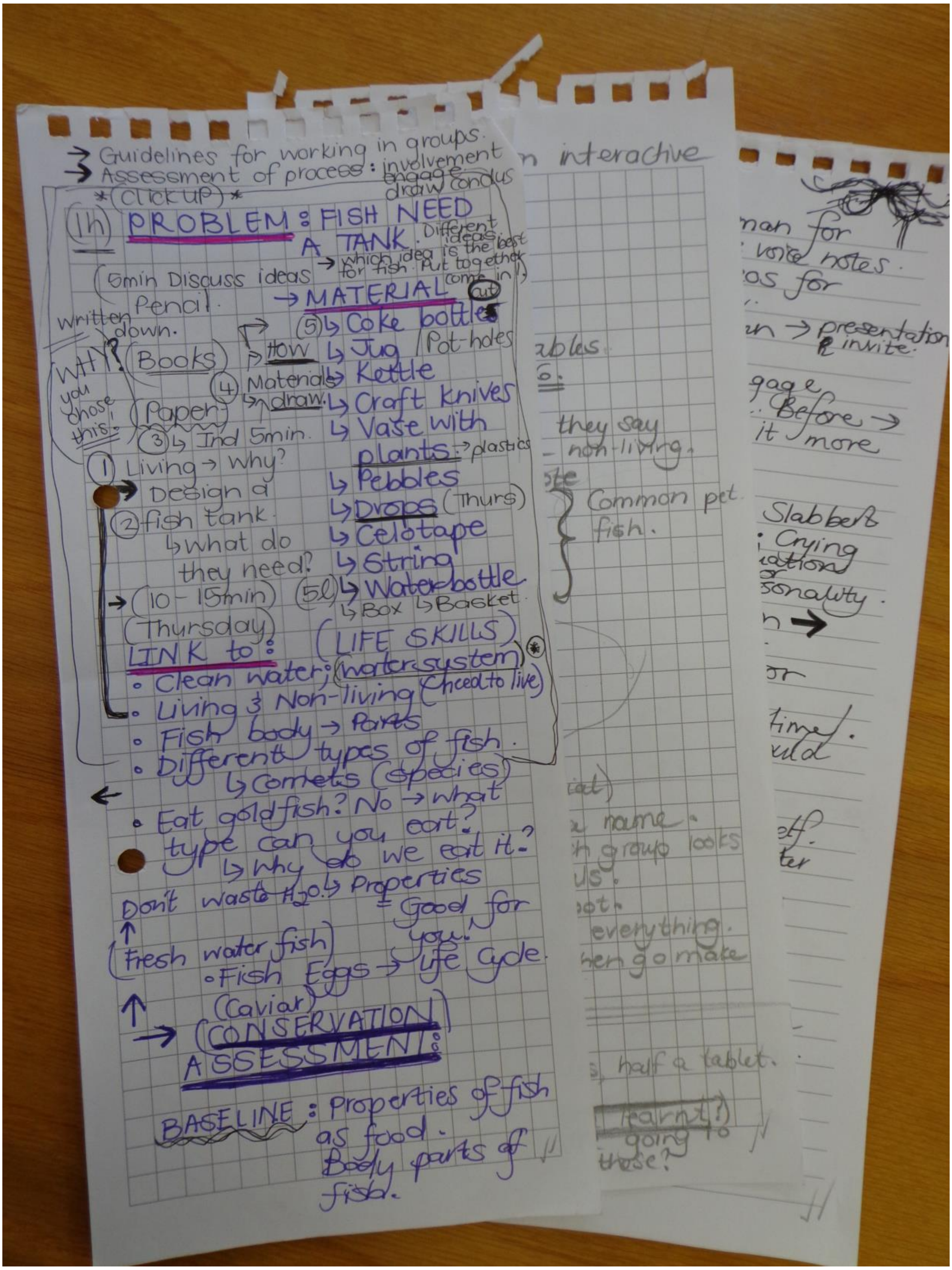
I think it is because then sometimes when you do it, you feel better. Hmm, because teachers, moms and dads can help you in your assignments or something	B_L_R_p6L333, 337-338
I think it's a yes, because, uhm, what Gaby said if you're doing your assignments you can, uhm, they can also help you and you can get a full mark for that thing that you did.	B_L_R_p6L343-345
I think it's important to tell adults because maybe you fail the first time and they can help you to fix your fail.	B_L_R_p7L358-359

I also know all the time, because they old, and sometimes they forget from their old school from last year.	B_L_R_p7L347-348
Sometimes they do, sometimes they don't, because kids are also in school, they also learn stuff, and they get ideas of it.	B_L_R_p7L379-380
And you also always have to tell your parents if it's really important or if your teacher says you have to, you have to like bring something, and you don't tell your parents, then the next day when you come, and the teacher asks you where is your thing, then you tell them I forgot to tell my mom, and then,…and then that's all.	C_L_R_p9L485-489
Not all the time, because children should not always get what they want	C_L_R_p8L456
I think adults need to know that uhm because well, uhm, you, you've been holding it in too much, and you can't … you can't just keep it in any more, and you just get so nervous, uhm like I can't tell, but I have to keep it inside but I have to tell, but uh no, you just get so confused if you wanna tell or not	B_L_R_p6L350-353

Strategies for talking to adults

Talk about it … Talk about it	A_L_FGp8L451
I would write so that they don't know it's me	A_L_FGp8L453

Appendix H: Lesson Plan and Reflection Analysis



SYNOPSIS OF IBSE LESSON PLANNING_STUDENT TEACHERS

SCHOOL A
Student teacher: Bronwyn

Synopsis of lesson planning for Grade 1 IBSE activity

THEME	Pets
Session-focus	Fish
By the end of the lesson learners should be able to know the requirements it takes to build a suitable habitat for fish as well as be able to build the habitat and appreciate the responsibility and hard work it takes to maintain and secure a habitat for pets and therefore they should be well looked after	
Integrated skills (Life Skills – CAPS)	
Science outcomes	How to look after pets; responsibility to look after pets; creating an environment that will sustain them. Concepts of life and living. Fish are living, and therefore certain requirements need to be met to sustain life. Knowledge of fish - body parts and habitat; knowledge of characteristics of living beings; how to look after pets; responsibility to care for and create sustainable habitat
Science process skills	Observe available materials, compare group fish tanks, classify specific fish types, communicate ideas and final fish tank to rest of the class
Technology and technological process skills	Using available materials and investigate, design, make, evaluate and communicate individual and group's fish tanks.
Language	Reading and viewing (Library books, Internet videos, PPT-presentation); Writing (individual and group ideas); Thinking and reasoning (choice of materials, characteristics of living organisms, choice of product and communication of product)
Visual Arts	Drawing 2D and making 3D models of the fish tank
Social	Work effectively as individuals and members of a team
Other	Responsibility towards environment - caregiving; respect for pets
IBSE-problem	To build a fish tank for living fish with the available materials
Materials and equipment	Variety of materials to build the fish tank; works sheet to label fish parts; IWB, laptop, Internet, library book; writing tools (p9)
Evidence of IBSE steps	Knowledge sharing (transmission) to acquire background knowledge prior to the investigation. Lesson sequence follows the IBSE steps: Introduce problem (p7); Engage (p7); Design/conduct investigation (p7); Communicate/Consolidation (p7)
Learning theories	Constructivism, transcendental paradigm (p5)
Evidence of IBSE approach/principles (words)	Questioning, prompting, individuals will draw/write own ideas; groups share; groups to design tanks using available materials, modify designs; groups explain their designs (in terms of what they built, out of what, why they think it is a good option, what they learned from changing their designs; explain why you built the specific tank, what changed) (p7) constant encouragement, curiosity, excitement, reasoning, constructive talk (p8)
IBSE classroom management strategies	Time/duration (p7); egg timer (p7); group rules (p7); positive discipline approach (p8); 1-2-3, look-at-me (attention-focusing strategy) (p8); learner support (p8)

(A_ST_LP, p1-8)

Structuring the classroom, materials, tools and resources for the IBSE activity:

Bronwyn had a variety of rather unusual materials to add complexity to the challenge of designing a fish tank. She displayed the materials and tools conveniently for easy access. Apart from the living fish, and materials and tools planned for the fish tank, she also had a selection resource books about fish, as well as an Internet source on pet fish.

(Photos from onsite observation)

SCHOOL B
Student teacher: Jean

Synopsis of lesson planning for Grade 2 IBSE activity

THEME	TRANSPORT
Session-focus	Building cars
By the end of the lesson learners should be able to apply their technological process skills during a car race technology design investigation. Learners should be able to design and make a miniature car out of recyclable materials, and follow rules (this car needs to roll in a straight line and roll a certain distance within the lesson time). By the end of the lesson learners should show respect for each other and develop better social skills by working together.	
Integrated skills (Life Skills – CAPS) science, technology, language	
Science outcomes	Learners should have a better knowledge of scientific concepts and vocabulary (p2)
Technology and technological process skills	Use technological processes to solve real world problem using recyclable materials; fine motor skills, problem solving and reasoning skills, social skills, respect and value social cooperation
Language	Listening and speaking; Read and viewing; Writing (p1)
Other skills	Fine-motor, technological process, problem-solving, reasoning skills; respect and social cooperation (p2)
IBSE-problem	To design a model of a car with recyclable material that can go as far and as straight as possible down an incline (p2)
Materials and equipment	A large variety of appropriate recyclable materials and tools (p6)
Evidence of IBSE steps	Lesson sequence planned according to IBSE steps (p4-6)
Learning theories	Social constructivism. Self-active, hands-on; construct and test ideas; group work, interaction, scaffolding. Paradigm: transcendental (p3)
Evidence of IBSE approach/principles (words)	Solve problems, use critical and creative thinking, work independently and in a group. Think on your own, trial and error, what did I learn, new questions, find a solution, listen and share ideas, value opinions and contributions (p2-5)
IBSE classroom management strategies	Evidence of knowledge of classroom management strategies that accommodate IBSE, e.g. discipline measures: countdown, robot system (p5)

(B_ST_ LP_p1-7)

Structuring the classroom and materials for the IBSE activity:
Jean structured the classroom by grouping learners in different groups according to numbers and colours. She placed out the science journals on learners' desks prior to the activity. She planned and provided a large variety of materials and tools for the activity, and also had a cardboard ramp for learners to test their cars.

(Photos from onsite observation)

SCHOOL C
Student teacher: Monique

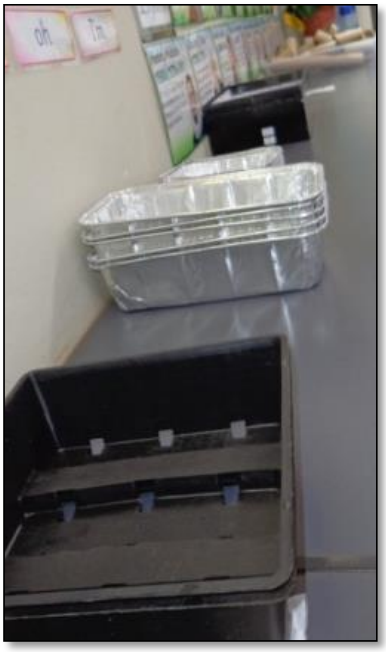
Synopsis of lesson planning for Grade 3 IBSE activity

THEME	TRANSPORT
Session-focus	Building cars
By the end of the lesson the learners should be able to understand the different parts of a car in a basic form, especially the aspects pertaining to the wheels. The learners should be able to use and manipulate recycled material to design a 3D model. The learners should value the ability to make their own 3D designs (p2).	
Integrated skills (Life Skills – CAPS) science, technology, language	
Science outcomes	The learners should be able to understand the different parts of a car in a basic form, especially the aspects pertaining to the wheels
Other	Physical, social, personal, emotional and cognitive development (p1)
Skills	To use and manipulate recycled material to design a 3D model and value the ability to make their own 3D designs (p2)
IBSE-problem	To design a car that can go as far and as straight as possible (p4)
Materials and equipment	Large variety of appropriate materials listed (p5)
Evidence of IBSE steps	Lesson phases according to IBSE steps (p4)
Learning theories	Humanistic approach; Transcendental learning (p3)
Evidence of IBSE approach/principles (words)	Work independently, problem solving (p3) Work together, learning from one another (p3) use own idea, merge as group, test models, analyse, make adjustments (p4)
IBSE classroom management strategies	Work together, free to talk (p4)

(C_ST_LP_p1-7)

Structuring the classroom and materials for the IBSE activity

Monique structured the class according to the requirements for IBSE. Learners desks were moved so that learners could work together in groups. She had a large variety of materials and tools to build the cars, as well as an incline from which learners could test their cars.




(Photos from onsite observation)

Lesson plan analysis, summarising lacunae

ST	Science outcome/s	Formulation of IBSE problem	Analysis
A_ST1_LP	Concepts of life and living. Fish are living, and therefore certain requirements need to be met to sustain life. Knowledge of fish – body parts and habitat; knowledge of characteristics of living beings; how to look after pets; responsibility to care for and create sustainable habitat (p 2).	To build a fish tank with the available materials (p. 2).	**Outcomes**: Mostly relevant, but too broad and not inquiry-focused. **Limitations**: • Formulation is not IBSE-focused and investigable. • Disconnection between outcomes and problem.
B_ST2_LP	Learners should have a better knowledge of scientific concepts and vocabulary (p. 2.	To design a model of a car with recyclable material that can go as far and as straight as possible down an incline (p. 2).	**Outcomes**: Concepts not specified, not inquiry-focused. **Limitation:** Disconnection between outcomes and problem.
C_ST3_LP	The learners should be able to understand the different parts of a car in basic form, especially the aspects pertaining to the wheels (p. 2).	To design a car that can go as far and as straight as possible (p. 4).	**Outcomes**: Too vague, not inquiry-focused. **Limitation**: Disconnection between outcomes and problem.

SCHOOL A
ST (BRONWYN) LESSON REFLECTION ANALYSIS
(LONG NARRATIVE POST LESSON REFLECTION)

BENEFITS for learners	CM	PLANNING	CONCERN	CHALLENGES	REFLECTION ON IMPROVEMENTS NEEDED	IMPACT on ST	ROLE	Success depended on…	Excerpts
p1 working together	p2 Egg timer	p2 thorough planning	p2 Potential to be chaotic	p2 Time	p5 class control; attention focus strategy; firmer; problem-formulation; time frame.	p2 The actual lesson was so much fun for me as facilitator and for the learners	p7 facilitate, guide, using leading questions	p6 thorough planning, time, effort on preparation; classroom preparation	p7 … the role of the teacher is merely to facilitate and guide, using leading questions in order for the learners to figure out the best solution and not told what to do.
p3 worked well together			p2 concern about children's reaction to a completely different environment	p3 SL challenge - upset when not using their ideas	p6 Move between groups more, facilitate; support children emotionally	p4 I was extremely excited when one girl got the correct answer			p3 The learner who did not like working in groups was frustrated as her real life problem was not getting along with the other learners and other learners were not using her ideas. Her problem was

									real to her own personal situation and she had to overcome this problem and therefore learnt how to work in groups better than before.
p3 learnt to work better in groups				p3 SL - some don't like working in groups (see excerpt)	p7 have science notebook	p5 The best moment for me			p5 I then sat down in the middle of 7 year excitement on the carpet
				p3-4 Egocentrism played a big role in children's lack of group work skills					
p4 Children figured out by themselves and modified accordingly				Facilitation challenge: guiding is tiring					p4 …the constant facilitation to guide learners to get to a correct answer was tiring compared to

									just telling the learners the answer or what to do
p6 children changed their minds without any prompting				p5 starting to lose control		p6 Emotionally drained			
p7 improve learners' cognitive and practical skills				p5 CM strategy to focus on instruction deteriorated		p6 extremely worth it			p7 IBSE should be implemented in all schools at it is a great way to improve learners' cognitive and practical skills and it will be beneficial to the learners in all aspects
				p5 firmer CM		p6 excitement			p6The first was the excitement and the belief that I had it in my students to create a solution to the

									problem. This was so rewarding and they found the solutions all on their own.
p7 beneficial to the learners in all aspects				p6 neglected emotional support		p6 belief in children's ability			p7 IBSE aims at developing of cognitive skills and higher order thinking as well as teaching the learners to use specific scientific skills such as questioning, reasoning, experimenting and checking hypothesis
						p6 rewarding			

ANALYSIS: POST-LESSON REFLECTION

F ROLE	IBSE VALUE FOR LEARNERS	IBSE ABILITY / impact on LEARNERS	ST Understand IBSE	CHALLENGES	PLANNING	IMPROVEMENTS NEEDED	Excerpts
p2 understand: let learners do thinking, come up with solutions; don't give answers	p2 encourages critical, creative and independent thinking; makes learners want to ask questions	p2 excitement	p2 I believe it is crucial for learners to question things, to test knowledge and to come to conclusions on their own	p3 time	p 4 proud of classroom organisation	p3 More discussion during engage	p2 Some of the benefits I could see for learners would be that IBSE encourages critical, creative and independent thinking. Further to this, it makes learners want to ask questions! I believe it is crucial for learners to question things, to test knowledge and to come to conclusions on their own
p2 not giving answers	p3 super excited and energetic	p4 able to communicate well		p3 Some groups did not work well together	Activity perfect for theme	p3 more clear in instructions	p3 I really feel like I encouraged the learners to think freely and promoted a culture of inquiry. I wanted the learners to ask questions and to find out the answers on their own. When I found some learners struggling, I encouraged them to redesign or change something and not to give up. When learners would ask me questions, I would answer with "I'm not sure, why don't you find out and tell me?"

p3 Posed good question	p4 Difficulty in GW overturned - learned the value of working together. Successful at resolving their issues and working together	p4 Able to record		p3 Time - spent on managing groups		p4 Present IBSE over more days	However, something changed and the learners ended up working together very successfully … They were so successful at resolving their issues and working together that their car actually won the race!
p3 walk between groups to listen to solutions, ask questions, stimulate further thinking		p5 some work well together		p3 Time for investigation (not finished) "pulled learners out of investigation"…		p5 GW difficult for learners	
p3 encourage to think freely; promotoed culture of inquiry; encouraged them to ask questions, find asnwers themselves				p3 Time - not time for communicate (rushed, disorganised)		p5 neglected recording scientifically - children too consumed by hands-on work and testing	
p3 supported struggling children - redesign/change				p4 Do not listen to other groups - excitement and disorder			
p3 don't give up				p4 disruptive CM (excitement, disorder)			
p3 challenged to figure out themselves				p4 time constraint - rushed			

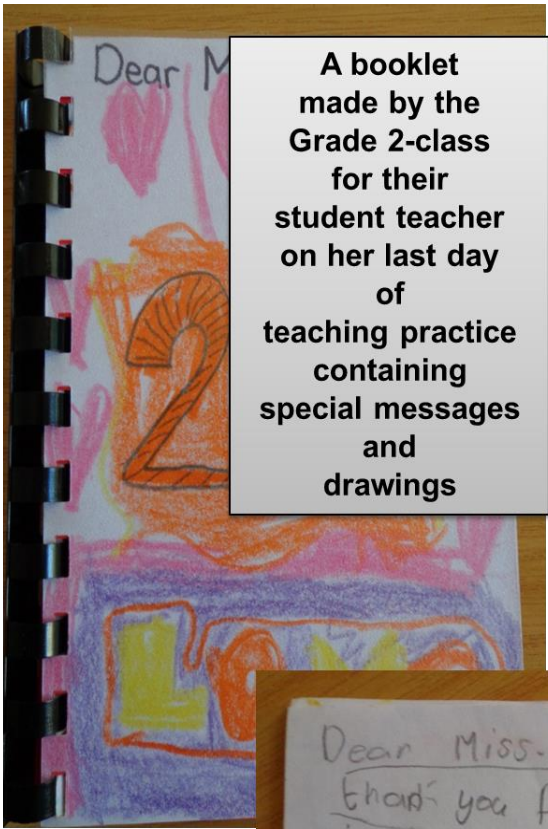
Proud - facilitation of ENGAGE phase				p4 Management of GW			
Make sure children record ideas				p4 some are incompatible regardless of efforts from both F and C			
				p4 Main challenges = time constraints			

POST-LESSON REFLECTION ANALYSIS
SCHOOL C (MONIQUE)
COMPLETED A SHORT NARRATIVE REFLECTION (1 page)

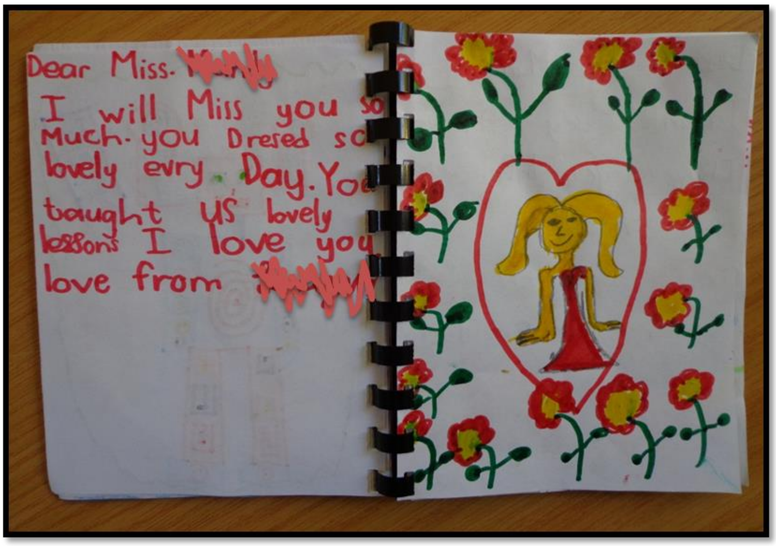
ST reflection on facilitation roles	Reflection on challenges experienced in presenting IBSE	ST view on learners' IBSE abilities	IBSE benefits for learners
PLANNING Lesson went according to plan as far as I could plan. The lesson was an open lesson where I did not know what the learners would come up with…	THINK ON YOUR OWN The learners were unsure of the requirements initially. They only thought of BMW and all the fancy aspects of the car and not the actual requirements of going as straight and as far as possible. The learners wanted to have automatic doors and booster buttons and all the gadgets but they did not focus on the practicality of the model until they tested it for the first time and started to realise what they should adjust.	CONCLUSION It surprised me that the learners made all these deductions on their own and they were able to figure this out without guidance… this made me realise that we underestimate the abilities of children to be able to learn when they are not given the answers.	LEARNING & REASONING There was a lot of synthesis and evaluation which allowed learning and reasoning to take place on a more complex level
ENGAGEMENT Introduction was short and simple and learners were presented with a problem which ensured they were excited and willing to do the activity	CONCLUSION (TIME CONSTRAINTS) The conclusion session occurred a few days later as there was not enough time to focus on the wrap up after a 2 hour lesson where the learners were tired.	L CAN SOLVE PROBLEMS ON THEIR OWN The groups may have struggled for nearly 2 hours with their models but they fixed their problems and managed to understand everything they needed to know about how a car works all on their own.	L MOTIVATION The learners were eager and excited which was the most important part of the lesson
INVESTIGATION I did not do everything for the learners. I stepped back and let them try and fail and adjust and improvise without me giving them ideas or answers.		L CAN THINK CRATIVELY The learners then used their imagination and looked at all the materials	
CONCLUSION When we discussed the cars the learners understood that the wheels need to be even and loose on the stick to be able to work. We discussed the terminology for the stick and I explained that it is an axle. We also discussed			

that the car couldn't be too heavy in the front or it crashed at the bottom of the ramp and the car body needed to be as high off the ground as possible.			
CLASSROOM MANAGEMENT The groups I chose worked well together and there was minimal fighting and disagreements. I also did not resolve all conflict over tools and equipment, I allowed the learners to engage in problem solving and learning to work with others and also to compromise			

Appendix I: Additional



A booklet made by the Grade 2-class for their student teacher on her last day of teaching practice containing special messages and drawings




Dear M. Mu[redacted]
thank you for teachi
me about scients
know I am professor
P[redacted] I am going to miss
you so much but I
am happy for you
Love
[redacted]

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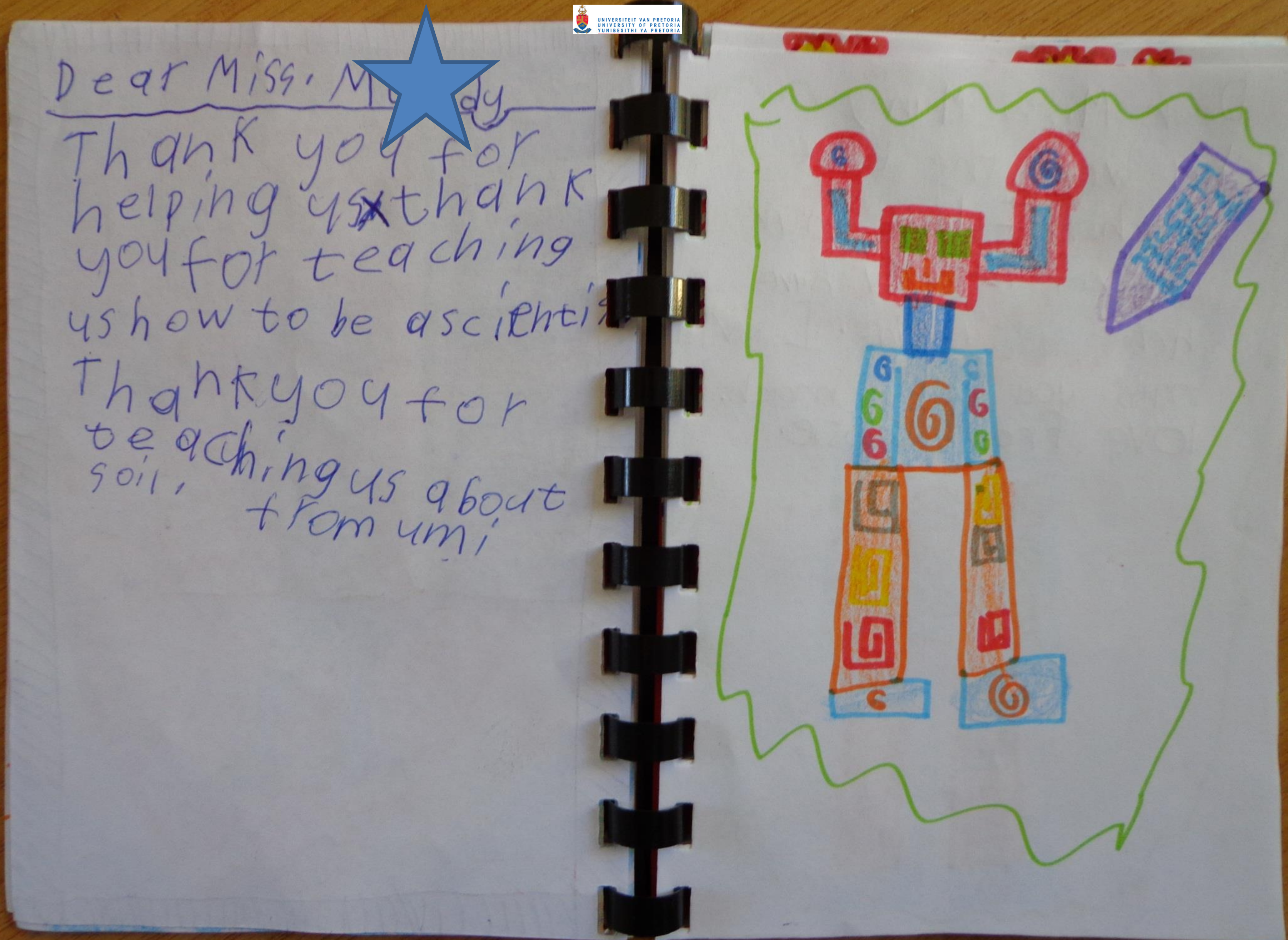

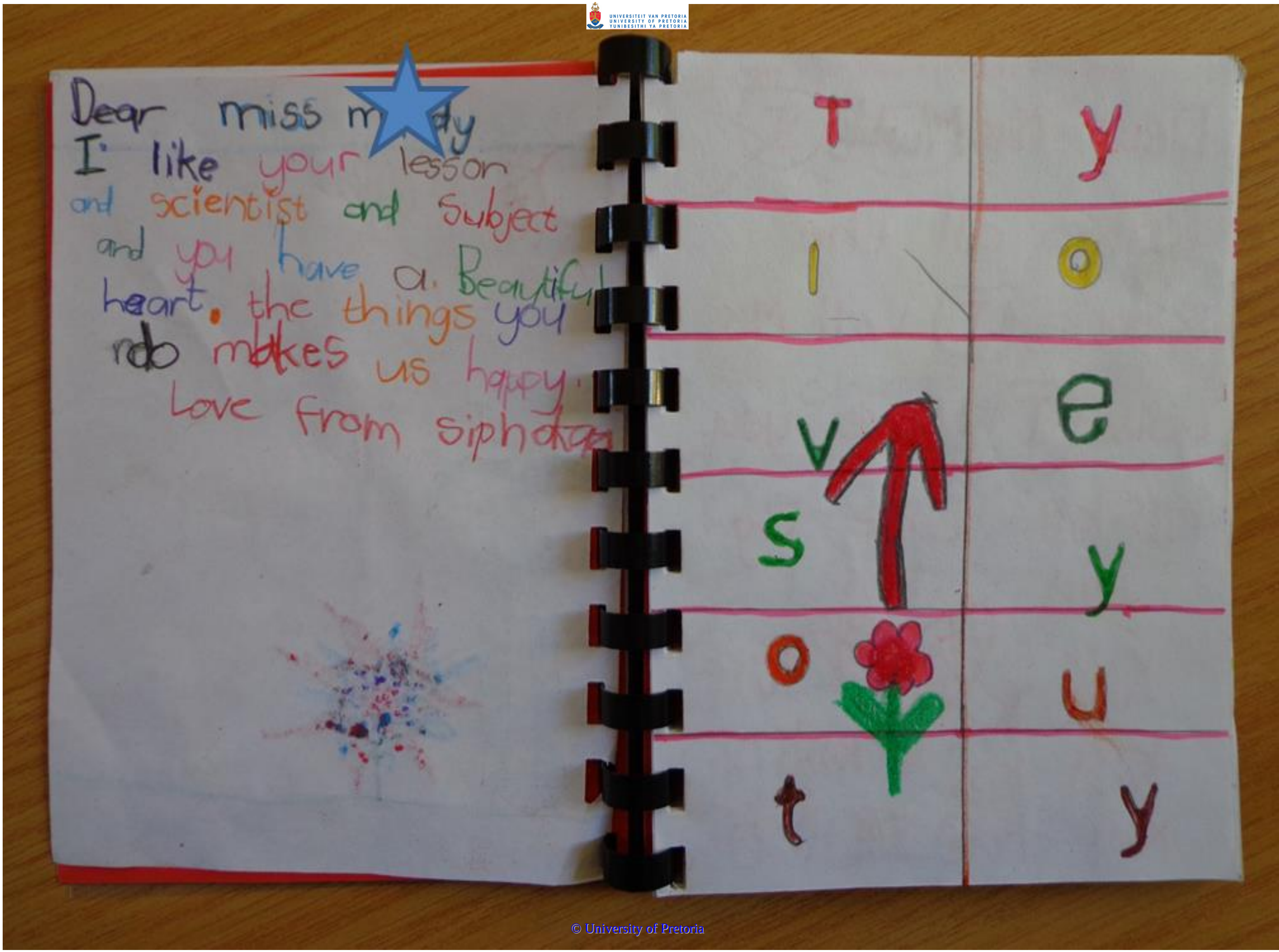

Dear miss
I like your lesson
and scientist and Subject
and you have a Beautiful
heart. the things you
do makes us happy.
Love from
T y
I o
v e
s y
o u
t y

Dear Miss [redacted]

thangk you for all that

you taught us.
You toib us how to
be a scienist.

From [redacted]

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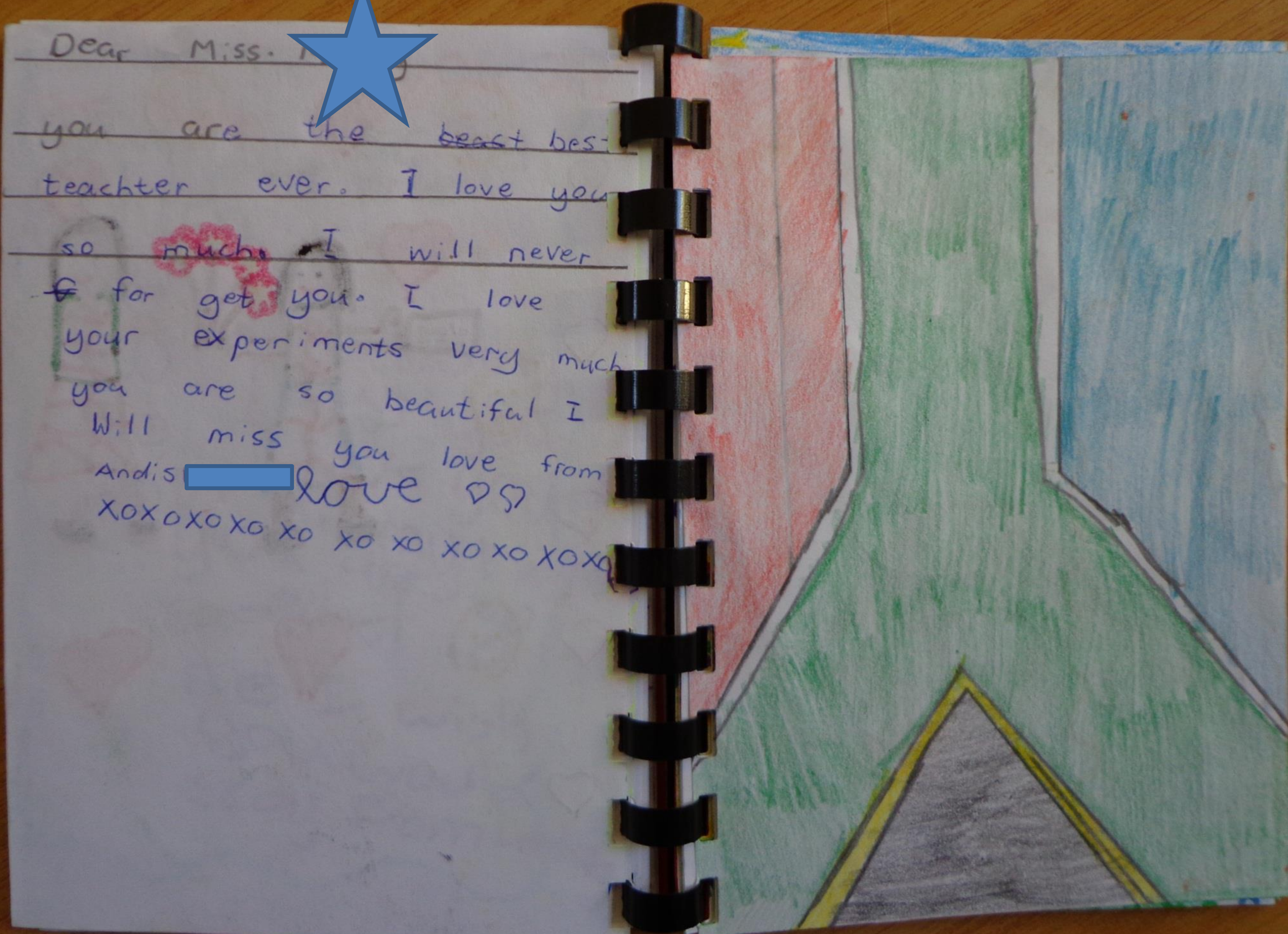

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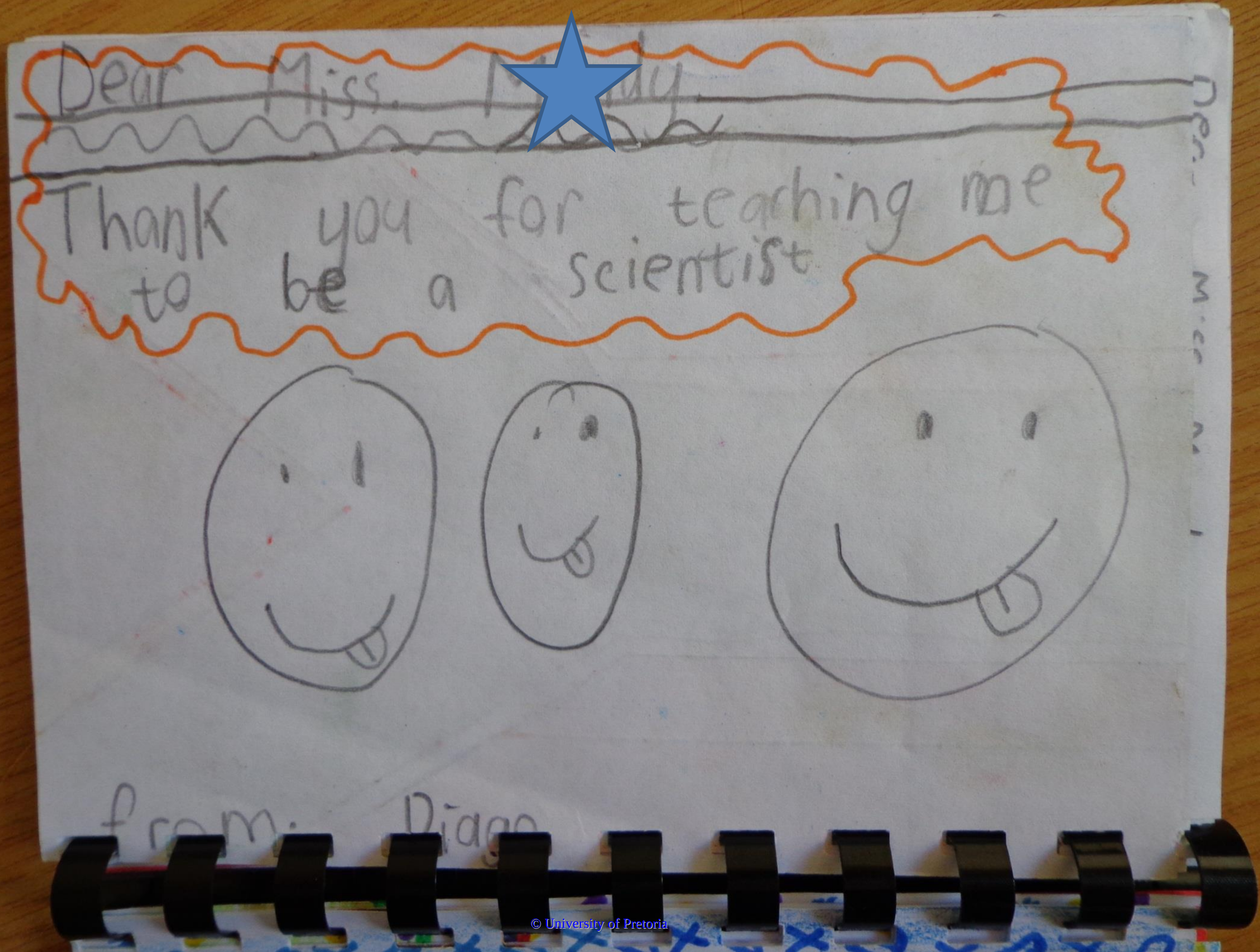

Dear Miss. M[illegible]dy

Thank you for teaching me to be a scientist

from: Diago


Dear Miss M[illegible]y
You were the best teacher ever. You were like a best mother ever. I loved your wonderful lessons you had with us. And you were so kind to me. I won't be [illegible]n with out you. And the game hang man was really fun and that [illegible]eat one. I will miss you
Love from Tara[illegible]