Hello world: Preparing Foundation Phase teachers in KZN to teach coding

by

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Supervisor: Prof R Callaghan

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The author, whose name appears on this thesis' title page, has obtained the applicable research ethics approval for the research described in this work. The author declares that she has observed the ethical standards required in terms of the University of Pretoria's Code of ethics for researchers, and the Policy guidelines for responsible research.

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Dedication

I dedicate this research to my children. Mvanakankulunkulu, Yethi-Smakade, Hawulamashiya. May I always make you proud.

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Abstract

The fast-evolving pace of technology demands an equally evolving workforce. This necessitates that education incites critical thinking, creativity, and problem solving from the Foundation Phase (FP). Coding is recognised as such an evolutionary subject that lacks trained teachers. This research investigated how Foundation Phase teachers in a district in the Kwa Zulu Natal province in South Africa can be prepared to teach coding.

The qualitative approach to this research was utilised within an Action Research (AR) strategy with two cycles. Document data pertaining to the introduction of coding in the FP was first analysed. The researcher then observed an introduction to coding training workshop offered to FP teachers, in the first research cycle. FP teachers from three schools from the province were sampled from a population of teachers who attended the workshop. They provided survey and focus group data in the second cycle of the AR process. The data was analysed thematically, according to the Assessment of Education Technology Professional Development (ETPD) framework. This framework integrates organisational learning; participant and research inquiry; and the Technological Pedagogical Content Knowledge (TPACK) framework.

The research produced a set of guidelines that is supported by, and expands on the Assessment of ETPD framework. The framework is realised in a practically applicable manner for the professional development structures needed to introduce coding in the FP. The findings offer a professional development process outlining the necessary factors that can lead to the preparedness of FP teachers to teach coding.

Key Terms:

Action Research, Coding, ETPD, Foundation Phase, Organisational involvement, Participant research and inquiry, professional development, TPACK.

Language editor

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Sincerely

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This certificate confirms the language editing I have done in my personal capacity and not on behalf of SPU

List of abbreviations

AR	Action Research
CPTD	Continuing Professional Teacher Development
CS	Computer Science
DBE	Department of Basic Education
ECD	Early Childhood Development
EGRA	Early Grade Reading Assessment
EPIRLS	Electronic Progress in International Reading Literacy Study
ETPD	Education Technical Professional Development
ICT	Information and Communication Technology
MOOCs	Massive Open Online Courses
NDP	National Development Plan
OL	Organizational Learning
PCK	Pedagogical Content Knowledge
PD	Professional Development
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PRI	Participant Research and Inquiry
SACE	South African Council of Educators
SACMEQ	Southern and East African Consortium for Monitoring Educational Quality
SDGs	Sustainable Development Goals
TCK	Technological Content Knowledge
TIAI	Technology Integration Assessment Instrument
TIMSS	Trends in International Mathematics and Science Study
TPACK	Technological Pedagogical Content Knowledge
UN	United Nations
USA	United States of America

Table of Contents

List of Figures

List of Tables

1. CHAPTER ONE: GENERAL ORIENTATION

1.1 INTRODUCTION

The World Economic Forum (WEF, 2020) reports on the future of schools, with specific regard to how schools are developing in preparing learners for the fast-changing world they are living in (DBE, 2020). This fast-changing world requires an individual to be prepared for effective contribution to the country's economic development (Presidential Commission On The 4IR, 2020) in the midst of the Fourth Industrial Revolution (4IR).

At the South African Digital Economy Summit in 2019, it was announced that subjects such as coding and data analytics will be introduced from primary school level to prepare young people for the jobs of the future (SABC News, 2019). This substantiated the recognition of knowledge of computing as an essential aspect required in current and future jobs (creation).

"Computing is involved in almost all aspects of our lives and knowing how to code has numerous benefits" (Labuscagne, 2019, p. 1). Robots will also affect everyone in their lifetime. It is therefore, important to understand robots (Sims, 1987) and coding.

In March 2019, the South African Government, announced the development of a curriculum for coding and robotics for Grades R to 9. Where coding is instructional lines for a computing device (Mason & Rich , 2019), and robotics involves machinery, actualising coding (Bicchi, Catalano, Grioli & Lentini, 2020).

The Minister of Basic Education, Angie Motshekga, indicated that coding can help prepare learners for contributions towards sustainable industrialisation, and to keep pace with developments in the world (DBE, 2021). She further explained that the Department of Basic Education (DBE) was focusing on Educational Robotics (ER) to foster the development of computational thinking (CT) skills.

Coding requires CT skills, which is the skill of breaking a problem into smaller components and solving it (Adler & Beck, 2020). CT is a skill largely associated with the 4IR (Arek-Bawa & Reddy, 2021; Monyela, 2021; Oh, 2020). It is a skill that fosters thinking, and allows the creating of instructions transferable to machinery. CT is the skill needed to actualise coding in ER (Chetty, 2015). Educational Robotics is gradually introduced in classrooms to implement activities aimed at fostering the development of students' CT skills (Motshekga, 2020).

With the introduction of a coding and robotics curriculum, it is essential to facilitate the preparedness of teachers to implement the curriculum, teaching CT using coding. Noteworthy, this research focuses on the teaching of coding, but also acknowledges that the teaching of coding entails the teaching of CT using coding. Professional development (PD) of teachers in ER is required (Anwar, Bascou, & Menekse, 2019) to introduce and impart to the South African learner, knowledge that will prepare learners for their futures.

1.2 RESEARCH CONTEXT

As part of the DBE's introduction of Coding and Robotics as a subject, the draft Curriculum and Assessment Policy statements (CAPS documents) Grade R-9 was released on 19 March 2021 (Department of Basic Education, 2021). Various interventions are being rolled out in the country to facilitate the introduction of Coding and Robotics as a subject.

The University of Johannesburg, in partnership with the DBE, Africa Teen Geeks, and UNICEF, hosted an online introduction to coding and robotics teacher training workshop on 30 October 2021 (Africa Teen Geeks, 2021). The Kwa-Zulu Natal Department of Education (KZNDOE) selected 112 pilot schools to be trained (in April 2021) in implementing the draft Curriculum and Assessment Policy statements (BusinessTech Staff Writer, 2021). The KZNDOE has also presented teacher training workshops for the piloting of Coding and Robotics with teachers from Amajuba, uThukela, Zululand, uMkhanyakude, King Cetshwayo and Pinetown Districts, since 2022, scheduled to end in 2024 (Dawood, 2022). The University of South Africa (UNISA) and the University of Johannesburg are also now offering a short course in Coding and Robotics for teachers (UNISA; UJ, 2023).

Unplugged coding is another intervention aimed at assisting with the introduction of coding in Coding and Robotics. Unplugged coding "is a pedagogy for teaching computational ideas without using a computer" (Bell, 2021, p. 25).

The Coding Unplugged initiative is an initiative that aims to teach coding using unplugged coding. The Coding Unplugged initiative was launched by the Nelson Mandela University working in partnership with Tangible Africa. Tangible Africa is a project run by a non-profit organisation called The Leva Foundation (Nyabor, 2023).

The Coding Unplugged initiative is aimed at introducing coding without the use of computers (unplugged coding). The initiative develops offline instruments that are cost-effective, to teach coding for teachers without programming experience. They also provide an education solution to places without electricity or internet connection (Malinga, 2023). The BOATS coding application and kit was developed by Tangible Africa, as a means to package unplugged coding learning, in an application that is available as an offline tool.

The BOATS coding application therefore needs internet access only to be downloaded and no internet access is required to run the application. The kit comprises cards depicting directional movement. The application poses a question requiring a sequencing of directions. The user then uses the cards from the kit, to sequence the directions required to solve the problem, and the sequence can be scanned on the application to be assessed for correctness.

FP teacher specific training, tailored to the BOATS unplugged coding app and kit, was developed by one of the teachers who attended the Coding Unplugged workshops hosted by Tangible Africa. The training was developed in the form of a series of coding lesson plans that can be used to teach FP learners. BOATS unplugged coding training was offered to all FP teachers around the country. Kwa-Zulu Natal (KZN) schools also participated in the training as part of the Department of Education support for coding.

This research explored how the BOATS training can support the preparation of FP teachers in KZN to teach coding. The focus of this research is through ER coding specifically; but in the context of Coding and Robotics. This emphasis is illustrated through the phrase coding (and robotics) in this dissertation.

1.3 PROBLEM STATEMENT

The Introduction of a Coding and Robotics curriculum is beset with varying challenges and problems. There is increasing concern over the following aspects:

a) Technology develops fast and it is difficult for teachers to keep up.

The world is changing at a rapid rate, and learners need to be prepared to live in this evolving world. For learner preparedness to occur, teachers need to prepare students for this rapidly changing world. These teachers need to be well equipped to teach their learners.

Adendorff and Collier (2015) estimate that up to 49% of jobs could be replaced by machines in the course of the next 10 years, with the figure for South Africa around 35%. Basic coding or computational instruction, once a specialist skill, is soon becoming a basic function requirement for employment in many careers. There is increasing concern that some learners are being disadvantaged in this regard (Issah, Olaitan, & Wayi, 2021).

b) One of the elements of the 4IR is to prepare learners for CT.

This can be applied through coding (and robotics). This is a new field in primary schools in South Africa for which teachers are not yet prepared.

Coding (and robotics) can be seen as an integral part of many, if not all, industries. (Sims, 1987). Teacher and school preparedness to implement the coding and robotics curriculum needs to be developed (Anwar, Bascou, & Menekse, 2019).

In response to the world-wide shift into a 4IR, the South African Government, announced the developing of a curriculum for coding and robotics for Grades R-9 (Department of Basic Education, 2021) in March 2019.

c) Introduction of coding (and robotics) from an early age.

Researchers agree that it would be beneficial to engage learners from an early stage in subjects dealing with technology, such as coding (Bers, Flannery, Kazakoff, & Sullivan, 2014; Manches & Plowman, 2017; Bers, Hassenfeld, Govind, & Ruiter, 2022). The introduction of Coding and Robotics from an early age is currently being undertaken by the DBE.

d) Pedagogical approaches and PD for teaching coding

From research, there seems to be a great deal of research into pedagogical approaches and PD for teaching coding, and utilising various technological resources in teaching coding (Alexander, Bell, Freeman, & Grimley, 2009; Bers, Seddighin, & Sullivan, 2013; McCoy-Parker, Paull, Rule, & Montgomery, 2017; Lentini, Grioli, Catalano, & Bicchi, 2020; Greyling, 2023). There is lack of literature on guidelines for preparing FP teachers to introduce coding that takes on a holistic approach, examining the various factors, besides pedagogy and resource application, that need to be considered for such to occur. There is therefore, a gap in professional development programmes for teachers to effectively implementing coding (and robotics) in teaching and learning.

This research will examine how FP teachers can be introduced to CT and coding, such that they can teach CT using coding to their learners.

1.4 RATIONALE OF THE RESEARCH

The South African Education system is constantly trying to catch up with the 4IR demands. The issue has grown in importance in light of recent demands of the work environment as the world evolves (Mkansi & Landman, 2021). The nature of work and that of the job market is changing. It no longer makes sense to ask children what they would like to 'do' when they grow up. By the time they 'grow up', many of the current job types will have disappeared, and many are presently not defined

(Butler-Adam, 2018). It is essential that learners are educated early for the changing world.

The core competencies aimed by the South African National Curriculum (NCS) Statement Grade R-12 school curriculum are to bring about education that is in-line with global societal context. These core competencies aim to produce learners that can identify and solve problems, making decisions using critical and creative thinking. Learners that can work effectively alone and collectively; that can effectively coordinate themselves; collect, analyse, organise and critically evaluate information; communicate efficiently; use science and technology in a critical and effective manner; and display an understanding of the world systems as interrelated when implementing problem solving. The global evolution to achieve the most desirable roll-out of Information and Communication Technology (ICT) as the core of teaching and learning has revealed that the core competences of the South African curriculum are contained in subjects such as robotics, coding and data analytics (Department of Basic Education, 2021).

The NCS accommodates such core competences through digital skills in subjects such as Information Technology (IT), taught from grade 10 to 12 (Department of Basic Education, 2011). As an Information Technology teacher for grade 10 to 12 learners (the Further Education and Training Phase), it has been noted that learner enrolment in IT tends to drastically drop as the learners continue to the next grade. IT is a subject that aims to develop CT through six subject areas (Department of Basic Education, 2011). These are solution development, communication technologies, systems technologies, internet technologies, data and information management, and social implications. Information Technology is only offered in grades 10, 11, and 12. Therefore the late introduction of such a subject creates fear in learners, as many lack the foundation to grasp computational concepts. An earlier introduction to CT concepts through coding would possibly allow learners to develop an interest in programming as a whole.

The DBE acknowledges that the teaching of coding and robotics from at an early stage relates to these core competencies as the driving reason necessary to prepare learners for the changing world. (Department of Basic Education, 2021).

The DBE also acknowledges that teachers who can teach coding in the FP are scarce, and training needs to be provided for those available.

These realities provide the rationale of the research, which was to investigate KZN FP teachers' preparedness and development for teaching CT using coding, and to make recommendations for better preparedness. The effective PD of teachers, through the new coding and robotics curriculum, could give rise to a greater community of teachers in the field of IT, not restricted to the FET phase. In can also contribute to a South African Education system that is consistent with the 4IR demands, and producing learners who meet the demands of the current work environment.

1.5 RESEARCH QUESTIONS

The study is guided by one main question and 2 sub questions.

Main research question – **How can Foundation Phase teachers in KZN be prepared for teaching coding?**

The sub research questions (SRQ) have questions which they address. The First SQR identifies skills that are required to teach CT using coding. The second SQR identifies the changed skills in the teachers after the training. The SRQ's are:

SRQ1: Which skills should teachers be prepared for to teach CT using coding?

SRQ1 will require the following points to be analysed in order to be addressed:

- What technological, pedagogical and content knowledge (TPACK) and skills for Organisational Learning (OL), and Participant Research and Inquiry (PRI) is needed to teach computational thinking using coding?
- How do the TPACK, OL and PRI concepts feature in the BOATS unplugged?

SRQ2: How do teachers' preparedness change during unplugged coding training?

SRQ2 will require the following points to be analysed in order to be addressed:

- How prepared were teachers before the training to teach CT using coding?

- How were the teachers' technological, pedagogical and content knowledge and skills refined through the training?
- How do teachers apply the technological, pedagogical and content knowledge and skills during teaching?

1.6 PURPOSE OF THE RESEARCH

The purpose of the research was to determine how FP teachers can be prepared to teach coding. This research had the following objectives:

a) To determine the necessary technology, pedagogy and content knowledge and skills that FP teachers need to teach coding.
b) To determine possible guidelines for preparing teachers for teaching computational thinking through the introduction to coding.

1.7 DELIMITATIONS

The research did not investigate the teaching of robotics. This research only uses the PD of the BOATS unplugged program as an example of a PD programme that can be offered to teachers to teach the introduction of coding. This research was not intended to evaluate the BOATS app or training course itself. It was used as an example of a PD course that is relevant to the focus of this research. The research only used the PD of the BOATS unplugged program due to it being a program offered in the timeframe for which the research was conducted, as well as participants being willing to be involved in the research.

The training workshop, in KZN, had been planned to be delivered through in-contact training, buts due to covid, it ended up being offered as an online program.

This research analysed the main concepts of the TPACK model, which are the Technological Knowledge (TK), Pedagogical Knowledge (PK), and the Content Knowledge (CK). The Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and the Pedagogical Content Knowledge (PCK, as explained in section 2.6.1.2.2, were not analysed.

1.8 LITERATURE OVERVIEW

The literature review in chapter 2 presents the following topics:

- An introduced definition of coding and CT in section, and the global call for coding in section 2.2.
- Teaching coding, by heeding the global call for coding, globally practice coding curriculums, and intended South African coding curriculum in section 2.3.
- Coding in the FP, by explaining the South African educational system and its FP, and teaching coding in the FP in section 2.4.
- Teacher PD, by explaining PD, and the how SACE enacts PD in section 2.5.
- The theoretical underpinnings, by presenting an overview of Borthwick and Pierson's model, presenting the Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed TPACK model, and
- Preparing through PD summarised in section 2.6.

A chapter summary is presented in section 2.7.

A definition of coding requires an explanation of CT as a necessary skill for the 4IR, which is realised through coding (Arek-Bawa & Reddy, 2021; Monyela, 2021; Oh, 2020). CT is actualised in three key dimensions; computational concepts, computational practices, computational perspectives (Brennan & Resnick, 2012; Haseski, Ilic & Tugtekin 2018). These concepts are explained as guiding factors for determining the readiness of teachers to teach coding in 2.2. This is followed by a discussion highlighting its reference to robotics also in 2.2.

The literature review focuses on the global request for coding as a means promote lifelong learning opportunities (Mthembu & Nhamo, 2021) in 2.2.

The need and attempts to prepare for teaching coding is discussed in 2.3. Global curriculum trends that heed the call for coding as a subject (Barksdale, et al., 2019) is discussed, followed by the analysis of the proposed South African Foundation Phase curriculum (DOE, 2020).

The importance of coding in the FP in 2.3 provides a background in the South African education system. This offers a view into the challenges prevalent in the FP (Hanushek & Woessmann, 2015; Combrinck & Mtsatse, 2019; Fritz et al., 2020; Govender & Hugo, 2020).

The lack of professionally developed FP teachers is presented as being problematic in 2.4.

The meaning of professional development (Dall'Alba & Sandberg, 2006; Deacon, 2010; Bos, 2011; Govender, 2018) is introduced in 2.5.

In order to identify whether teachers have been effectively professionally developed, there needs to be an assessment. An assessment of Education Technical Professional Development (ETPD) model by Borthwick and Pierson (2010) is presented as the theoretical framework guiding the research in 2.6.

1.9 METHODOLOGICAL OVERVIEW

This research was situated in the interpretive paradigm, as teacher experiences of training to teach coding to FP learners were investigated and interpreted on the basis of their experiences (Bhattacherjee, 2012). The researcher incorporated the hermeneutic principles, proposed by Klein and Meyers (Klein & Myers, 1999), to ensure that the interpretation is a true reflection of the participants' experiences. The interpretivist research philosophy is described in detail in section 3.2. The approach to theory development was deductive, as the research planned to move from generalisations as packaged within the Assessment of ETPD framework, to specific observations during the research (Lewis, Saunders, & Thornhill, 2019). The deductive approach to research is elaborated in section 3.3. A qualitative methodological choice was chosen for this research design. This allowed the researcher to obtain a deeper understanding of the views of participants on their preparedness to teach coding (Bloomberg & Volpe, 2019). The qualitative methodological choice for the research is extended on in section 3.4. The time horizon for the research is longitudinal (Cook & Ware, 1983; Lewis, Saunders, & Thornhill, 2019; Jansen, 2020). This is presented in further detail in section 3.6.

This research was conducted following the Action Research strategy. It was conducted in cycles. There were two cycles implemented, referred to as Action Research cycle 1 (ARC1), and Action Research cycle 2 (ARC2). Each Action Research cycle resulted in a different version of guidelines addressing the research question. The Action Research strategy for the research is explained further in section 3.5.

This research was situated in a training course that introduces FP teachers to the teaching of coding. The training was offered as an online programme, which aimed to introduce teachers to the Unplugged Coding initiative. The researcher attended the workshop and collected data through observation. After the workshop, participants completed a survey. Data was also collected through focus groups. Data collection procedures follow in further detailed in section 3.7.

The research sampled Foundation Phase teachers from schools in KZN, who attended the BOATS unplugged coding training. They gave consent to participate. Section 3.7.1.1 explains more on the population sampling in the research.

This research required primary qualitative data collected from the participants. This data emanated from surveys, focus groups, and observations. Secondary data included document analysis (Barrett & Tywcross, 2018; Jamshed, 2014; Pollock, 2021), allowing the researcher to gather primary feedback. Section 3.7.2 explains the data collection instruments and processes employed.

The chosen method for data analysis was Thematic analysis, as adapted from Denscombe (2010), is detailed in section 3.8. The data was organised by breaking it into smaller pieces and creating a computer database.

The appropriate processes were followed to ensure that the research was done in an ethical manner, according to the University of Pretoria and the Department of Basic Education approval processes.

1.10 DISSERTATION OVERVIEW

The chapter layout is as follows:

Chapter 2: Literature Review

A literature review related to this research are provided. The review follows a narrative that leads to the use of the Assessment of ETPD framework model in the research. The framework is represented within its structural frameworks, TPACK, OL, and PRI.

Chapter 3: Research Methodology

The research methodology is unpacked according to the layers of the research onion (Lewis, Saunders, & Thornhill, 2019). As the layers are peeled, the interpretive research philosophy, the deductive approach to theory development, and the qualitative methodological choice is revealed. The Action Research cycle is also presented as the research strategy, and the adapted model for the research will be unveiled. The longitudinal time horizon, and the data collection and analysis, following the thematic analysis steps, are also presented.

Chapter 4: Results and Findings

The results from the research are presented in the two Action Research cycles in the sequence of the Action Research model adapted for the research. These findings are presented in line with the Assessment of ETPD framework model as guidelines that relate to the aims and research questions, on which the findings and recommendations are based.

Chapter 5: Conclusion and Recommendations

The findings of the research are discussed in relation to the research questions. The limitations of the research are also recognised, as well as the strengths and contributions of the research. In the conclusion, the research's recommendations and suggestions for future studies are offered, based on the findings of the research.

1.11 CHAPTER SUMMARY

This chapter has provided a brief overview of the research, the research context, the problem statement, the rationale, the research questions, the purpose of the research, the literature review, the methodological overview, and summary of the dissertation chapters to come.

The subsequent chapter provides a concise literature review and the frameworks for the research.

2. CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In order to review the literature related to the topic of this research, "Preparing Foundation Phase teachers in KZN to teach coding"; it was necessary to first analyse the composition of the topic itself.

- Preparing: What it is to prepare in the context of teaching?
- Foundation Phase: The South African Basic Education system (Grade 1 to 12) is separated into three phases. These are the Foundation Phase, the Intermediate Phase, the Senior Phase, and the Further Education and Training Phase. What is the Foundation Phase?
- Kwa-Zulu Natal: What are the provincial structures like in the context of the research?
- Teach coding: How is coding taught?

The chapter unfolds in the following manner:

2.2 CODING AND ROBOTICS: A definition of coding, and its delivery as a subject.

2.3 TEACHING CODING: The definition of the subject, how it is and ought to be taught, and the local and international curriculums.

2.4 CODING IN THE FOUNDATION PHASE: The intended coding curriculum in the Foundation Phase in South Africa.

2.5 TEACHER PROFESSIONAL DEVELOPMENT: Once the curriculum was reviewed, its delivery became the topic to be investigated. It was then discovered that preparing teachers to teach coding was a form of professional development.

2.6 THEORETICAL UNDERPINNINGS: A relevant theoretical framework that underpins the focus of the research is represented in a model of Assessment of ETPD for meaningful assessment and reflection (Borthwick & Pierson, 2010).

2.2 CODING AND ROBOTICS

In order to understand what it means to teach coding, as the title of the research presents, some relevant concepts are presented:

2.2.1 Computational Thinking

2.2.2 Coding (and robotics) - Focusing on the teachers, their training and somewhat of their practice. Not on the learners.

2.2.3 The global call for coding (and robotics)

2.2.1 Computational Thinking

Computational thinking (CT) is one of the skills alluded to in discussions on the Fourth Industrial Revolution (4IR) by various researchers (Arek-Bawa & Reddy, 2021; Monyela, 2021; Oh, 2020). The 4IR follows three precursor industrial revolutions. Industrial revolution describes a technology, influencing industry production, taking over the task of one or more technologies, making previous technologies obsolete. The First Industrial Revolution involved technologies running on steam for mass production. The Second was the introduction of technologies running on electricity. The Third was the automation of production using computer technologies and improved communication technologies. The 4IR is the digitalisation and automation of industries. Through digitalisation, systems of production can run without human effort. The 4IR is therefore, blurring the lines between the physical, digital, and biological spheres; expanding at an exponential rate, and impacting almost every, if not all, industries (Eberhard, et al., 2017; Krapež, Meško & Roblek; 2016; World Economic Forum, 2017).

With the 4IR, the world is changing at a rapid rate, and there has been an increasing amount of literature on the need to align society and education to the 4IR. This is because the 4IR presents a new scope of skills needed to keep up with the rapidly digitalised world development, which calls for new skills set. Krapež, Meško, and Roblek (2016); Eberhard, et al. (2017); Kayembe and Nel (2019), and Monyela (2021) all confirm that radical change of education systems to produce learners that contribute to the 4IR ideals, needs strategic approaches that increase creativity and innovation.

Brennan and Resnick (2012), and Allexsaht-Snider and Boz (2021) observe that CT is one skill that can engender creativity and innovation. They also note that coding is linked to self-expression, creativity, and innovation needed by today's students, to transfer computational thinking to machinery. CT is a general problem-solving process that answers to the call for 4IR skills set to increase creativity and innovation. It is a process that, when mastered, grants a learner the ability to develop problem solving strategies. It teaches techniques that assist in the design and use of algorithms in such a way that instructions can be transferred and computed by machinery (Chetty, 2015). CT is based on abstraction (a programming skill to reduce complexity), analysis (a programming skill to check for correctness of code, bugs and vulnerability), automation (a programming skill that transfers code to be accomplished automatically by some system in order to complete a desired task), and modelling (Wing, 2014). *These concepts, upon which* CT *is based, have their relevance revealed in coding, in the curriculum, and in the training course investigated in this research.* Brennan and Resnick (2012), and Haseski, Ilic and Tugtekin (2018) concur with these observations, and consider CT a skill 21st-century individuals should acquire and utilise in solving problems encountered in life. They explain that CT involves three key dimensions:

1. The concepts designers employ as they program. This is *abstraction* as identified by Wing (2014);
2. The practices designers develop as they program. This is *analysis* identified by Wing (2014); and
3. The perspectives designers form about the world around them and about themselves. This is realised through *automation* as identified by Wing (2014).

In addressing the research question, "How can Foundation Phase (FP) teachers in Kwa-Zulu Natal (KZN) be prepared for teaching coding?", the research analysed the meaning of the above three key dimensions in pedagogy, abstraction, analysis, and automation. In this research, the curriculum and a training course that prepares teachers to teach the curriculum were investigated for their impact in the development of the computational thinking skills through coding.

In a quest to define coding, CT has been explained as a skill largely seen as necessary for the 4IR. CT is effectively realised through coding. Coding will be discussed in the following section. In this section, the topic "coding and robotics" is represented as coding (and robotics). This is to flag that this research focuses on the "coding" aspect within this topic.

2.2.2 Coding (and robotics)

Coding is the provision of instructions meant to be so precise that a machine can follow them. These instructions are typically fed into some computing device. Coding is the act of writing a code, where code is "any set of instructions expressed in a programming language" (Mason & Rich, 2019, p. 793). There are many coding languages (Skyla, 2020). They range from block based, "which is a way to introduce coding in a more manageable way" (Skyla, 2020, p. 3) coded using drag-and-drop functions; to text based; coded by typing each line of code.

"Robots are intended to do a job and operate on their own" (Skyla, 2020, p. 4). Robots can also be computer controlled. "Robotics is the use of computer-controlled robots to perform manual tasks" (Quest, 2019, p. 33). Robotics enable learners to build and operate robots; and grow their skills in science, technology, engineering and mathematics (STEM).

Coding instructs robots, and computer-controlled robots follow the coding instructions fed to a computer or computing device driving them (Bicchi, Catalano, Grioli & Lentini, 2020).

Coding and robotics support the development of creativity, critical thinking, design thinking, and digital skills (Brennan & Resnick, 2012; Allexsaht-Snider & Boz, 2021). Brennan and Resnick (2012) and Allexsaht-Snider and Boz (2021) substantiate that coding is linked to self-expression, creativity, and innovation, needed by students to be creators and innovators. As explained by Krapež, Meško, and Roblek (2016), Eberhard, et al. (2017), Kayembe and Nel (2019), and Monyela (2021), strategic approaches to increase creativity and innovation is required by the 4IR.

The research on coding and robotics can be found in the Computer Science (CS) discipline in international curriculums (Angeli C. , et al., 2017). CS includes a number of sub-disciplines, "including software engineering, databases, systems planning, and artificial intelligence" (Eads & Gafner, 2022, p.3). From these sub disciplines, computer scientists solve problems through designing and automating machinery that can think and act like humans, using mathematical models (McGuffee, 2000; Eads & Gafner, 2022).

This research focused on the coding aspect of Coding and Robotics, to determine teachers' preparedness with teaching this aspect. One such strategic approach within an unplugged coding program presented to teachers were investigated.

The value of coding and robotics worldwide can be seen in the global call for skills that promote sustainable development, which is explained in the following section.

2.2.3 The global call for coding (and robotics) explained

In 2012, the United Nations (UN) held a conference known as the UN's Rio+20. The conference committed nations to a new global sustainable development agenda which is aimed at being achieved by the year 2030. There are 17 universal sustainable development goals (SDGs) within the sustainable development agenda (Mthembu & Nhamo, 2021), where sustainable development is development that provides needs that outlive the present. The UN hailed the steps taken by world leaders 70 years earlier, to create the Charter of the UN; and pledged to do better going to 2030, building a better future for all.

SDG 4 aims to ensure quality education that promotes lifelong learning (UN, 2015). Goal 4.4 particularly states that, by 2030, the number of youths with relevant technical and vocational skills should be increased. The relevant skills are identified in the 2019 World Development Report. The report focused on the foundational skills necessary to acquire more advanced skills, and how the nature of work changes because of advances in technology. Three skills types were identified as increasingly important in current and future labour markets, the most notable of which being CT, which brings about advanced cognitive skills, such as complex problem-solving (World Bank, 2019).

One way to fulfil the SDG4 and promote lifelong learning for all, through relevant technical skills in line with current and future labour markets, is to answer the call *for a subject which can teach the youth the required computational thinking skills needed. The clear answer to the global call for such a subject is coding (and robotics) in the FP. The quest that follows is how then such a subject can be taught. The following section offers an explanation.*

2.3 TEACHING CODING

CT is realised through coding (Bicchi, Catalano, Grioli & Lentini, 2020). The previous section covered the global call for teaching coding. This section focuses on how this is addressed through:

2.3.1 identifying the steps that have been taken in heeding the call,
2.3.2 presenting some existing global coding curriculums, and
2.3.3 reviewing the intended South African curriculum.

2.3.1 Heeding the call for coding (and robotics)

Benetti (2012) observes that coding (and robotics) was already being taught in over 35,000 education settings in the United States of America (USA) in 2012, while according to Valenzuela (2021), coding and robotics is implemented across the curriculum in all ages in the USA. Researchers and teachers have underlined the potential of coding (and robotics) lessons to reinforce students' mathematical understanding; explaining that learning coding (and robotics) early, coupled with a more graphic and realistic approach, will see learners writing a piece of code that moves a 3D object. This allows their robots to come to life and solve problems in a visible manner (Al Mahmud et al., 2013; Anderson et al., 2017). In addition to being in-line with the technological advancement of the 4IR, coding (and robotics) offers skills that improve comprehension through engagement. Anderson et al. (2017) further underscore the importance of engagement by explaining that, without engagement, learning hardly occurs. Engagement is defined as behavioural, cognitive, and emotional participation realised through coding (and robotics). Lombardi and Ryu (2015) also see engagement as being central to understanding in education. Huen et al. (2016) opine that graphic input offered by coding can keep children focused on problem solving because of the engagement it fosters.

The Department of Basic Education (DBE) acknowledges that, to solve the problems of development arising from a fast-changing world, it must heed the call for a coding (and robotics) curriculum (DBE, 2021). In working towards solving the problems of development in South Africa a National Planning Commission was appointed to draft the National Development Plan (NDP) in May 2010. Membership consisted of 26 people, selected for their expertise in key areas (Fonteyn & Davie, 2014). The commission identified “South Africa’s achievements and shortcomings since 1994” (Fonteyn & Davie, 2014, p. 12), in order to adopt goals to eliminate income poverty by 2030, as explained by Fonteyn and Davie (2014) and Mthembu & Nhamo (2021). The NDP’s vision for 2030 is summarised in the South African SDG Voluntary review (SDG_ZA, 2019) in the phrase “Our future, make it work” (p. 7), and was adopted in 2012 by the time of the UN’s Rio+20 conference. The NDP prioritises job creation, the elimination of poverty, as well as the reduction of inequality and growing an inclusive economy by 2030.

The NDP consists of fifteen chapters. Chapter 9 of the NDP outlines educational objectives that must be achieved by 2030. The NDP states that the key to overcome the legacy of apartheid is for everyone to have access to quality education.

The DBE’s commitment to the NDP is outlined in the Action Plan to 2024, scripted in August 2020. It is the third five-year plan of its kind. It is a plan in which the DBE attests to government’s commitment to redressing the inequalities of South Africa’s colonial past. It is aligned to government’s NDP, and reflects the DBE’s commitment to the SDGs of the UN as outlined by the DBE’s Action Plan to 2024-Towards the realisation of Schooling by 2030 (2020).

The DBE’s Action Plan to 2024 identifies six priorities, the second of which is immediate implementation of a curriculum with skills and competencies for a changing world. The DBE emphasizes that such a curriculum is characterised by it being based on the Three Stream Model: entrepreneurship education, focus schools, and coding and robotics.

Action Plan 2024 (DBE, 2020) notes that the DBE has taken a number of steps to improve the readiness of learners for the 21st century, and to implement the second of its six priorities by implementing a coding and robotics curriculum.

Turning to the primary level, the DBE completed a preliminary curriculum for coding and robotics for Grades R to 3, and Grade 7 in 2019. The piloting of this curriculum in selected schools began in 2020 (DBE, 2021).

Coding (and robotics) curriculums have been implemented internationally. The next section analyses globally practised coding (and robotics) curriculums.

2.3.2 Globally practiced coding (and robotics) Curriculums

The DBE plans to introduce coding (and robotics) as a subject. In 2009, Alimisis and Kynigos (2009) found that the pedagogy of teaching was still very much in its infancy. It is reported by Hypertext (2021) that the pedagogy is no longer the issue at hand, but rather DBE's ability to provide the support teachers need when teaching coding. As identified by the National Centre for Computing Education and other researchers, there are different emerging teaching approaches that are constantly being tried, tested, and advocated (Mason & Rich, 2019; NCCE. 2022). Strategies such as discussions, collaboration, peer learning, fostering computational thinking skills, and coding away from the computer (unplugged coding) (Wing, 2014; Csizmadia & Sentance, 2015; Allexsaht-Snider & Boz, 2021), are also relied upon.

It must be highlighted that, although the pedagogy of teaching coding (and robotics) is still being tried and tested, teachers should understand the fundamentals of the discipline they teach, and develop various methods of transferring that content to their learners (Teacher Knowledge) (Shulman,1987; Cain, Koehler, & Mishra, 2013). With the technological paradigm shift in the workforce necessitating a shift in education, the teacher knowledge needs redress. According to Cain, Koehler and Mishra (2013), teacher subject knowledge is largely guided by their Pedagogical Content Knowledge (PCK).

The term PCK, coined by Shulman, is a combination of the knowledge of the content to be taught, and how that content is taught. Shulman identifies PCK as one of the seven knowledge bases required by effective teachers (Shulman, 1987). Shulman's (1987) seven knowledge bases are: (1) content knowledge; (2) general pedagogical knowledge; (3) curriculum knowledge; (4) pedagogical content knowledge; (5) knowledge of learners and their characteristics; (6) knowledge of educational contexts; and (7) knowledge of educational ends, purposes, and values, and their philosophical and historical backgrounds.

Different researchers apply these knowledge bases. Parker (2006), however, notes that, because primary school teachers tend to be generalist teachers who teach all subjects, they are unlikely to have in-depth content knowledge of specific (especially Science) subjects; especially with coding content, as it is a new subject. Parker (2006) then opines that general pedagogical knowledge is of more importance than content knowledge for primary school teachers. Tambouris and Tivka (2021) reviewed 15 studies that presented the knowledge base required in computational thinking education. The majority of studies listed programming elements as having the strongest presence from the years 2006 to 2022, and the specific sub-categories of Abstraction, Decomposition, Recognition of Patterns and Algorithms as the most unchanging and requisite topics for teaching computational thinking effectively. A knowledge base of programming is therefore, a guiding factor for globally practiced coding (and robotics) curriculums.

Most researchers agree that PCK and Curriculum Knowledge are fundamental knowledge bases needed for effective teaching (Shulman,1987; Cain, Koehler, & Mishra, 2013). They also recognise that actual in-depth content knowledge may not be realised in primary school, and let alone, in the FP.

The pedagogy of teaching coding (and robotics) is, not only a conundrum for the DBE in South Africa alone, but also an international preoccupation and concern. Many countries (such as Australia, Cyprus, Israel, New Zealand, Poland, United Kingdom and USA) have already integrated part of educational standards for CS in their school curriculums, where pedagogical content of coding would be found (Alexander et al., 2009; Bowcher Owens, et al., 2011; Gal-Ezer & Stephenson, 2014; Angeli et al., 2016; Angeli C. et al., 2017; Bollin, Mischeuz, & Pasterk , 2017).

Alexander et al. (2009) provide a definition of CS taught in these countries, as being the use of computers beyond just simply word processing and web browsing, to the scientific and practical aspects, and the application of computation, as Angeli et al. (2016) observe. It is the research of the algorithmic processing of computers (Angeli C. et al., 2017), which applies to every field in the 21st century (Bowcher Owens et al., 2011).

This basic understanding of CS' importance in the 21st century can be derived from the curriculum offerings of Australia, Cyprus, Israel, New Zealand, Poland, UK and USA. In these countries, CS is a subject that was already included in secondary schooling. As Angeli et al. (2017) observe, the challenge is that of introducing the fundamental concepts of CS to all students, beginning at the elementary school level (FP). Angeli et al. (2016) also warn against the introduction of CS following the same fate as Information and Communication Technology (ICT) (the concept of learning how to use a computer), that was introduced and meant to be integrated with other subjects, with no success. This warning is especially relevant as these observations are visible in ICT Education in South Africa (Gent & Meyer, 2016). The weakness of its offering stems from ICT being introduced as a support model for teaching, and it is aimed at improving learner marks; with its overall value not clearly understood by teachers (Gent & Meyer, 2016). For these reasons, Angeli et al. (2016) advise that CS be a stand-alone subject. Dagiene and Sentance (2016) alternatively explain that there is an increasing focus on computational thinking within the teaching of CS, computing or informatics, and that such a skill cannot be taught in isolation with other subjects. They advocate integration of coding into curriculum through the Bebras challenge held in schools across Europe. This is a kind of Olympiad that incorporates CS concepts into general knowledge questions aligned with learners' developmental levels. Balanskat and Engelhardt (2015) note that, by 2015, nine countries across Europe had already planned to integrate coding in some way at primary level. These were Estonia, France, Spain, Slovakia, UK (England), Belgium (Flanders), Finland, Poland, and Portugal.

In order to sufficiently look at globally practiced coding (and robotics) curriculums, it should be noted that there are a variety of terms used by countries to describe the integration of coding in the curriculum, such as "coding", "programming", "computing", and "computational thinking", "algorithmic applications", "algorithmic problem solving" or "algorithm design and data models", or "algorithmic and robotics" (Balanskat & Engelhardt, 2015). In most cases, the curriculum is still referred to as CS, while in some countries, such as Australia, it is referred to as Digital Technologies. However, it is curricular dealing with CS Education. It is worth noting that, for most countries, digital competence is the main goal to reach at the elementary school level. Digital competence can be understood as the confident use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society (Balanskat & Engelhardt. 2015; Bollin, Mischeuz, & Pasterk, 2017).

In an international research of K-12 CS implementation across Australia, England, Ireland, Italy, Malta, Scotland and the United States; a comparison was done between the CS curriculum requirements (intended curriculum), what teachers identify as enacted in their classroom, and curricular content students used in the classroom (the enacted curriculum). The research also examined the differences between programming languages and CS topics implemented in the seven countries. The research noted that CS curricula in the countries concerned can be classified intro three broad types: those with a state plan for CS in place, those without, and those still in development (Barksdale, et al., 2019). Visual programming, or block-based languages programming is used for countries with CS state plane in place from K-6 (Barksdale, et al., 2019). As depicted in
Figure 2.3-1, England had the highest percentage of actual content intended and taught, compared to intended and enacted curriculum topics related to coding across the countries studied (as seen blocked in
Figure 2.3-1).

Figure 2.3-1 ***Global intended and enacted curriculum***

CS Topics	Australia	England	Ireland	Italy	Malta	Scotland	USA
Algorithms	79%*	100%*	68%*	70%*	33%*	100%*	82%*
Artificial Intelligence	7%	44%	32%	10%	0%	6%	30%*
Computational Thinking	57%*	96%	68%	45%*	17%	89%*	72%
Cybersecurity	71%	83%	16%	35%	17%	72%*	57%*
Data analysis and visualisation	29%*	44%	26%	25%	0%	11%	43%*
Data representation (e.g. digital data, binary)	57%*	88%*	53%*	45%*	33%*	100%	68%*
Databases	14%	71%	42%	45%*	17%*	89%	*27%
Design process (or Design Thinking)	86%*	54%*	58%*	20%*	17%	56%	72%
Ethics	29%*	88%*	58%	35%	0%	56%*	75%
Hardware	26%*	90%	68%*	55%*	50%*	94%*	61%*
Information Systems	50%*	58%	21%	30%*	33%	72%*	35%
Machine Learning	7%	23%	26%	5%	17%	11%	21%
Networks and Digital Systems	64%*	90%	16%	40%	17%*	39%*	45%*
Privacy	64%*	77%	42%	40%	17%*	61%*	64%*
Programming skills and concepts	79%*	100%*	100%*	80%*	50%*	100%*	87%*
Robotics	79%	33%	42%	40%	50%*	11%	47%
Web Systems	36%	62%	37%*	50%*	17%	94%*	38%
Total sample (n)	14	52	19	19	6	18	115

Note. Comparison of intended and enacted curriculum topics across countries. Source: Barksdale, et al. (2019).

England is one of few countries where CS is a compulsory subject in Education. Figure 2.3-1 depicts countries' demographics regarding the offering of CS Education in schools. The CS topics related to this research have been grouped within the red boxes in
Figure 2.3-1.

It is instructive to further present the topics of the English curriculum pertaining to coding in the FP (Key Stage 1 and 2).

Figure 2.3-2 shows the structure of the English national curriculum, in terms of which subjects are compulsory at each key stage, and the recommended age-group for each key stage.

Figure 2.3-2 ***English National Curriculum structure***

	Key stage 1	Key stage 2	Key stage 3	Key stage 4
Age	5 – 7	7 – 11	11 – 14	14 – 16
Year groups	1 – 2	3 – 6	7 – 9	10 – 11
Core subjects				
English	✓	✓	✓	✓
Mathematics	✓	✓	✓	✓
Science	✓	✓	✓	✓
Foundation subjects				
Art and design	✓	✓	✓	
Citizenship			✓	✓
Computing	✓	✓	✓	✓
Design and technology	✓	✓	✓	
Languages[4]		✓	✓	
Geography	✓	✓	✓	
History	✓	✓	✓	
Music	✓	✓	✓	
Physical education	✓	✓	✓	✓

Note. From “National Curriculum”, by DoE England, 2013, http://www.gov.uk/dfe/nationalcurriculum.

In the English National Curriculum, the subject listed as Computing has the outcomes for Key stages 1 and 2 depicted in Figure 2.3-3 and Figure 2.3-4 below. The outcomes have been grouped within the red boxes in the figures below.

Figure 2.3-3 ***Computing Outcomes for Key Stage 1***

Computing

Subject content

Key stage 1

Pupils should be taught to:

- understand what algorithms are; how they are implemented as programs on digital devices; and that programs execute by following precise and unambiguous instructions
- create and debug simple programs
- use logical reasoning to predict the behaviour of simple programs
- use technology purposefully to create, organise, store, manipulate and retrieve digital content
- recognise common uses of information technology beyond school
- use technology safely and respectfully, keeping personal information private; identify where to go for help and support when they have concerns about content or contact on the internet or other online technologies.

Note. Computing Outcomes for Key Stage 1 in the English National Curriculum From “National Curriculum”, by DoE England, 2013, http://www.gov.uk/dfe/nationalcurriculum.

Figure 2.3-4 ***Computing Outcomes for Key Stage 2***

Key stage 2

Pupils should be taught to:

- design, write and debug programs that accomplish specific goals, including controlling or simulating physical systems; solve problems by decomposing them into smaller parts
- use sequence, selection, and repetition in programs; work with variables and various forms of input and output
- use logical reasoning to explain how some simple algorithms work and to detect and correct errors in algorithms and programs
- understand computer networks including the internet; how they can provide multiple services, such as the world wide web; and the opportunities they offer for communication and collaboration
- use search technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content
- select, use and combine a variety of software (including internet services) on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals, including collecting, analysing, evaluating and presenting data and information
- use technology safely, respectfully and responsibly; recognise acceptable/unacceptable behaviour; identify a range of ways to report concerns about content and contact.

Note. Computing Outcomes for Key Stage 2 in the English National Curriculum From "National Curriculum", by DoE England, 2013, http://www.gov.uk/dfe/nationalcurriculum.

As revealed earlier by Tambouris and Tivka (2021), generally, the core topics CS students should master when they complete primary and secondary education are the following:

- Abstraction - ideas for problem solving.
- Decomposition - breaking down a problem to smaller sub-tasks.
- Algorithmic thinking - Thinking in steps towards a solution.
- Programming - Transferring a solution to machine language, or coding.
- Debugging - identifying, then removing or fixing errors.

(Angeli C. et al., 2016; Fowler , Hansen, & Vegas, 2021)

These competencies have all been displayed in the English Computing Curriculum for Key stages 1 and 2 (figure 8 and figure 9 above).

The next section provides an overview of the preliminary coding (and robotics) curriculum proposed in South Africa.

2.3.3 An intended South African coding (and robotics) Curriculum

The preliminary coding (and robotics) curriculum proposed in South Africa was designed for the three phases of schooling; the FP, which is Grades R–3; the Intermediate Phase, which is Grades 4–6; and the Senior Phase, which is Grades 7–9. The phases of the South African schooling system are further explained in section 2.4.1. For most of this section, this research analysed the preliminary Curriculum and Assessment Policy Statement (CAPS) document for Coding and Robotics in FP (Grades R–3) (DOE, 2020).

The preliminary curriculum has five overarching focus content areas or Knowledge strands, namely:

1. Pattern Recognition and Problem Solving
2. Algorithms and Coding
3. Robotics Skills
4. Internet and E-Communication Skills
5. Application Skills

These five content areas have topics that converge and overlap. In instruction, for instance, Pattern Recognition and Problem Solving lend themselves to Algorithms and Coding, and the latter is needed for robotics (DOE, 2020). Thus, the topics all intertwine in actual teaching. Bers et al. (2014) also note such an overlap of content areas in their research on the learning outcomes of a Tangible Robotics program. Bers et al. (2022) also highlight the overlap of coding topics with writing skills, citing significant “overlap between writing skills and programming skills”.

With respect to coding in the FP, only the first two strands below are discussed, as it links to this research:

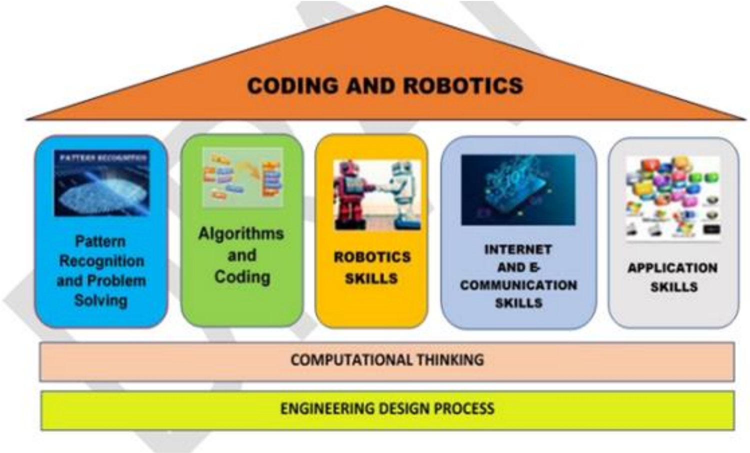
1. Pattern Recognition and Problem Solving
2. Algorithms and Coding

Pattern Recognition and Problem Solving is only found in this phase, where learning to identify abstract and geometric patterns is crucial in reinforcing CT (DOE, 2020). This is done through teaching of the skills of:

- Identification and analysis of regularities in patterns.
- Repetitions and change in patterns, with increases in size and number of physical objects, drawings and symbolic forms.
- Making predictions and solving problems about patterns.
- Description of patterns and relationships using symbolic expressions and grids.
- Recognition of code patterns through the sequences of lines, shapes and objects in the world.

With the "Algorithms and Coding" strand, FP learners are introduced to programming principles using unplugged coding techniques to introduce sequential programming concepts.

Figure 2.3-5 ***Coding and robotics Curriculum Focus and Content Areas***



Note. From "Curriculum and Assessment Policy Statement Grades R-3 ", *DOE,* 2020, p. 13.

The intended preliminary coding (and robotics) curriculum is planned for three phases of schooling. This research focuses on coding in the FP. The context of the FP is presented in the following section in order to provide its informative overview of the intended preliminary coding (and robotics) curriculum.

2.4 CODING IN THE FOUNDATION PHASE

With the acknowledgement of teaching coding in the first schooling year being an international preoccupation (Bollin, Micheuz, & Pasterk, 2017), and the focus being on coding in the FP (Grade R-3) in South Africa; a background into the South African Education Systems' FP is beneficial for understanding the status of coding in South Africa's FP classrooms.

2.4.1 The South African education system and its Foundation Phase

According to the DBE (DBE, 2022), the fields of specialisation for teachers in South Africa are:

- Foundation Phase (±5–9-year-olds), which is Grades R–3.
- Intermediate Phase (±10–12-year-olds), which is Grades 4–6.
- Senior Phase (±13–15-year-olds), which is Grades 7–9.
- Further Education and Training (FET) Phase (±16–18-year-olds) which is Grades 10–12. (Mpofu & Maphalala, 2022).

This research was conducted among FP teachers. Knowing the kind of learners that are in the FP helped put the findings of the research into perspective.

The FP is schooling from Grade R (Receptive year) to Grade 3. Learners in this grade are primarily taught Numeracy and Literacy (a Home Language, and a First Additional Language) and Life skills. The outcomes of the FP are Listening and Speaking, Reading and Phonics, as well as Writing and Handwriting in the English Home Language curriculum (DBE, 2011). The curriculum document indicates that thinking and reasoning are integrated into all these language skills. The Mathematics FP curriculum lists the following skills to be developed in a learner:

- To "develop the correct use of the language of Mathematics".
- To "develop number vocabulary, number concept and calculation and application skills".
- To "learn to listen, communicate, think, reason logically and apply the mathematical knowledge gained".
- To "learn to investigate, analyse, represent and interpret information" (Department of Basic Education, 2011, p. 8).

Among some of the listed research areas in the Life Skills FP curriculum are scientific process skills, technological process skills, and creative skills (Department of Basic Education, 2011).

The National Research Council (NRC) in the United States of America convened workshops on the topic of 21st century skills, in which it recognised five skills as increasingly valuable in modern times globally. These were: adaptability, complex communication skills, non-routine problem-solving skills, self-management/self-development, and systems thinking. These five skills were further summarised into three, namely; cognitive skills, interpersonal skills, and intrapersonal skills (National Research Council (US) Committee, 2011).These skills are in line with the intended FP curriculum subject offerings of Numeracy, Literacy, and Life skills in South Africa.

As mentioned above, the FP is centred around Literacy, Numeracy, and Life Skills. An additional language is introduced in Grade 2 (CAPS, 2010). According to the policy document, the most important learning outcome of the FP is to learn to read. Forty per cent of teaching time in the FP is therefore, allocated to literacy (Long & Zimmerman, 2008). However, Long and Zimmerman (2008) and Govender and Hugo (2020) reveal that, from their participation in international literacy assessments studies such as the Early Grade Reading Assessment (EGRA), the Southern and East African Consortium for Monitoring Educational Quality (SACMEQ), and the Progress in International Reading Literacy Study (PIRLS); one can deduce that South African learners have low levels of literacy in the FP. Long and Zimmerman (2008) say the 2005 PIRLS research particularly noted that the South African Grade 4 and 5 learners achieved the lowest mean performance scores in comparison to Grade 4 learners from 39 other participating countries; where the mean performances were well below the fixed international mean of 500 points. In the 2021 PIRLS research, South African Grade 4 learners still achieved the lowest mean performance scores amongst 57 countries (Fishbein, et al., 2023). They note that this was particularly due to learners not receiving a sound literacy foundation in the FP. South Africa also participated in the electronic version of the Progress in International Reading Literacy Study (ePIRLS) in 2016, and a decline in access to or provision of resources was observed, regarding paper-based reading material, despite the importance of school and classroom libraries in promoting reading literacy skills. Despite that, the results showed no significant improvement (Combrinck & Mtsatse, 2019).

International studies such as Programme for International Student Assessment (PISA) or Trends in International Mathematics and Science Study (TIMSS) have consistently reported low performance of South African learners in mathematics (Kotze & van de Berg, 2019). Researchers have noted that such low performance is in contradiction with the assumption that countries with above average national wealth have better educational success. This is because South African learners continuously score lower than learners from countries with a lower gross domestic product, on international panels of assessment (Hanushek & Woessmann, 2015; Fritz et al., 2020).

Bartholomew, Love and Yauney (2022) found that computational thinking at early age can help improve literacy, and mathematics. Understanding the context of the average FP learner's literacy and mathematical development presents a sound reason for the introduction of coding in the FP.

Introduction of coding in the FP requires teachers who can teach coding in the FP. The next section explores the idea of how these teachers can be attained.

2.4.2 Teaching coding in the Foundation Phase

It must also be noted that, with the introduction of a Coding and Robotics curriculum, it is essential to facilitate teachers' preparedness to implement it. Paramount to the problems and development challenges arising from the fast-changing world, is the professional development (PD) of teachers in Educational Robotics (Anwar, Bascou, & Menekse, 2019). Confidence in the offering of Coding and Robotics is something teachers who will teach the subject should have.

Parker (2006) reminds us that primary school teachers tend to be generalist teachers, who are unlikely to have in-depth content knowledge, especially of science subjects. Ingersoll (1999) advises that, for proper educational reform to occur, education departments should avoid having teachers teach subjects for which they have little education or training in. However, Williams, Williams and Kendal (2020) understand that this may not be possible, as qualified Information Technology (IT) or CS teachers would unlikely choose to continue in the education field, given the lucrative IT careers that exist outside of teaching. Rather, more rigorous PD programmes are needed for current teachers, that either run weekly or for months on end.

This is explored in the research, as there is a visible the gap in effective and rigorous PD programs for teachers in implementing coding and robotics. The research aimed to find out if such a gap can be filled with the FP teachers that schools have. How can these FP teachers be prepared to teach computational thinking through coding?

2.5 TEACHER PROFESSIONAL DEVELOPMENT

In observing the gap in effective and rigorous PD programmes for teachers in implementing Coding and Robotics, it became clear that PD has to be defined. This section will endeavour to:

2.5.1 define professional development.

2.5.2 explain how the South African Council of Educators (SACE) enacts professional development of teachers.

2.5.1 Professional Development

Kong and Wong (2017) point that teacher are the drivers of all successful education endeavours, hence, the need for PD. *This research investigated how to prepare FP teachers in KZN to teach computational thinking through coding, subsequent to attending PD in an online coding training workshop*. For the purpose of this chapter, PD is a variety of developmental models of knowledge and skills “being acquired by passing through developmental stages such as novice, competent, and expert” (Dall'Alba & Sandberg, 2006, p. 383). Preparing teachers to teach coding has “fixed sequences of stages representing successively higher levels of knowledge and skills acquisition” (Dall'Alba & Sandberg, 2006, p. 385). These stages, observed as rather competencies by Kong and Wong (2017) are: (1) to understand the concept of computational thinking, (2) to have relevant PCK and C, (3) to have the ability to overcome non-cognitive factors such as lack of confidence or anxiety in teaching coding, and (4) having a school culture that allows the PD to be a long-lived experience.

Several studies show that PD and the preparation of teachers is an entire genre of courses, seminars, and workshops (Deacon, 2010; Bos, 2011; Govender, 2018). These are programmes usually designed for serving teachers, providing continuing education to keep current skills, and providing training on new initiatives. Bain, et al. (2019) state that most of these PD courses are usually run over a relatively short period of time. They also add that participation in formal research programmes, informal consultations with colleagues, and research should also be considered as PD. Recent studies note that PD can be done through distance learning, to accommodate the high workloads of professionals, and cut down on travel time to venues, among others (Blau, Hadad, Leykin, & Shamir-Inbal, 2021).

2.5.2 SACE enacts Professional Development

The DBE (Grade 1-12) in South Africa has left the task of defining worthy PD activities and their preparation to the South African Council for Educators (SACE). SACE is a council tasked with upholding the SACE Act no 31 of 2000, that provides registration for teachers, promotes their PD, and regulates their ethical and professional standards (South African Government, 2000).

SACE promotes the continuing PD of teachers (SACE, Vision And Mission, n.d.). SACE has outlined a PD policy framework. The policy framework focuses on two sub-systems; the initial professional education of teachers (formal tertiary PD), and continuing PD of currently serving teachers, called Continuing Professional Teacher Development (CPTD) (Mosoge & Taunyane, 2009). SACE CPTD is used to track PD points earned by teachers in a three-year cycle. PD points are awarded to teachers' profile for PD attended that meets their developmental needs (Steyn, 2008). The framework identifies four types of activities as PD activities under CPTD. These are school, employer, qualification-driven activities, and activities provided by approved organisations (Steyn, 2008).

SACE introduced a formalised structure of CPTD to ensure professional conduct by teachers. According to the National Policy Framework, amongst some of the aims of the CPTD, is to enable and empower teachers by improving their professional confidence and their learning area/subject knowledge, and to assist them in identifying suitable PD programmes that may contribute to their professional growth, and protect them from corrupt continuous PD (CPD) providers. The formal CPTD programme stipulates those teachers and principal are required to accumulate a minimum number of points from accredited CPD providers over a period of time, and upload the relevant documentation onto their CPTD profiles (Botha, 2019). In addition, currently available courses on the CPTD website (SACE, 2022) range from 1 day to weeks of attendance; on both face-to-face and online platforms.

The efficacy of PD and factors that might assist with the preparation of teachers to teach coding, guided the research's theoretical underpinnings discussed in the following section.

2.6 THEORETICAL UNDERPINNINGS

The discussion in this section focuses on Pierson and Borthwick's model for meaningful assessment and reflection (Borthwick & Pierson, 2010). The Technological Pedagogical Content Knowledge (TPACK) framework is embedded in this framework. A framework of the individual and organisational learner, as well as a framework of participant research and enquiry informs the TPACK framework in the model. The purpose of the Borthwick and Pierson model is to explain the assessment of Education Technical Professional Development (ETPD) through the collaboration of three frameworks (Borthwick & Pierson, 2010).

2.6.1 Overview of Borthwick and Pierson's model

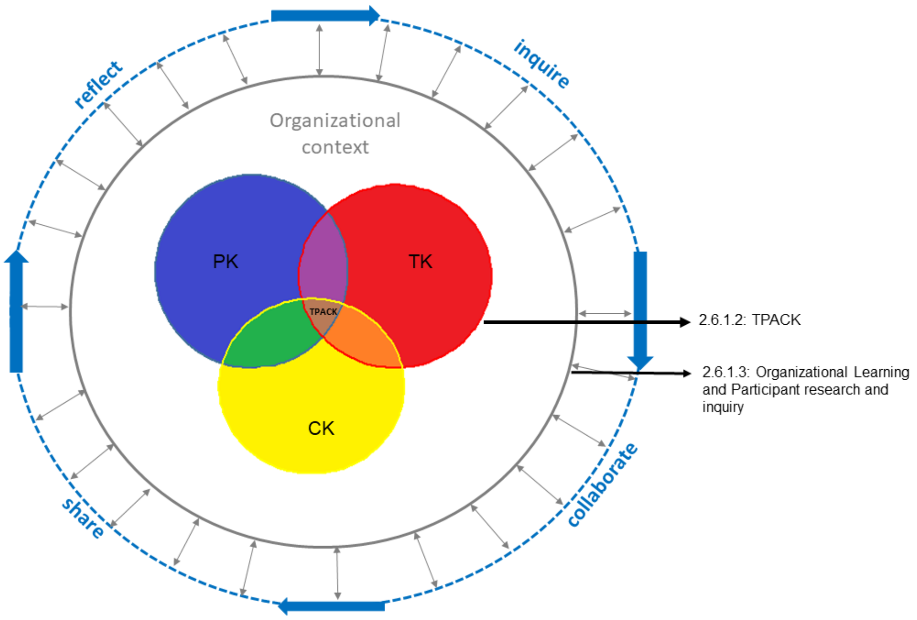
When defining 'Preparing' according to the TPACK Framework, it is evident that teachers' knowledge of pedagogical, and technological knowledge is not a natural process (Dall'Alba & Sandberg, 2006; Bos, 2011; Kong & Wong, 2017; Govender, 2018). Bers, Seddighin and Sullivan (2013) even mention that most early childhood development (ECD) teachers need knowledge and understanding about pedagogical approaches of Technology and Engineering in their classrooms. Deacon (2010) says teachers should try to develop the knowledge required for optimising technology within a given subject. A model presented by Borthwick and Pierson (2010) represents preparing teachers in Technological Pedagogical Content. Below is the Assessment of ETPD model.

Figure 2.6-1 ***Assessment of ETPD model***

Note. Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed TPACK model. Pierson and Borthwick's model for meaningful assessment and reflection. From "Framing the assessment of educational technology professional development in a culture of learning", Borthwick. A & Pierson. M, 2010, *Journal of Digital Learning in Teacher Education, 26(4)*, p. 130.

To fully understand the Pierson and Borthwick's model for meaningful assessment and reflection in Figure 2.6-1 above, and its relevance for preparing teachers to teach coding as a form of PD, how it was preferred as the theoretical framework of this research must first be explained. In this research, the model has been adapted in Figure 2.6-2 and is referred to as the Assessment of ETPD model.

Figure 2.6-2 ***Assessment of ETPD model*** **adapted for this research**



Note. Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed TPACK model. Pierson and Borthwick's model for meaningful assessment and reflection. Adapted From "Framing the assessment of educational technology professional development in a culture of learning", Borthwick. A & Pierson. M, 2010, *Journal of Digital Learning in Teacher Education, 26(4)*, p. 130.

2.6.1.1 Theoretical Framework: The Assessment of ETPD's model

There are theoretical concepts that informed the design of this research. These are the Technological Pedagogical Content Knowledge framework (TPACK), the Organisational Learning (OL) theory, and the Participant Research and Inquiry (PRI).

The TPACK Framework informs this research, which aims to describe the meaningful use of technology in teaching and learning (Bell & Bull, 2009; Fisser et al., 2015). The OL Theory focuses on the creation and use of knowledge within an organisation, by transferring individual learning to that of an organisation through people interacting and solving a problem (Wang & Ahmed, 2003). Brindley et al. (2019), like Bain et al. (2019), note that research can contribute to practitioners' thinking. This framework suggests that research practitioners, through their research and involvement of teachers, can invoke organisational learning through teachers' reflection on matters concerning the research. The PRI informs this research, as the teachers play a critical role as participant researchers, by reflecting on crucial instructional strategies (Borthwick & Pierson, 2010).

A combination of the three above-mentioned theoretical concepts resulted in a theoretical model for meaningful assessment of the effectiveness of Educational Technology Professional Development (ETPD) (Borthwick & Pierson, 2010), which Borthwick and Pierson (2010) term "The Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed TPACK model".

The three theoretical constructs (TPACK, OL, and PRI) are described in the context of this research. The Assessment of ETPD as a culture of learning, based on a contextually-situated and inquiry-framed TPACK model, is presented as the Theoretical Framework for this research.

Figure 2.6-2 above describes the three theoretical constructs (TPACK), Organizational Learning, and Participant research and inquiry.

2.6.1.2 TPACK

The TPACK framework is at the centre of the Assessment of ETPD model (Figure 2.6-2)

2.6.1.2.1 The Framework

Koehler and Mishra (2005) define the TPACK Framework as "a complex interaction of three bodies of knowledge: content, pedagogy, and technology" (Matthew & Mishra, 2009). Fisser et al. (2015) expand on this definition by offering three different views of the TPACK Framework.

1) First, is that the TPACK, according to Shulman (1987), is the integration of pedagogical use of technology as described as Pedagogical Content Knowledge (PCK).
2) Second, TPACK is described as understanding each of the three bodies separately, and the interaction of these "three bodies of knowledge: content, pedagogy, and technology" (Koehler & Mishra, 2005).
3) Third, is that TPACK is viewed as one body, and developed as a whole.

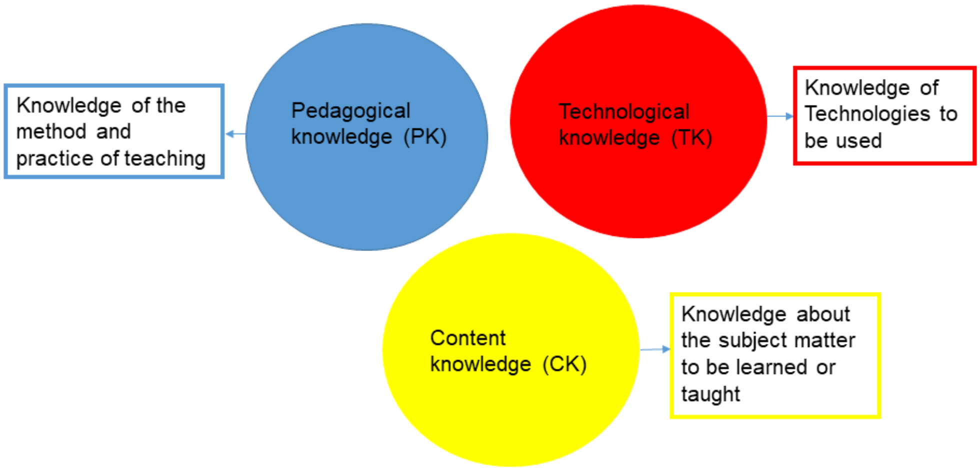
Koehler and Mishra (2005) built the TPACK framework on the foundation laid by Shulman (1987), and describe PCK (described in section 2.3.2) as a combination of the knowledge of the content to be taught, as well as how to teach that content. Bull and Bell (2009) describe PCK as a connection of important features of pedagogical practice with specific content areas.

In their TPACK framework, Koehler and Mishra (2005) underscore the importance of knowledge of the effective use of technology in the teaching process. They further point that it should, not merely be the introduction of technology, but also, its contextual use by teachers in the classroom. Technology needs to be viewed as a knowledge system related to the content, users, and practices in a classroom. They "proposed a framework describing teachers' understanding of the complex interplay between technology, content, and pedagogy" (Koehler & Mishra, 2005, p. 3).

Analysis of different works (Koehler & Mishra, 2005; Bell & Bull, 2009; Cain, Matthew & Mishra, 2009; Koehler, & Mishra, 2013; Fisser et al., 2015) shows that there are three main components of teachers' knowledge; content, pedagogy, and technology. They interact as three bodies of knowledge known as PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge). These three bodies of knowledge must be understood as separate entities. Improvements in each of the three main components of teachers' knowledge suggests an improvement in each interaction (body of knowledge), and subsequently, an effective implementation or improvement in the implementation of the TPACK.

These three bodies of knowledge are represented in Figure 2.6-3 and Figure 2.6-4**.**

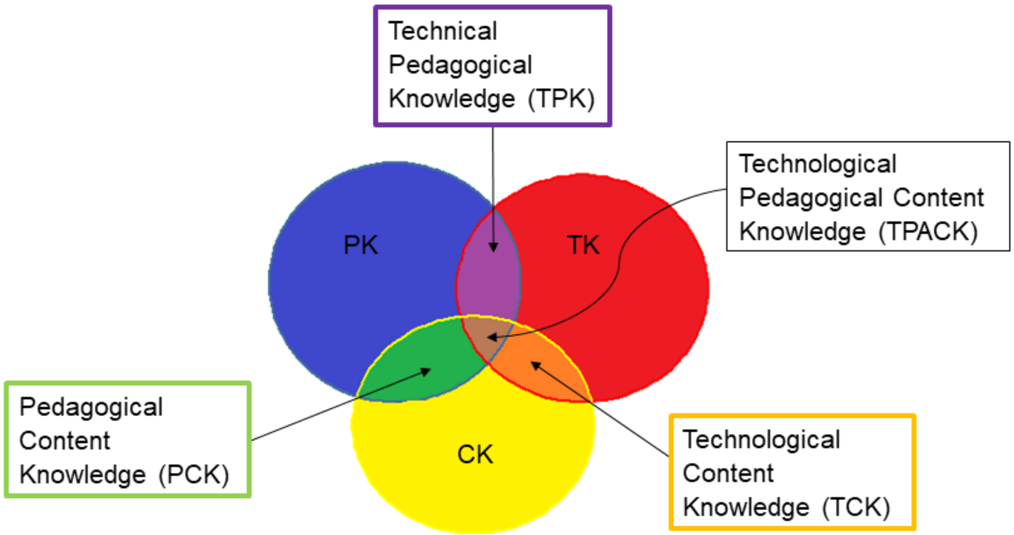
Figure 2.6-3 ***The three Bodies of Knowledge of the TPACK Framework***



Note. Adapted from "What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge", by M. Koehler & P. Mishra, 2005, *Journal of Educational Computing Research, 32(2)*, p. 133.

The TPACK Framework suggest that when the three bodies of knowledge interact, it is only then that true integration of technology occurs.

Figure 2.6-4 ***The TPACK Framework illustrated***



Note. Adapted from "What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge", by M. Koehler & P. Mishra, 2005, *Journal of Educational Computing Research, 32(2)*, p. 133.

Considering Pedagogy and Content together, the result is Pedagogical Content Knowledge. Koehler and Mishra (2005) explain that this is similar to Shulman's (1986) idea of knowledge of pedagogy applicable to the teaching of specific content. Considering Technology and Content together, the result is Technological Content Knowledge. The authors explain that this describes the teachers' knowledge of how a subject matter is transformed by the application of technology. Considering Technology and Pedagogy together, the result is Technological Pedagogical Knowledge. The authors explain that this describes the knowledge of how technology can support pedagogical goals. Koehler and Mishra (2005) explain that when considering all three elements together (T, P, and C), the result is Technological Pedagogical Content Knowledge (TPCK), which is true technology integration.

2.6.1.2.2 The Conceptual Framework of the TPACK

The TPACK framework was utilised as a conceptual framework for this research as illustrated in Figure 2.6-5.

The Pedagogy knowledge (PK) in this research, is the method and practice of teaching, comprises the teaching strategies and theories implemented in the training of teachers, and is proposed for teaching learners in the FP.

The Technology knowledge (TK) in this research, describes the technologies utilised during the training and teaching, such as the online environment for virtual training, as well as the app/s utilised in the process.

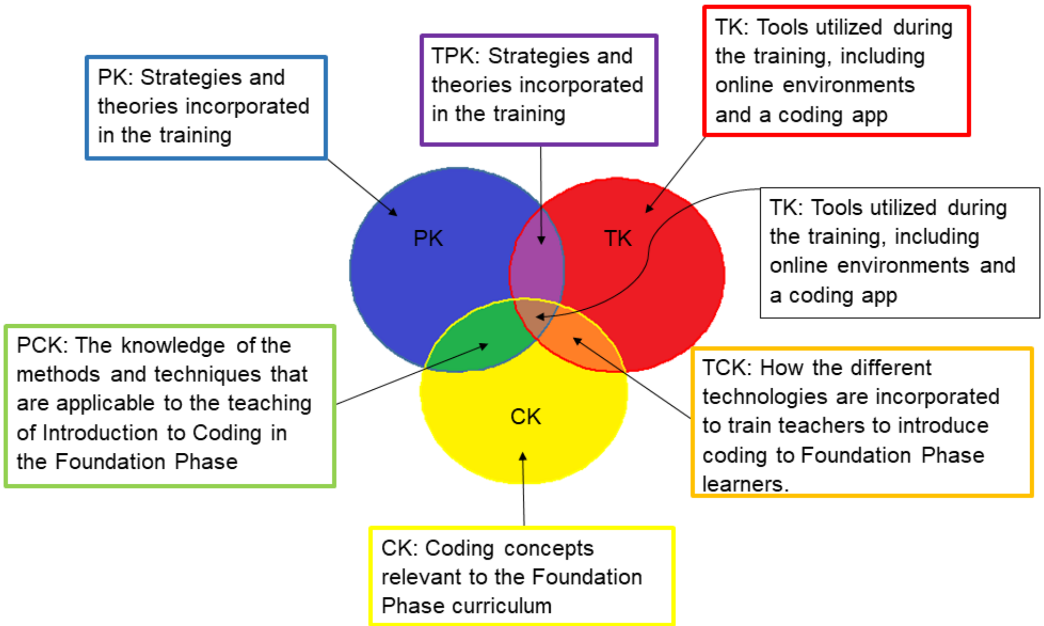
The Content knowledge (CK) in this research, is the coding content included in the curriculum for the Foundation Phase learners.

The Pedagogy Content Knowledge (PCK) investigated questions related to how coding is introduced, and how learning outcomes of the coding component in Foundation Phase are achieved in the Coding and Robotics curriculum.

The Technology Pedagogy Knowledge (TPK) focused on how relevant technology can be utilised to train the teachers to teach the learners.

The Technology Content Knowledge (TCK) investigated which technology worked best to train the teachers the specific coding content.
The integration of all these aspects was investigated in the **TPACK integration** of the intervention during the teacher training, as well as when applied in the FP classrooms.

Figure 2.6-5 ***The TPACK Framework illustrated and conceptualized***

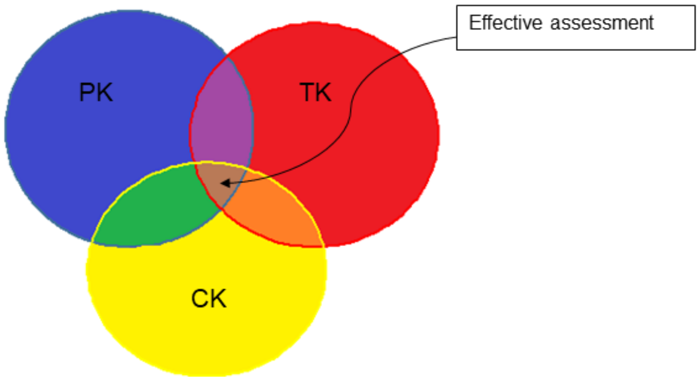


2.6.1.2.3 The TPACK in the Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed TPACK model

Pierson and Borthwick (2010) suggest that, just as the infusion of content, pedagogy, and technology represent effective technology-integrated teaching through the TPACK framework model, it logically follows that effective assessment, as represented in Figure 2.6-6, is found at the same intersection. Assessment in this framework should not be confused with assessments such as tests given to learners to test content, but is rather evaluation of teachers (Borthwick & Pierson, 2010). According to the authors, assessment is an integral and inseparable part of the curriculum development and teaching process. For a teaching process to occur effectively, assessment of what is taught needs to occur constantly, “one leading to the next and cycling back again” (Borthwick & Pierson, 2010, p. 127).

For effective technology integration to occur, assessment of that technology integration should be the goal of educational technology PD. Such educational technology PD is deemed as effective technology only when "enhancing teachers' content knowledge and pedagogical content knowledge" (Guskey & Yoon, 2009, p. 497).

Figure 2.6-6 ***Effective assessment in the TPACK model***



Note. Effective assessment is at the centre of the TPACK model. Adapted from "Framing the assessment of educational technology PD in a culture of learning", Borthwick. A & Pierson. M, 2010, *Journal of Digital Learning in Teacher Education, 26(4)*, p. 128.

2.6.1.3 Organisational Learning and Participant Research and Inquiry

The outer layer in the Assessment of ETPD model (Figure 2.6-2) focuses on organizational learning.

2.6.1.3.1 The Framework

"Organisational learning (OL) is a term introduced in the 1970s by Chris Argyris and Donald Schön" (Hariharan & Vivekanand, 2017, p. 1) to describe a process involved in transfer of learning from individual level to that of an organisation (Really Learning, 2013). This, as Boreham and Morgan (2004) suggest, means that the workplace can be a place of learning. Simon (1991) says there are two ways in which learning can occur in the workplace; (1) learning from the members as they develop themselves, or (2) learning from new members who can bring in new knowledge.

Hariharan and Vivekanand (2017) explain that there is no theory or model of OL that is commonly recognised. They note that each research approaches OL from a different perspective which creates divergence. Most divergence with the OL Theory is that there is no specific explanation on how the organisation will learn from its members. Should it be informal as suggested by Cole et al. (1998), or should it be formalised as suggested by Fuller and Unwin (1992). Basten and Haamann (2018) also note that, just because an individual has attained some learning, does not mean the organisation will actually learn, unless it makes accommodations for the learning to systematically occur. Because of that, to refer to OL perspectives, they use the term “theory to indicate what organizations should master for effective OL” (Basten & Haamann, 2018, p. 4).

Various recommendations are suggested on implementing a process of organisational learning (Kolb, 1984; Senge, 1990; DiBella, Gould, & Nevis, 1995; Konno & Nonaka, 1998; Leavitt, 2011; Valamis, 2022). The spiral of organisational knowledge creation suggested by Konno and Nonaka (1998), has points that describe the spiral shape of OL. First, is Socialisation, which is communicating with others to gain knowledge; second, is Externalisation, which is the sharing of what has been learnt with others; third, is Combination, which requires structurally grouping members in an organisation to master common knowledge relevant to them; fourth and last, is Internalization, which is converting that knowledge to tactical knowledge relevant to the organisation.

Leavitt (2011) explains three OL theories.
(1) Experiential Learning Theory, suggested by Kolb (1984) in Leavitt (2011), explain stages of experience as fundamental process for OL. The stages are summarised into two. These are those that represent the grasping component (concrete experience and abstract conceptualisation), and the experience component (reflective observation and active experimentation).
(2) Adaptive and Generative Learning Theory inspired by Peter Senge (1990) in Leavitt (2011), which lists the five traits required for OL to occur. These are personal mastery, building shared vision, team learning, and systems thinking.
(3) Assimilation Theory by DiBella, Goulds and Nevis (1995) in Leavitt (2011), which believes OL will occur in the three stages of acquiring knowledge, sharing knowledge, and using that knowledge.

OL is proving to be an important, yet untapped resource in organisations, as there are constantly new innovations to foster it. Valamis (2022), an end-to-end-user learning software, offers a platform for OL to occur, allowing organisation members to communicate with, and learn from each other.

It can be deduced, as Ellefson, Frank, and Zhao (2006) advocate that "schools should develop a culture" (p. 173), because at the centre of successful OL is the culture of learning in an organisation. This is especially relevant when schools are trying out new technologies to allow for success.

Borthwick and Pierson (2010) suggest that evaluation of ETPD effectiveness must include an assessment of the setting in which that PD is occurring. This will determine the ways in which PD can be scaled up in that organisation and other organisations.

Participant research and inquiry (PRI) allows teachers to have a variety of ways in which they look at their practice, for the purpose of evaluation and feedback as a form of PD (Linn, 2006; Borthwick & Pierson, 2010). When teachers do so, they are, as researchers, constantly asking questions about their teaching; collecting and analysing multiple forms of data, and collaborating with one another to inform future teaching plans.
"Promoting lifelong learning means enabling students to monitor the cohesiveness of their ideas and their progress in understanding. When students are prompted to reflect, they analyse their progress" (Linn, 2006, p. 47). In other words, the approach of participant research and inquiry to the evaluation of PD allows for teachers to gain lifelong learning.

2.6.1.3.2 The Conceptual Frameworks

In this research, individual learning is transferred to OL, as teachers create a culture of engaging with the technical, pedagogical and content knowledge of coding, after taking part in the training workshop, and engaging with the researcher.

Engagement through data collection is done by the researcher and other teachers. It happens through the researcher asking questions about their experience in learning the teaching content (inquire), coupled with their experience in teaching (sharing); collecting and analysing multiple forms of data (reflecting), and collaborating with one another to inform future teaching plans in the implementation of the coding curriculum (collaborating).

2.6.1.3.3 The TPACK in the Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed Organisational Learning model

In their model, Borthwick and Pierson (2010) illustrate that individual and OL occur over and over again, as teachers and their research partners engage in the Action Research process within the organisational context. That allows for Assessment of ETPD as a culture of learning.

Borthwick and Pierson propose extending the TPACK model, to become a guide for effective assessment of ETPD, supported by a frame of context and PRI, presented in the phases of Reflection, Inquiry, Collaboration, and Sharing.

The effectiveness of ETPD can therefore, be attained as a result of constant individual and OL occurring from effective technology-enhanced teaching. PRI promotes a culture of lifelong learning as a result of Educational Technology PD.

2.6.2 Preparing through Professional Development Summarised

In line with the Framework presented in section 2.6.2, the TPACK in the Assessment of ETPD as a culture of learning based on a contextually-situated and inquiry-framed TPACK model; Martin's (2015) conclusion that "Reflection and evaluation is an inseparable component of ongoing teacher action and growth" (p. 22) confirms that meaningful Assessment of ETPD attests to the preparedness of teachers to implement the knowledge taught in that PD.

Looking at the model again (Figure 2.6-2), this deduction can adequately explained for the purpose of this research. At the core of preparing, is the initial professional education of teachers, as explained by the National Policy Framework. In the case of this research, the core of preparing, which is the is the initial professional education of teachers, is the BOATS unplugged coding training. The TPACK framework is the model used for the initial PD, within the organisational context. The organisational context can expand through individual and organisational learning from the PD (the area with the arrows the figure). Individual and organisational learning is a result of collaborating, sharing, reflecting, and inquiring about the said PD to inform future teaching, and to form lifelong learning and create an organisational culture informed by that PD. With respect to the research, the culture would be that of being effectively prepared to teach coding.

It can be concluded that, in line with the National Policy Framework, and with the guidance of the TPACK Framework; “preparing”, in the context of this research, describes undergoing an online course, hosted by an expert well-versed in the subject matter, and being engaged in this research. That is a form of collaboration, sharing, inquiry, and reflection meant to influence individual and organisational learning.

2.7 CHAPTER SUMMARY

This chapter provided a detailed introduction into the literature review of readings related to this research, a definition of CT, coding, and robotics; and the global call for coding. The teaching of coding heeded the call for coding, globally practiced coding (and robotics) curriculums, and an intended South African Coding (and Robotics) curriculum. Coding in the FP described the South African education system and its FP, and teaching coding in the FP. Teacher PD described PD, and how SACE enacts PD. The theoretical underpinnings provided an overview of Borthwick and Pierson’s Assessment of ETPD model. A summary of preparing through PD concluded the chapter. The subsequent chapter will provide the research methodology.

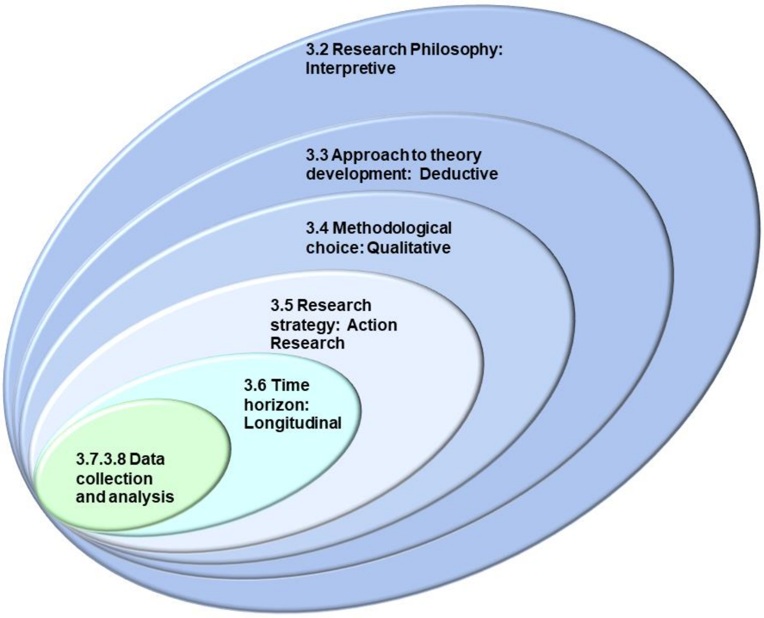
3. CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter 2 reviewed the major theoretical work that pertains to the aim of this research, which is to discover how Foundation Phase (FP) teachers in Kwa-Zulu Natal (KZN) can be prepared for teaching coding. It also outlined the gap present in current research on professional development (PD) programmes for teachers to effectively implementing coding (and robotics) in teaching and learning. Ultimately, the research aimed to find out if such a gap can be addressed with the FP teachers. That addressed the research question: How can FP teachers in KZN be prepared for teaching coding?

This chapter presents the research methodology, structured according to the proposed layout of the Research Onion (Lewis, Saunders, & Thornhill, 2019), in terms of main research decisions taken. This guides discussions from the most abstract research decisions pertaining to the research philosophy layer, to the most practical decisions pertaining to the data collection processes. The structure as well as the specific paragraphs of the respective layers is illustrated in Figure 3.1-1.

Figure 3.1-1 ***Research Onion model for the research***



Note. The structure of the chapter is in line with the Research Onion model illustrating the stages informing the data collection choice and analysis for this research. Adapted From *Research Methods for Business Students* (8th ed., p. 124), by P. Lewis, M. Saunders, A. Thornhill, 2019.

The research philosophy is discussed in section 3.2. In this section, the interpretive paradigm and its beliefs and assumptions about the researchers' development of knowledge are outlined.
The approach to theory development is discussed in section 3.3. In the section, it is clear that by researching literature and collecting data, the researcher arrived at conclusions and recommendations for the research questions, following the deductive approach to theory development.
The methodological choice is discussed in section 3.4. In this section, the qualitative methodological choice is outlined.
The research strategy is discussed in section 3.5. In this section, it is demonstrated how the research followed an Action Research to address the research question.
The time horizon is discussed in section 3.6. This section explains how the research occurred over a longitudinal time frame.
Section 3.7 presents research participants, population and sampling, as well as the data collection instruments.

In section 3.8, the chapter presents the data analysis process, criteria relating to the research quality in 3.9, and an explanation on the ethical considerations in 3.10. The chapter is summarised in section 3.11.

3.2 RESEARCH PHILOSOPHY: Interpretivist

This research is situated in the interpretive paradigm. Interpretive research subscribes to the idea that a set of criteria should be determined and applied in a qualitative way. Research in a scientific discipline such as Information Systems (IS), is classified as interpretive if it is focused on understanding the complexity of making sense of human experience as the situation unfolds (Klein & Myers, 1999).

In this research, the teachers' experiences of training to teach coding to FP learners was investigated and interpreted on the basis of their experience (Bhattacherjee, 2012). In Interpretive research, the researcher is a mediator between the participants and the research, with the responsibility to interpret the educators' experiences on the hand of the research design. Interpretation is applied in an appropriate manner for interpretive research to be trustworthy.

Hermeneutics was used in order to interpret the participants reflections. Hermeneutics, is the art of interpretation. It refers to the theory and practice of interpretation, where interpretation involves an understanding that can be justified (Bingham, 2010; Dyer, 2010). The researcher incorporated the seven hermeneutic principles proposed by Klein and Meyers (1999) to ensure that the interpretation was a true reflection of the participants' experiences. The seven hermeneutic principles are briefly outlined in Table 3.2-1 below. The seven hermeneutic principles are further outlined in the section 3.9 on trustworthiness, where examples of their application in this research are illustrated.

Table 3.2-1 ***The Summary of the 7 Principles for Interpretive Field Research***

1	**The Fundamental Principle of the Hermeneutic circle** This principle suggests that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. This principle of Human understanding is fundamental to all other principles.
2	**The Principle of Contextualisation** The principle requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.
3	**The Principle of Interaction Between the Researchers and the Subjects** The principle requires critical reflection on how the research materials (or "data") were socially constructed through the interaction between the researchers and participants.
4	**The Principle of Abstraction and Generalisation** The principle requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action. It is important that theoretical abstractions and generalisations should be carefully related to the field research details as they were experiences and/or collected by the researcher. This is so readers can follow how the researcher arrived at his or her theoretical insights.
5	**The Principle of Dialogical Reasoning** The principle requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tell") with subsequent cycles of revision
6	**The Principle of Multiple Interpretations** The principle requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under research. This is similar to multiple witness accounts even if all tell it as they saw it.
7	**The Principle of Suspicion** The principle requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants.

Note: From "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems", by H.Klein & M.Myers, 1999, *MIS Quartely, 23(1),* p. 72.

3.3 APPROACH TO THEORY DEVELOPMENT: Deductive

An inductive approach to theory development is commonly defined as a method of reasoning that moves from bottom up.
A deductive approach to theory development is commonly defined as a method of reasoning that moves from the general to the specific or particular; or reasoning that tests a theory through research (Daellenbach & Woiceshyn. 2018; Lewis, Saunders, & Thornhill. 2019). Kenneth (2000) further explains that "inductive reasoning is a theory building process" (p.83) while "deductive reasoning is a theory testing process" (p.83). Harriman (as cited in Daellenbach & Woiceshy, 2018) clarifies that inductive and deductive reasoning complement each other. Inductive reasoning was necessary to develop theories, and deductive reasoning logically came after, to test those theories. Harriman argues that the two should not be viewed as opposites, but rather as complementary.

The approach to theory development in this research was done in a deductive manner. The research moved from premises implied by the assessment of Educational Technology Professional Development (ETPD) framework (section 2.6) to detail in the research. The research moved from a set of theory-derived premises (Lewis, Saunders, & Thornhill, 2019) about what the framework and literature says teachers require to be able to teach coding.

The research used specific scenarios, with data gathered from the online focus group. The research also used a combination of logical thinking and observations with experiential information (Herrity, 2023) to present a conclusion generalisable for this research.

3.4 METHODOLOGICAL CHOICE: Qualitative

The methodological choice for this research, was qualitative. Qualitative research involves gathering data through an iterative process of understanding and interpreting the viewpoints and experiences of people and analysing the data in which they express their viewpoints (Klein & Myers, 1999; Bloomberg & Volpe, 2019; Aspers & Corte, 2021). It is interpretive in nature and a naturalistic approach to the world. Aspers and Corte (2021) indicate that as qualitative research aims at understanding people in a given environment, at a given context in time; there can be no clear description of features of qualitative research. Bloomberg and Volpe (2019) advise that, in qualitative research, the researcher finds answers in observations, surveys, interviews with participants, photos, and even find recommendations of questions regarding the research that has not occurred to the researcher.

Almeida, Faria, and Querios (2017) say that “qualitative research is therefore, concerned with aspects of reality that cannot be quantified” (p. 370) but can be summarised. Aspers and Corte (2021) argue that, maybe for the lack of a better definition, qualitative research is research that is just not quantitative. Qualitative research, as Bloomberg and Volpe (2019) observe, is in contrast with quantitative research, where the researcher seeks to quantify known answers. Qualitative research seeks to address a phenomenon.

This research investigated the preparedness of teachers to teach coding, after attending the BOATS unplugged coding training (see section 1.2), which the researcher also attended. In Chapter 2, it was explained that, to prepare is to engage meaningfully in some form of PD. The purpose of the workshop, presented by an expert well-versed in the subject matter, was to support the preparation of teachers. Teacher preparedness was investigated on the ETDP framework. The ETDP framework equates preparedness in the context of this research with undergoing an online course, where a form of collaboration, sharing, inquiry, and reflection to influence individual and organizational learning must occur. This research did not necessarily aim to test, in a quantifiable fashion, the preparedness of teachers, but rather to hear and analyze their views on it, prior and post the training workshop.

The use of the qualitative approach enabled the researcher to gather sufficient information from the participants. Merriam and Grenier (2019) identifies qualitative research by the fact that it places the researcher at the centre of the data-gathering phase, and asserts that the researcher is the instrument by which data becomes information. In this research, the researcher gathered all the necessary data, examined the available documents containing guidelines for implementing the

Coding and Robotics curriculum in the Foundation Phase, as well as interacted with all parties concerned.

3.4.1 Strengths of qualitative research

Qualitative research offers extensive understanding of the subject of research (Bloomberg & Volpe, 2019). Almeida, Faria, and Querios (2017) and Klenke (2018) list that, among the strengths of qualitative research, is its non-concern for numerical representativity, but for the depth of understanding of a research problem. This research was concerned with in-depth understanding of the preparedness of teachers to teach coding in the FP. It was concerned with the opinions of participants on their preparedness. The research did not seek numerical representation to determine participants' preparedness to teach coding in the FP.

Almeida, Faria, and Querios (2017) further indicate that the sample size in qualitative research, should not be of the same importance as in quantitative research where large sample sizes are necessary for statistical analyses. This research worked with a rather small sample size. The research aimed to work with FP teachers who had attended the training workshop, and had views on the development or lack of development in their preparedness to teach coding in the FP. This is explained further in the sampling section, 3.7.1.2.

Boddy (2016) adds that qualitative research is also flexible, as the researcher can employ different techniques at different stages in the research, which are also interchangeable in order to gather a more in-depth insight to address the topic researched. It is also of note that in qualitative research, data is collected in a naturalistic setting, and is based on the participants' interpretation as well (Rubbin, 2007). The flexibility of qualitative research was prevalent in this research, because of the iterative nature of qualitative research, and the different techniques employed at different stages. This was further accommodated by the research strategy dealt with in section 3.5. Upon analysing data at each stage, the researcher employed a different technique and gathered further data until the responses revealed more in-depth views. The researcher first employed the technique of observation, then survey, then focus group. This was all in an attempt to gather in-depth insight.

3.4.2 Weaknesses of qualitative research

Boddy (2016) and Rubbin (2007) explain that the very same characteristics of qualitative research that speak to its strengths, also speak to its weaknesses. The minimal sample size of qualitative research has been associated with it not being generalisable. In order to mitigate this weakness in this research, the initial participants sampled from the beginning of the research represented the variations of school demographics in KZN. The variations of school demographics mean the schools displayed varying properties as identified by the Assessment of ETPD framework. The three schools had varying, infrastructure and resources, which indicated different levels of Technological Pedagogical Content Knowledge (TPACK) development. The organisational involvement structured as explained by the Organisational Learning (OL) Theory in literature, varied in the three schools. Participation and inquiry structures as put forth by Participant Research and Inquiry (PRI) varied in the three schools (see section 2.5). Therefore, having incorporated participants from different school demographics in KZN mitigated the weakness usually observed in qualitative research's minimal sample size not being generalisable.

As qualitative research requires the interpretation by the researcher and interpretation of events by participants, it becomes prone to bias (Rubbin, 2007). Rubbin (2007) also warns that qualitative research allows for bias during sample selection or data collection stages. This research attempted to mitigate such a weakness by random sample selection, as the research was open to all FP teachers who had attended the training workshop (Berk, 1983 in Readingcraze, 2019). In the data collection stages, bias was minimised by constructing survey questions that did not lead to instrument bias (Readingcraze, 2019). The survey instrument and the focus group also worked as an instrument, allowing for multiple data collection methods for the same observations (Readingcraze, 2019). Bias was also precautioned because the researcher is an Information Technology teacher, who has been teaching coding in the form of text-based programming for nine years. The researcher therefore had her own assumptions of how coding is introduced and these assumptions created expectations of the training workshop. Having multiple data collection methods, such as the survey instrument completed by the participants, as well as focus group discussion; assisted in eliminating bias from the researcher that would have occurred during the observations by the researcher. The focus group, as advised by Lasch et al. (2010) and Onwuegbuzie et al. (2010) (in Fusch and Ness, 2015), was “small enough for all members to talk and share their thoughts, and yet large enough to create a diverse group” (p.1410). This was also in order to avoid bias by having a platform of diverse interpretations. Therefore, the weaknesses of qualitative research in this research are acknowledged. The techniques of addressing these discrepancies are addressed further in this chapter.

3.5 RESEARCH STRATEGY: Action Research

3.5.1 Introduction

This research followed an Action Research (AR) strategy. AR “in its most simple form, has its roots in the question ‘How can I improve my practice’. It implies a range of sub-questions from ‘Why should I improve?’ to ‘What does improvement mean?’ and ‘Where does my practice and possible changes reside in a policy, theoretical and ideological framework?’” (McAteer, 2013, p. 8). Messikh (2020) explains that Action Research was first termed by Kurt Lewin in 1946; and McAteer (2013), shares the same sentiments as Lewin (Messikh, 2020) in that research and taking action should be synonymous, or rather as McAteer (2013) plainly puts it AR is aimed at improving practice. AR is proposed as a suitable research strategy for this research to address the challenges teachers face with regard to the teaching of computational thinking (CT) in coding and robotics in the current rapidly evolving educational environment (as discussed in the Problem Statement in section 1.3). Cohen, Manion, and Morrison (2007) praise AR as a powerful tool for change. This research aimed to develop guiding principles for teacher preparation for teaching coding in the FP.

McAteer (2013) explains that an AR should have a practice-based approach, incorporate and build on critical reflection on practice, be driven by a desire to improve practice, and contribute to the development of professional practice.
AR was incorporated into this research in that it

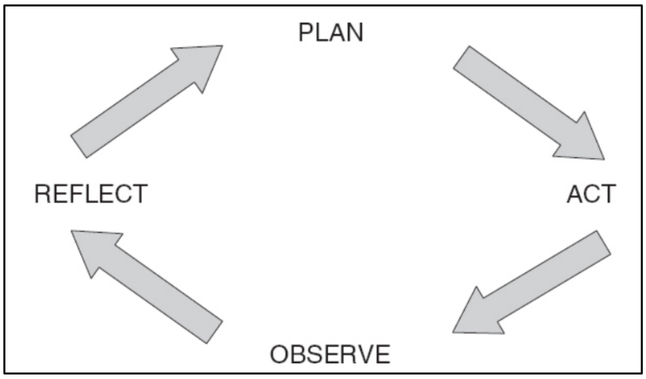
- **Had a practice-based approach** as the participants were actively involved in engaging with the training and teaching of computational thinking through coding throughout the research timeline. The researcher endeavoured to elicit the guiding principles for teacher preparation for teaching coding.

- **Incorporated and built on critical reflection of practice** as the researcher observed and reflected on the training itself, as well as participants' experiences and implementation of the training in their teaching. Bloomberg and Volpe (2019) explain that this is a testament of AR creating a democratic inquiry process between the researcher and the participants. Bergmark (2022) calls AR a collaboration impacting change through reflection. The researcher also incorporated the reflections of the participants in the guidelines, to help redefine the guidelines for teaching computational thinking.
- **Was driven by a desire to improve (personal) practice** and to improve technological education for the researcher and teachers in general. Bloomberg (2019) and Cohen, Manion and Morrison (2007) credit AR with promoting actual change by combining research and practice for the researcher, and positively affecting practice, procedure, system or environment for the teachers.
- **Can contribute to the development of professional knowledge** through the development of guiding principles that can strengthen the development of professional knowledge of teachers on how to introduce coding in the FP.

3.5.2 Action Research model

The AR model that was employed for this research was the 'Plan, Act, Observe, and Reflect' process, as proposed by McAteer (2013) and illustrated in Figure 3.5-1.

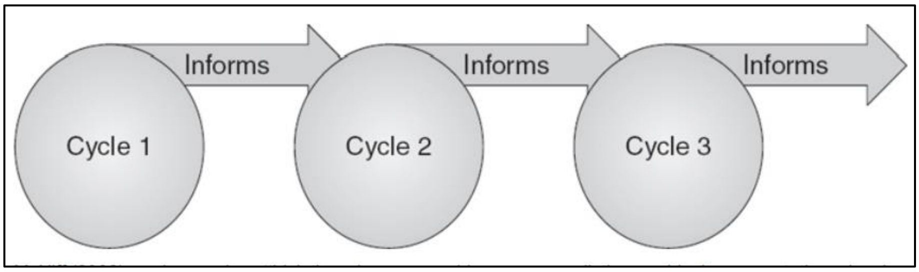
Figure 3.5-1 ***The Action Research cycle***



Note. From *Action Research in Education* (p. 29), by McAteer, 2013.

Figure 3.5-2 illustrates the flow between the cycles in a typical AR design (McAteer, 2013) with three cycles. The reflection of cycle one informs the planning of cycle two. The reflection of cycle two informs the planning of cycle three, and so on.

Figure 3.5-2 ***The Action Research process***



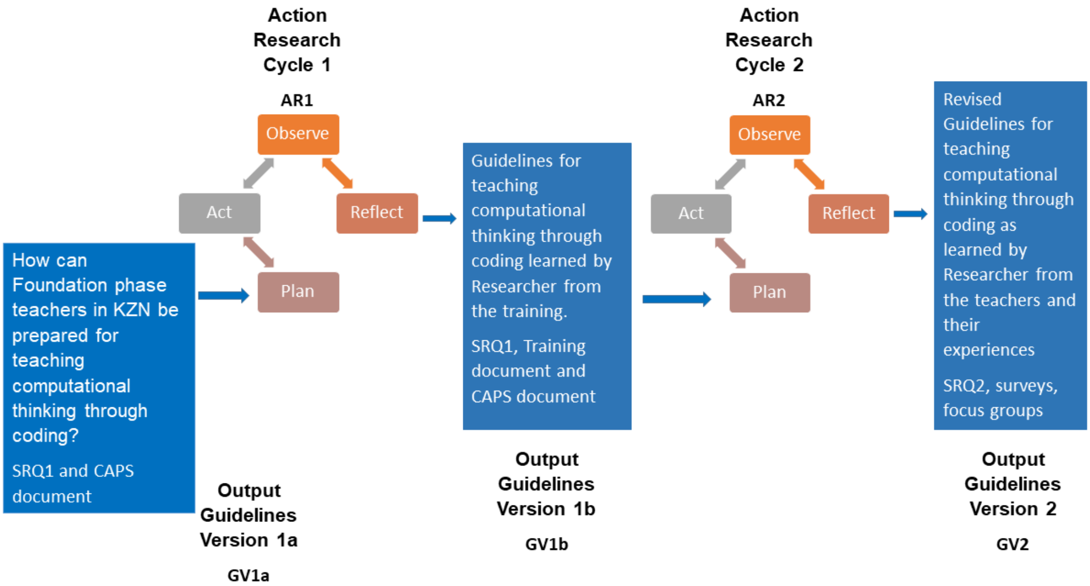
Note. From *Action Research in Education* (p. 30), by McAteer, 2013.

This research implemented two AR cycles, as illustrated in Figure 3.5-3 below. The next section explains how the AR process was implemented. To reiterate the phases of the AR cycle in the instances of their implementation, the words 'Plan, Act, Observe, and Reflect' have been italicised.

Before the first cycle, in the first cycle, and in the second cycle, the focused sub-researched question, the processes that occurred, and the output guidelines that resulted, are highlighted for emphasis.

Figure 3.5-3 illustrates the AR cycle adapted for this research

Figure 3.5-3 ***The Action Research cycle adapted for this research***



Note. Adapted from *Action Research in Education*, by McAteer, 2013.

3.5.2.1 Preparation

The researcher prepared for the first cycle by clarifying the problem statement and the focus of the research (section 1.2, 1.3, and 1.4)

Before the first cycle the researcher identified the set of theory-derived guidelines from the Assessment of ETPD framework through a literature review (Chapter 2).

These included the TPACK skills needed to teach computational thinking as embodied in coding. The process of implementing OL by transferring individual learning to that of an organisation in order to foster how FP teachers can be prepared to teach coding. PRI, as the variety of ways in which teachers play a critical role as participant researchers by helping to identify crucial instructional strategies that FP teachers identify for being prepared to teach coding.

Focus SRQ1: Which skills should teachers be prepared for to teach computational thinking through coding?

Before the first cycle the researcher also sought to do a document analysis (section 1.11.2) for the proposed coding curriculum in order to have a foundation of the focus of the research (*plan).* the researcher identified possible training guidelines that addressed the TPACK, OL and PRI through the document analysis (act*).*

Output: Guidelines Version 1a

3.5.2.2 Action Research cycle 1: Teacher training analysis

Focus SRQ1: Which skills should teachers be prepared for, to teach CT through coding?

During the first cycle the researcher identified possible training guidelines that addressed the TPACK through the BOAT training course 1 design and rollout as she attended the training with the teachers, as a teacher (*act*). During this training, the researcher *observed* the training process and the interaction of the TPACK on an observation instrument. She also analysed the training course material. During this process the researcher continuously *reflected* on the current guideline (Version 1a) and emerging guidelines, and revised set of guidelines.

Output: Guidelines Version 1b

3.5.2.3 Action Research cycle 2: Teacher reflections

Focus SRQ2 How do teachers' preparedness change during training?

The second cycle focused on the experiences and views of teachers on their preparedness to teach coding prior to and after the training; and the insights from emerging guidelines.

Firstly, the data collection process was designed to ensure that through surveys and focus group sessions, the researcher can collect relevant data to refine the guidelines further *(plan).* Data was collected and the results analysed *(act and observe).* The last phase included a reflection on the process and all the results to refine the final set of guidelines.

Output: Guidelines Version 2

For most Action Researchers in educational settings, emphasis is on the development of practice (McAteer, 2013). This brings emphasis to the Reflection phase of the AR cycle as the informative part of the cycle that advises on the improvement of practice.

The methodology of the above AR cycles is elaborated further in the data collection section 3.7.3, to illustrate how the data was collected in each cycle.

3.6 TIME HORIZON: Longitudinal

The time horizon for this research is longitudinal. "Longitudinal studies collect data repeatedly from the same subjects over time, often focusing on a smaller group of individuals that are connected by a common trait" (Thomas, 2020, para. 3). Cook and Ware (1983), and Jansen (2020) both agree that longitudinal research is research where data for the same research focus is collected more than once from the same individuals or variables over time.

In this research, data was collected through document analysis, observations, and surveys, and then through focus groups. Longitudinal research is to assess how (and why) things change over time. This research assessed how teachers can be prepared to teach coding, as a result of change occasioned by 5 weeks of attending the training workshop.

Jansen (2020) reminds us that there is no set amount of time required for longitudinal research, as long as the participants are repeatedly observed. They can range from as short as a few weeks to as long as several decades. In the case of this research, the participants were observed during the training and during the focus group sessions. The course material used was also observed.

3.7 DATA COLLECTION

As explained in section 1.2, the Coding Unplugged initiative was launched by the Nelson Mandela University. The BOATS training course on coding was an initiative launched by the Nelson Mandela University. The training was developed by one of the teachers who attended the Coding Unplugged workshops. The training was developed in the form of a series of coding lesson plans that can be used for FP learners.

The lessons, available on Kelly Bruton - YouTube, had been planned to be offered at School A (a school in which four of the participants work) in August 2021, but due to Covid 19 restrictions, it ended up being offered as an online programme. Though the training course was hosted online, teachers who had attended were tracked and surveyed.

The survey instrument was first sent via email to all the FP teachers based in KZN who had attended the BOATS training course. Non-respondents were then tracked telephonically. The researcher also undertook a face-to-face approach to get the remaining non-respondents to take part in the survey.

3.7.1 Research participants

This research focused on a training course that introduces FP teachers to teaching coding through unplugged coding (without the use of a computer) and offline coding (without the need of internet access) as explained in section 1.2. Alexander, Bell, Freeman and Grimley (2009) explain that by providing relatively free resources for Computer Science (CS) teaching, unplugged coding has helped to somewhat remedy the problem of student decline in CS facing many countries.

3.7.1.1 Population

In this research, population refers to FP teachers employed in schools in South Africa who attended the BOATS training. The BOATS Coding Unplugged initiative was open to any FP teacher who was interested in the preparation for teaching coding. The course had 104 teachers registered to attend.

3.7.1.2 Sampling

Bhardwa (2019) defines a sample as a group of people, objects, or items that are taken from a large population for more manageable investigations.

The schools in the Durban area in KZN that participated in the online course were within close proximity of the researcher. The teachers from these schools were the only teachers who attended the course in this area. In maintaining confidentiality, the teachers, along with their schools, were assigned codes in the data collection. The three schools were assigned the codes A, B, and C. There were four teachers from school A, one teacher from school B, and one teacher from school C. All the participants were FP teachers.

When sampling is done, it is for either representative or exploratory reasons (Steinmetz, Toepoel, & Vehovar, 2016; Denscombe, 2017; Etikan & Iliyasu, 2021). Denscombe (2017) reports that representative samples are associated with large samples used in quantitative research. A representative sample will have variables from all sectors of a population, which is called a cross-section of the population. Exploratory samples are often used in small-scale research as a way of probing unexplored topics, or to discover new ideas or theories. Exploratory samples are usually used as data for qualitative research.

The sampling in this research was done for exploratory reasons. The sample was small-scale as the research aimed at exploring the unexplored gap on effective and rigorous PD programmes for teachers on implementing Coding and Robotics.

How the sample is selected can be either through probability or non-probability sampling. Probability sampling involves randomisation to select data for the sample. Non-probability sampling is purposeful sampling that generally takes in judgment (Etikan & Iliyasu, 2021). According to Steinmetz, Toepoel, and Vehovar (2016), there are various ways of choosing participants for non-probability sampling. Among them is:

- Purposive/ judgemental sampling: sampling that follows the judgement or purpose of the researcher to satisfy some criteria.
- Convenience sampling: Also referred as accidental, availability, haphazard, or unrestricted sampling. The sample is made up of the units at hand.

The sample in this research was selected in a manner of non-probability sampling. The type of non-probability sampling used was that of purposive and convenience sampling. The participants were chosen by their ability to contribute towards answering the research question, being FP teachers who attended the BOATS training course on coding.

Klenke (2018) notes that, even though it is inappropriate to estimate sample size quantities for qualitative research, the importance of sample size in qualitative research is not totally irrelevant. However, the guiding principle should be the concept of saturation. Boddy (2016) explains the concept of data saturation as the point at which no new information or themes are observed in the data when conducting further data extraction from more participants. In fact, Boddy (2016) says saturation can be reached so long as at least two participants have been employed in qualitative research.

“This idea of sampling until data saturation is reached can be used as a justification for the use of a particular sample size in any qualitative research which is guided by this idea” (Boddy, 2016).

The researcher employed goal-directed or theoretical sampling. The researcher intentionally selected participants who could contribute in-depth understanding of the problem under investigation (Klenke, 2018).

In this research, the participants were from three schools. In order to have referential understanding of each participant in the upcoming chapters, it is explained how The research derived to the codes assigned to each participant.
The schools were assigned the codes A, B, C. The teachers were assigned the codes 1, 2, and 3, and so on in data collection. Assigning of codes was done randomly. The teachers were assigned codes as follows:

Table 3.7-1 ***Participants***

School A		**School B**		**School C**	
Teacher 1	1A	Teacher 1	1B	Teacher 1	1C
Teacher 2	2A				
Teacher 3	3A				
Teacher 4	4A				

The sample was an exploratory sample as the research is a small-scale research, based on FP schools in KZN. It is assumed that training courses are sufficient to equip teachers with the skills needed for PD, and that their effectiveness relies on improving their delivery, timeframe, and support (Hunzicker, 2011; Tate, 2009). In fact, some researchers have found that the mean scores of knowledges between the groups of teachers who attend a course and those who do not was not significantly different (Azhar et al., 2011). It is noted though, that attendence of a course was effective in promoting attitude change of teachers towards a subject matter (Azhar et al., 2011). Upon their return from courses, teachers are assumed capable enough on their own to implement the PD undergone.

The research employed non-probability sampling of FP teachers in KZN who had attended the BOATS training course on coding. For the same reason, sampling was purposive and convenience, as the participants had to satisfy the criteria of being FP teachers from KZN, who had attended the training course.

3.7.2 Data collection instruments

Qualitative data collection instruments include a vast selection (Adosi, 2020). Denscombe (2017) sees qualitative data collection instruments as yielding primarily textual data. Mertens (2018) notes that data collection instruments are of such a large spectrum that the researcher is often referred to as a data instrument as well. Nonetheless, their content must be appropriate enough to answer the research question. They must also be in-line with the theoretical framework chosen for the research.

As was explained earlier (section 3.9.2), the qualitative researcher is expected to draw upon at least two sources of evidence to attain triangulation through convergence and corroboration of results (Bowen, 2009).

This research required primary qualitative data collected from the participants and secondary data in the form of document analysis. The participant data was collected through observations, surveys, and focus groups. Since the research followed an AR strategy with two cycles; there was document data collection prior to the first cycle. There was observation and survey data collection in the first cycle. There was focus group data collection in the second cycle. After each cycle, a version of guidelines for teaching coding, was designed.

3.7.2.1 Document

The Department of Basic Education's (DBE) draft Curriculum and Assessment Policy Statement (CAPS) curriculum document on Coding and Robotics were analysed as part of the development of the first set of guidelines on preparing teachers to teach CT through coding. This emanates from the themes presented in the draft curriculum, before the first AR cycle**.** This document is the Coding and Robotics draft CAPS document from Grade R-3 (DBE, 2021).

When using policy documents as a research instrument, Karppinen and Moe (2012) advise that the researcher looks at both what lies behind it and within it. Policy documents as a research instrument particularly lend themselves to being employed as a method in qualitative research.

3.7.2.2 Observations

As explained at the beginning of the section (3.7), due to Covid-19, the BOATS training course on coding was hosted as an online course. The planned observations were conducted on the online course that was also attended by the researcher. Deng and Benckendorff (2017) observe that, even though surveys, interviews, and log files were among the most used forms of data collection in articles that researched the effectiveness of Massive Open Online Courses (MOOCs- which are online platforms for education delivery), observations were also noted as used for data collection. Chen and Chen (2015) add that complementing observations with face-to-face interaction can also deepen understanding of phenomenon. Barrett and Tywcross (2018) add that, in qualitative research, participant and non-participant observation allow researchers to gather more in-depth verbal and non-verbal data of communication.

Lesson plans were used as the main resources to guide the training during the course. These lesson plans were thus, used in the observation process. The instrument used and adapted for this research during this observation was the

Technology Integration Assessment Instrument (TIAI) constructed by Grandgenett, Harris, and Hofer (2010).

The TIAI rubric was constructed to "assess the quality of TPACK-based technology integration" by teachers (Grandgenett, Harris, & Hofer, 2010, p. 4). The rubric was meant to assess detailed lesson plan documents, but as Grandgenett, Harris, and Hofer (2010) recognise, practicing teachers typically do not write detailed lesson plans, but supplement the detailed information with other resources describing the lesson plan. This proved to be maximumly useful.

Figure 3.7-1 which follows, shows the TIAI rubric as constructed by Grandgenett, Harris, and Hofer (2010), and adapted as the observation instrument for the research.

There are four criteria to consider in the TIAI rubric:

1. Curriculum Goals and Technologies
2. Instructional Strategies and Technologies
3. Technology Selection(s)
4. Fit

The scoring of the TIAI (Grandgenett, Harris, & Hofer, 2010) ranged from 1 to 4, 1 being the lowest score, and 4 being the highest.

In this research, the scoring range was excellent, proficient, adequate, and unsatisfactory. The following discussion expands on the application of the four criteria in the TIAI. In order to attain a score, the guidelines listed under the bullet-points in each criterion were subscribed to. Each criterion is described, followed by an explanation of how it was evaluated in the research. The guidelines listed under the bullet-points in each criterion expands on the levels, by offering a few examples of results to illustrate an example of the research's application of the TIAI.

As noted in section 1.7, this research was not to evaluate this course itself. The scoring criterion was used as a guide for the comment criterion that was added to the TIAI as an adaptation for the research. This was done in order to provide a supported observation by the researcher. That observation summarised in the comment criteria is what was used for the data analysis section (chapter 4).

- Curriculum Goals and Technologies: This criterion determined if the "technologies selected for use in the instructional plan are strongly aligned with one or more curriculum goals". In this research, the technologies selected in the use of the course training lesson were examined, as well as the BOATS lesson plans. It was assessed if training course lesson, as well as the BOATS lesson plans met the following aspect: If these technologies were in-line with the Coding and Robotics curriculum goals for the outcomes aligned with that lesson, thereby supporting the skills needed to teach computational thinking as encompassed in coding.
- Instructional Strategies and Technologies: This criterion determined if the "technology use optimally supports instructional strategies". In this research, the technologies selected in the use of the course training lesson were examined, as well as the BOATS lesson plans to determine if the in fact supported the instructional strategies. It was assessed if course training lesson, as well as the BOATS lesson plans, met the following aspect: If the technologies selected were in-line with the Coding and Robotics curriculum goals for the outcomes aligned with that lesson, thereby supporting the instructional strategies needed to teach computational thinking as encompassed in coding.
- Technology Selection(s): This criterion determined if the "technology selection(s) were exemplary, given curriculum goal(s) and instructional strategies" identified.
- Fit: This criterion determined if the "content, instructional strategies and technology fit together strongly within the instructional plan".

The scoring levels were determined as follows:

- Excellent: Meeting the aspect in both the BOATS online training lesson, as well as the BOATS lesson plan. The Curriculum Goals and Technologies, Instructional Strategies and Technologies, Technology Selection(s), or Fit; in both the BOATS online training lesson as well as the BOATS lesson plans, were in-line with the coding (and robotics) curriculum goals for the outcomes aligned with that lesson. They also supported the skills needed to teach computational thinking through coding. They exceeded expectations as they supported the teachers in the training and resources to teach the curriculum goals using the technology.

- Proficient: Meeting the aspect in the BOATS online training lesson only. The Curriculum Goals and Technologies, Instructional Strategies and Technologies, Technology Selection(s), or Fit in only the BOATS online training lesson were in-line with the coding (and robotics) curriculum goals for the outcomes aligned with that lesson. They also supported the skills needed to teach computational thinking through coding, although it is recognised that the criterion was not aligned to the BOATS lesson plan. The teacher would have to improve the alignment between the lesson plan and the Coding and Robotics curriculum goals themselves. They would do so having proficient knowledge on how to do so from the BOATS online training lesson.
- Adequate: Meeting aspect in the BOATS lesson plan only. The Curriculum Goals and Technologies, Instructional Strategies and Technologies, Technology Selection(s), or Fit in only the course training lesson plan, were in-line with the coding (and robotics) curriculum goals for the outcomes aligned with that lesson. They also supported the skills needed to teach computational thinking as through coding. However, it is recognised that the aspect was not aligned with the BOATS online training lesson. The teacher would have to improve on how to teach computational thinking as encompassed in coding, in line with that BOATS lesson plan. The teacher would have access to adequate knowledge through the lesson plan, but would have to discern and train themselves on how to implement the teaching of the BOATS lesson plan.
- Unsatisfactory: Not meeting the aspect in both the BOATS online training lesson, as well as the BOATS lesson plan. The Curriculum Goals and Technologies, Instructional Strategies and Technologies, Technology Selection(s), or Fit in both the BOATS online training

lesson as well as the BOATS lesson plan, were not in-line with the coding (and robotics) curriculum goals for the outcomes aligned with that lesson. They also did not support the skills needed to teach computational thinking through coding.

- A comments section was also added after each criterion (see Figure 3.7-1), to allow the researcher to note down notable observations in the BOATS online training lesson presentation and the BOATS lesson plans. That observation, summarised in the comment criterion, is what was used for the data analysis section (chapter 4).

Figure 3.7-1 ***The observation instrument***

Observation Instrument:

The Technology Integration Assessment Instrument (TIAI) is a rubric that can be used to assess technology integration in a lesson plan. The TIAI explores seven dimensions of planning with specific attention to levels of technology integration (Harris, Grandgenett, & Hofer, 2010).

Observations must earn a minimum score of "adequate" on all indicators

Lesson:________________________ Date:_________________________

		EXCELLENT Exceeds Expectations	PROFICIENT Meets Expectations	ADEQUATE Partially Meets Expectations	UNSATISFACTORY Fails to Meet Expectations
Curriculum Goals & Technologies (Curriculum-based technology use)	use of technology the skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan strongly supports the skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan supports the skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan partially supports the skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan do not support the skills needed to teach computational thinking through coding.
	Comments:				

Instructional Strategies & Technologies (Using technology in teaching/ learning)	Use of offline coding technology and Boats app supports instructional strategies needed to teach computational thinking through coding.	Technology use intentionally makes it easier to understand concepts/ideas that wouldn't be possible without this technology.	Technology use intentionally makes it easier to understand concepts/ideas.	Technology use incidentally makes it easier to understand concepts/ideas.	Technology use provides limited/ no opportunities to understand concepts/ideas.
	Comments:				
	Use of offline coding technology and Boats app supports learning	Students/ teachers use technology to engage in discovery learning.	Students/ teachers use technology to extend their learning.	Students/ teachers use technology to apply prior learning.	Students/ teachers passively receive information.
	Comments:				

Technology Selection(s) (Compatibility with curriculum goals & instructional strategies)	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are exemplary.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are appropriate, but not exemplary.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are marginally appropriate.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are inappropriate.
	Comments:				
"Fit" (Content, pedagogy and technology together)		Content, instructional strategies and technology fit together strongly within the instructional plan.	Content, instructional strategies and technology fit together within the instructional plan.	Content, instructional strategies and technology fit together somewhat within the instructional plan.	Content, instructional strategies and technology do not fit together within the instructional plan.

	Comments:

Adapted from (Harris, Grandgenett, & Hofer, 2010) and (Ohio Wesleyan University, 2020)

Score:____________________

Sign:____________________

Note. The Technology Integration Assessment Instrument (TIAI) Observation instrument used for this research. Adapted from" Testing a TPACK-Based Technology Integration Assessment Rubric", by Grandgenett, Harris, & Hofer, 2010.

Assessment of the TPACK through the TIAI addressed the core of the ETPD conceptual framework (section 2.6.1.2).

3.7.2.3 Survey

A common characteristic of qualitative data collection, as some researchers (Jamshed, 2014; Pollock, 2021) agree, is through surveys with participants. A survey is a "general term used to describe the collection of information, but is often used interchangeably with questionnaire" as defined by Hammer (2017). A questionnaire is a list of focused questions, which is very similar to a survey, as survey questions have some degree of focus as well.

Traditionally, surveys were collected either through face-to-face interviews or through mail questionnaire. The internet has allowed for a cost and time efficient way to administer surveys. It has become the most popular method to date (Dillman, 2000; Couper, 2000; de Leeuw, 2005;). It is of note that, though surveys administered over the internet may be cost and time effective, they also have limitations such as non-coverage for participants without access to the internet, and non-response. Mixed-mode surveys are then of popular interest, as they help in the reduction of nonresponse error (de Leeuw, 2005). De Leeuw explains that an example of a mixed-mode survey is one where a mail survey would be the initial survey, with follow-up telephone interviews for non-respondents, followed by face-to-face interviews for a sub-sample of the remaining nonrespondents.

The survey instrument was structured in the following manner (see Figure 3.7-2):

Figure 3.7-2 ***The survey instrument***

Survey Instrument:

Domain	Question
TK	TK1 How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions? TK2 How confident are you in integrating offline coding app/s utilized in the training in regular delivery of instructions?
PK	PK1 How confident were you in your knowledge of teaching and learning strategies, prior to the training? PK2 How confident are you in your knowledge of teaching and learning strategies? PK3 How confident are you to organise your lessons to interest students of varying abilities in your classes?
CK	CK1. How confident were you that you knew and understood the Introduction to coding that you are going to teach, prior to the training? CK2. How confident are you that you know and understand the Introduction to coding that you are going to teach? CK3. How confident are you that you can answer all students' questions on the introduction to coding you are going to teach and give meaningful explanations

TK3. I have the technical skills I need to use the Boats app and offline technology.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

CK4. I have sufficient knowledge about the Introduction to Coding.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

CK5. I can use a computational way of thinking.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

PK4. I can adapt my teaching of the Introduction to Coding based-upon what students currently understand or do not understand

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

PCK1. I know how to select effective teaching approaches to guide student thinking and learning in the Introduction to Coding.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

TCK1. I know about technologies that I can use for understanding and doing Introduction to coding.

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

Note. "Survey instrument used for this research"**.** Adapted from "Synthesis of survey questions that accurately discriminate the elements of the TPACK framework", by S. Jaikaran-Doe, 2015, *Australian Educational Computing, 30(1).*

The survey instrument was adapted from Jaikaran-Doe's (2015) adaptation of a TPACK survey instrument by Schmidt et al. (2009). Jaikaran-Doe's (2015) adaptation of a TPACK survey instrument by Schmidt et al. (2009) showed how applying the rules defining the bodies of knowledge (basic elements of knowledge) can generate survey questions that discriminate the elements of TPACK.

The survey instrument addressed three basic elements of knowledge that make up the TPACK (Koehler & Mishra, 2005), namely, technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK). The TPACK, as explained in section 2.6.1.2. The interaction of these three bodies of knowledge (TK, PK, CK), produces three bodies of knowledge known as PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge). The intersection of these three bodies of knowledge (PCK, TCK, TPK) brings about the TPACK.

The questions in the survey were constructed to assess the change in each of the bodies of knowledge (TK, PK, CK). Jaikaran-Doe (2015) observes that survey questions which discriminate between the basic elements of TPACK, help to construct a survey of validated survey questions equivalent to synthesised questions, that allow the assessment of each of the three bodies of knowledge (TCK, TPK, PCK). The questions under each body of knowledge address the change in each participant's confidence in each body of knowledge with regards to the PD programme, and therefore, the teaching of coding. This is because, as explained in section 2.5.1.2.1, improvements in each of the three basic element of knowledges is an improvement in the each of the three main bodies of knowledge, and thus, an effective implementation of the TPACK.

These questions can serve just as valid survey questions as when synthesised. The survey instrument aimed to raise that awareness. The inverse can be applied to analyse synthesised questions in survey instruments (Jaikaran-Doe, 2015)

The questions in the survey instrument explicitly address the change in each body of knowledge. An example of the first two questions under the TK:

TK1 How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions?

TK2 How confident are you in integrating offline coding app/s utilised in the training in regular delivery of instructions?

The questions, as advised by Jaikaran-Doe (2015), were "only seeking information about the teacher's confidence in the use of technology, and are not concerned with the teacher's pedagogical skills or their confidence of subject knowledge" (p. 7).

The last two questions of the research instrument were concerned with demonstrating the results of synthesising the questions. The questions were synthesised to discover the participant's confidence in the PCK (Pedagogical Content Knowledge), and the TCK (Technological Content Knowledge). In this research, the PCK was the knowledge of pedagogy that is applicable to the teaching of coding content. The TCK was the teachers' knowledge of how coding is transformed by the application of unplugged technology.

The questions were constructed as follows:

Table 3.7-2 ***Constructing survey instrument questions***

Domain	Element constructs	Question
PCK1	PK1 + CK1 PK1: How confident were you in your knowledge of teaching and learning strategies, prior to the training? CK1: How confident were you that you knew and understood the Introduction to coding that you are going to teach, prior to the training?	(Do) I know how to select effective teaching approaches to guide student thinking and learning in the Introduction to Coding?
TCK1	TK1 + CK1 TK1: How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions? CK1: How confident were you that you knew and understood the Introduction to coding that you are going to teach, prior to the training?	(Do) I know about technologies that I can use for understanding and doing Introduction to coding?

Note. Adapted from "Synthesis of survey questions that accurately discriminate the elements of the TPACK framework", by S. Jaikaran-Doe, 2015, *Australian Educational Computing*, *30(1).*

Jaikaran-Doe (2015) illustrated how to compile questions using the basic elements of knowledge that make up the TPACK, and how those questions can be readjusted to construct questions synthesised into the three bodies of knowledge. This research also illustrated that with the last two questions of the survey.

Why does this research's instrument only demonstrate this with two questions, PCK1 and TCK1, and not illustrate the synthesis with a third question on TPK?

Jaikaran-Doe (2015) explains that TPK "refers to how teaching might change as the result of particular technologies" (p. 4). He cites Koehler and Mishra (2007) to explain that, that would mean the teacher has a great understanding of the different types of technologies that exist for coding, in the case of this research. This research recognised that the teachers had only just been introduced to BOATS and offline techniques, as the type of technologies that exist for coding in the course.

3.7.2.4 Focus Group

Qualitative research requires answering the research question (Crump, Kairuz, & O'Brien, 2007).

A focus group was also used as a method of data collection. A focus group is explained by a number of researchers (Denscombe, 2017; Hammer, 2017; Barrett & Tywcross, 2018) as a group interview that provides a more relaxing environment than a one-to-one interview (Barrett & Tywcross, 2018). With a focus group, participants would have had time to reflect on the course attended (Barrett & Tywcross, 2018), allowing the researcher to gather more genuine feedback. Unlike in one-to-one interviews, Denscombe (2017) explains that in a focus group, the interviewer can get answers from different perspectives to a single question. This results in a variety of experiences and opinions, which enriches the research data collected. To assure reliability of the data, the focus group interviews were recorded and transcribed. These were then used during the interpretation of the findings to allow for relevant themes to be drawn from them.

Focus groups require participants' contribution on a topic, or participants' sharing similar qualities, such as being within the same age group, having similar socio-characteristics, and to be comfortable talking to the interviewer and to each other (Rabiee, 2004). As mentioned in section 3.5.2, after one focus group session, it became evident that only teachers 1A and 1B were the only participants who could contribute significantly to the research question. Klenke (2018) notes that in qualitative research, the researcher purposely chooses participants who can contribute in-depth understanding to the problem under investigation. This was further enhanced by the continued willingness to contribute to the research by teachers 1A and 1B after the first focus group session. Therefore, two teachers from school A were selected to be a part of the final focus group. They both attended the training course, and were further engaged in the teaching of coding in the FP. They were both in-line with the methodological framework of the effectiveness of ETPD, as they already had the structure to accommodate for constant individual and organisational learning occurring from effective technology-enhanced teaching. Again, the focus group discussion aimed at identifying the perceptions of a group of teachers after having time to ponder on the attended training course.

A focus group must consist of a moderator who serves as a facilitator and ensures the conversations cove the research agenda (Crump, Kairuz, & O'Brien, 2007). The researcher was also the moderator of the focus group. The discussions continued until data saturation was reached and no new information was being obtained (Crump, Kairuz, & O'Brien . 2007; Boddy. 2016). The discussions were structured around commenting on the survey instrument, and each of the lessons from the BOATS training course.

The focus group questions were open-ended questions, aligned to the research objective to address the ETDP framework. The research sought to address the framework by establishing:

- how the course affected the teachers' change in TPACK with regards to coding in the FP (TPACK),
- if the teachers' learning of the teaching content had been accommodated by collaborating with one another and their organisations to inform future teaching plans in implementing the coding curriculum (OL), and
- what measures of inquiry had the teachers undertaken to have a variety of ways in which they looked at their practice in learning to teach coding in the FP? Had they been "prompted to reflect, they analyse their progress" (Linn, 2006, p. 47) with regard to learning to teach coding in the FP? (PRI)

Focus groups provide an opportunity for follow-up questions that provide more genuine feedback (Barrett & Tywcross, 2018).The questions are aligned with the research objectives (section 1.6). These were:

a) To determine the necessary technology, pedagogy and content knowledge and skills that FP teachers need to teach computational thinking through coding.
b) To determine the circumstances necessary for OL to occur that FP teachers need to teach computational thinking through coding.
c) To determine the strategies for lifelong of coding learning through participant research and inquiry.
d) To determine possible guidelines for preparing teachers for teaching coding.

Asking open-ended questions increases the effectiveness of research (Finch & Lewis, 2003). Finch and Lewis (2003) also advise that the moderator (being the research in the case of this research) must "encourage open, iterative discussion, but also control it" (p.180). They provide techniques that help with such control, which can be expressed in how the questions are asked. These techniques were incorporated in the questions asked in the focus group.

For the focus group session 1, the objective was to discuss the teachers' TK, PK, and CK of the teachers regarding coding, after having attended the training course.

Questions:

a) What was your understanding of what coding is before the course? **(CK)**
b) Has that understanding changed? If so, how? **(CK)**
c) How did you feel about teaching coding before the course? **(PK)**
d) Has that feeling changed? If so, how? **(PK)**
e) How do you feel about constructing lesson plans for coding? (In terms of resources) **(TK)**
f) How do you feel about using the BOATS app to teach coding? **(TK)**

For the focus group session 2, the objective was to discuss how the teachers felt they could be assisted with learning to teach coding after having attended the training course. A WhatsApp group was formed, where the teachers were provided with the Coding and Robotics draft CAPS document, and the topics relating to coding in the FP were highlighted.

a) Having seen the coding and robotics draft CAPS document, how do you feel about teaching coding? **(CK) (PRI)**
b) What technologies do you have access to in your institution that can help or have helped with complementing the learning you have received from the training course? **(TK) (OL)**
c) What support systems do you have access to in your institution, that can help or have helped with complementing the learning you have received from the training course? **(PK) (OL)**

The questions were not presented verbatim, but rather the techniques advised by Finch and Lewis (2003) were employed to encourage a controlled iterative discussion.

For instance, when only one participant seemed to be answering, the researcher tried to engage the others by interjecting:

"How do other people feel?" (Finch & Lewis, 2003, p. 182)

In order to get a more in-depth anser from a participant, the researcher would also ask: "Can you say a bit more about *that?" (indicating at the gist of the participants' answer)* (Finch & Lewis, 2003, p. 182)

3.7.3 Alignment of the research design

The research was undertaken in the following steps, in line with the chosen Action Research strategy:

1. The researcher analysed the available documents for guidelines for implementing the Coding and Robotics curriculum in the FP (Guidelines Version 1a). Prior to ARC1.
2. The researcher observed the BOATS online training programme aimed to teach CT through coding for FP teachers, through recording her observations. During ARC1.
3. The researcher then developed the guidelines for implementing the Coding and Robotics curriculum in the FP (Guidelines Version 1b). After ARC1.
4. The researcher surveyed the participants' views on the online training programme they had attended. The researcher also facilitated focus group

discussions, with the participants further discussing the training programme and their readiness to implement the Coding and Robotics curriculum in the FP. During ARC2.

5. The researcher further improved on the guidelines for implementing the Coding and Robotics curriculum in the FP (Guidelines Version 2). After ARC2.

Table 3.7-3 depicts the above-listed steps, undertaken aligned to the research design. The table depicts each step aligned with the AR cycle, the research questions, the data collection instrument used, participants involved in each step, the output because of the research step, as well as the aspects of the framework involved.

Table 3.7-3 ***Alignment of the research design***

Research Steps	Action Research	Research questions	Data collection	Participants Material	Output	ETDP framework
1		SRQ1	Literature review Document analysis	Literature CAPS Docs Training material	Guidelines Version 1a	TK PK CK OL PRI
2 **3**	Cycle 1	SRQ1	Observation	Researcher as participant	Guidelines Version 1b	Training material TK, PK, CK, TPK, TCK, PCK
4	Cycle 2	SRQ2	Survey	Teachers		Pre-knowledge PK, TK, CK
		SRQ2	Focus group	Teachers		Development of TK, PK, CK, TPK, TCK, PCK, OL, PRI
5		SRQ2	Focus group	Teachers	Guidelines Version 2	Application of TK, PK, CK, TPK, TCK, PCK, OL, PRI

3.8 DATA ANALYSIS TECHNIQUES

After data collection, data has to be analysed. Qualitative data can be analysed in various ways, according Denscombe (2014) and Kawulich (2004). Kawulich (2004) explains that data analysis is the process of reducing data collected to a story explaining its interpretation to make sense of it.

Thematic analysis is the method chosen to analyse the research data. The way which the data was analysed was guided by the questions asked, the theoretical framework, and the suitability of the data analysis technique to answer the research question (Kawulich, 2004).

Thematic analysis commonly follows a six-step process which will be presented in the following sections:

1. familiarisation,
2. data coding,
3. generating themes,
4. reviewing themes,
5. defining and naming themes,
6. and writing up

(Caulfield, 2019)

Denscombe (2014) provides the four guiding principles of analysing qualitative data. The first is that the conclusions drawn from the analysis of data should strictly be rooted in the data. Secondly, is that the researcher's explanation of the data should be based on thoroughly reading of the data. Denscombe notes that qualitative data always involves a process of interpretation, where the researcher attaches meaning to the raw data, but this means that the researcher must be careful to derive her explanations by looking closely at the empirical data. Thirdly, preconceptions prior to the analysis of data should be avoided. Fourth, and lastly, is that data analysis is not a linear process, but rather an iterative process. The theory development, leading to hypotheses, which can be generalisable, is an iterative process between comparing the empirical data with the codes, categories and concepts that are being used (Denscombe, 2010).

Denscombe (2010) continues to explain the five stages generally involved in the analysis of qualitative data. These steps have been matched to the steps in the thematic analysis method. In logical order these are:

1. preparation of the data;
2. familiarity with the data *(matching the familiarization step in thematic analysis);*

3. interpreting the data: developing data codes, categories and concepts *(matching coding step in thematic analysis);*
4. verifying the data *(matching the generating themes, reviewing themes, defining and naming themes steps in thematic analysis);* and
5. representing the data *(matching the writing up step in thematic analysis).*

These five stages were used to describe data analysis process in this research. The researcher kept in mind that the above-mentioned stages do not actually take place in sequence as listed, but sometimes one needs to go back and forth between stages (Denscombe, 2010). Denscombe explains that this is a normal process in qualitative data analysis, and the process is particularly iterative when it comes to coding, interpreting, and verifying the data, as the first two stages are regularly revisited when one reaches this stage. It is of note that in interpreting, the research incorporated, as mentioned in section 3.6, the seven hermeneutic principles, proposed by Klein and Meyers (1999) to ensure that the interpretation is a true reflection of the participants' experiences.

3.8.1 Document Data (prior to ARC1)

3.8.1.1 Stage 1 of the Data Analysis Process: Preparation of the Document Analysis Data (prior to ARC1)

The Coding and Robotics draft CAPS document was thoroughly read. It was then summarised by selecting the content dealing with coding in the FP. The selected content made up the new summarised document from which further data would be analysed. Examples below depict how summarising of Coding and Robotics draft CAPS document was done thorough content selection.

Figure 3.8-1 ***Page 9 coding and robotics CAPS document***

1.4. Subjects and Time Allocation

1.4.1 Foundation Phase

(a) The instructional time in the Foundation Phase is as follows:

SUBJECT	GRADE R (HOURS)	GRADE 1-2 (HOURS)	GRADE 3 (HOURS)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Coding and Robotics	1	1	2
Life Skills: • Beginning Knowledge • Creative Arts • Physical Education • Personal and Social Well-being	6 (1) (2) (2) (1)	6 (1) 2 2 (1)	7 (2) (2) (2) (1)
TOTAL	**(24)**	**(24)**	**(27)**

(b) Instructional time for Grades R, 1 and 2 is 24 hours and for Grade 3 is 27 hours.

(c) Ten hours are allocated for languages in Grades R-2 and 11 hours in Grade 3. A maximum of 8 hours and a minimum of 7 hours are allocated for Home Language and a minimum of 2 hours and a maximum of 3 hours for Additional Language in Grades 1-2. In Grade 3 a maximum of 8 hours and a minimum of 7 hours are allocated for Home Language and a minimum of 3 hours and a maximum of 4 hours for First Additional Language.

(d) In Life Skills Beginning Knowledge is allocated 1 hour in Grades R – 2 and 2 hours as indicated by the hours in brackets for Grade 3.

1.4.2 Intermediate Phase

(a) The instructional time in the Intermediate Phase is as follows:

SUBJECTS	HOURS
Home Language	6
First Additional Language	5
Mathematics	6
Natural Sciences and Technology	3.5

Note. From "Curriculum and Assessment Policy Statement Grades R-3 coding and robotics", by DBE, 2021 (p.9).

Figure 3.8-2 ***Selected content for document summary from page 9***

1.4. Subjects and Time Allocation

1.4.1 Foundation Phase

(a) The instructional time in the Foundation Phase is as follows:

SUBJECT	GRADE R (HOURS)	GRADE 1-2 (HOURS)	GRADE 3 (HOURS)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Coding and Robotics	1	1	2
Life Skills: • Beginning Knowledge • Creative Arts • Physical Education • Personal and Social Well-being	6 (1) (2) (2) (1)	6 (1) 2 2 (1)	7 (2) (2) (2) (1)
TOTAL	**(24)**	**(24)**	**(27)**

Note. Content selected for the document summary from the coding and robotics draft CAPS document page 9. From "Curriculum and Assessment Policy Statement Grades R-3 coding and robotics", by DBE, 2021 (p.9).

Figure 3.8-3 ***Page 27 coding and robotics CAPS document***

TERM 2				
Topics	**Grade R**	**Grade 1**	**Grade 2**	**Grade 3**
Pattern Recognition and Problem Solving	• Identify different patterns • Pattern Recognition - patterns repeating up to 2 times. • Complete a Pattern • Minimum of 2 repetitions. • Movement as a Pattern.	• Explain pattern sequences. - patterns of 3 shapes and 3 repetitions. • Complete a pattern - patterns repeating up to 3 times. • Debugging in a sequence - patterns of 3 shapes and 3 repetitions.	• Introduction to Algorithmic thinking • Continue Creating patterns	• Algorithmic Thinking.
Algorithms and Coding	• Decomposition. • Sequences. • Code Cards with the following basic instructions: ○ Move forward ○ Go back ○ Turn left ○ Turn right	• Introduction to Loop functions (Loop block).	• Introduce new features of the interface: ○ Changing backgrounds ○ Event triggers (Begin/End) ○ Change speed of Character/Agent or Object (Speed block) • Introduce that more than one sequence of programming can take place at once in a single program. • Introduce more than one Character/Agent or Object.	• Introduction to: ○ Repeat and repeat forever block ○ Creating a custom object ○ Use the switch/next costume block ○ Pen block / stamp block
Robotics	• Introduction of Robots. • Introduction of input and output allowing the control of robots. • moving a robot ○ Forward ○ Back ○ Left ○ Right	• Programming a Robot • Basic Shape identification	• Propulsion through an elastic band and a Fan	• Continue with Basic breadboard layout • Connect components using a breadboard. ○ LED ○ Resistor ○ Switch • Mechanical systems ○ Basic Pulleys ○ Basic Linkages • Structures that use pulleys or linkages
Internet and E-Communications	• Introduction to Username • Introduction and Passwords (Pattern).	• Introduce Digital Safety • Introduce Online Identity	• Digital Communication –Text	• Introduction to Computer Network Hardware Components. ○ Connector ports ○ Cables ○ Modem ○ Router ○ Switch • Introduction to Wired and Wireless networks.
Application Skills	• working on a digital device. • Move an object (drag and drop) • Rotating the display of the user interface	• Continue with using basic drawing and colouring tools. • Introduce learners to ○ creating a new file. ○ saving a file	• Introduction to a Text editor Application. • Using and identifying the following keys on a (Physical/virtual) keyboard: ○ Enter key ○ Space bar	• Introduction to Data Capture on a spreadsheet application: ○ Headings for grids ○ Numbering of Items in a list ○ Lists

Note. From "Curriculum and Assessment Policy Statement Grades R-3 coding and robotics", by DBE, 2021 (p.27).

Figure 3.8-4 ***Selected content for document summary from page 27***

TERM 2				
Topics	**Grade R**	**Grade 1**	**Grade 2**	**Grade 3**
Pattern Recognition and Problem Solving	• Identify different patterns • Pattern Recognition - patterns repeating up to 2 times. • Complete a Pattern • Minimum of 2 repetitions. • Movement as a Pattern.	• Explain pattern sequences. - patterns of 3 shapes and 3 repetitions. • Complete a pattern - patterns repeating up to 3 times. • Debugging in a sequence - patterns of 3 shapes and 3 repetitions.	• Introduction to Algorithmic thinking • Continue Creating patterns	• Algorithmic Thinking.
Algorithms and Coding	• Decomposition. • Sequences. • Code Cards with the following basic instructions: ○ Move forward ○ Go back ○ Turn left ○ Turn right	• Introduction to Loop functions (Loop block).	• Introduce new features of the interface: ○ Changing backgrounds ○ Event triggers (Begin/End) ○ Change speed of Character/Agent or Object (Speed block) • Introduce that more than one sequence of programming can take place at once in a single program. • Introduce more than one Character/Agent or Object.	• Introduction to: ○ Repeat and repeat forever block ○ Creating a custom object ○ Use the switch/next costume block ○ Pen block / stamp block
Application Skills	• working on a digital device. • Move an object (drag and drop) • Rotating the display of the user interface	• Continue with using basic drawing and colouring tools. • Introduce learners to ○ creating a new file. ○ saving a file	• Introduction to a Text editor Application. • Using and identifying the following keys on a (Physical/virtual) keyboard: ○ Enter key ○ Space bar	• Introduction to Data Capture on a spreadsheet application: ○ Headings for grids ○ Numbering of Items in a list ○ Lists

Note. Content selected for the document summary from the coding and robotics draft CAPS document page 27. From "Curriculum and Assessment Policy Statement Grades R-3 Coding and Robotics", by DBE, 2021 (p.27) .

As seen in the examples above, the summarising of the Coding and Robotics draft CAPS document through content analysis selection was done by selecting content relevant to the research question. For instance,

Figure 3.8-1 depicts the subjects' time allocation for all schooling phases where coding is offered, but the version in the summarised document (Figure 3.8-2) only had the subjects' time allocation for the FP. Similarly, Figure 3.8-3 depicts an overview of all the topics for the term 2 teaching plan in the FP. The version in the summarised document (Figure 3.8-4) only depicted an overview of the topics for the term 2 teaching plan in the FP, which were relevant to the research question.

3.8.1.2 Stage 2 of the Data Analysis Process: Familiarity with the Document Analysis Data (prior to ARC1)

The researcher read and reread the organised data in order to become familiar with it. Reading at first, was to understand the data in context; reading for a second time to discover any implied meanings that might be contained in the data. The researcher familiarised herself with the data.

3.8.1.3 Stage 3 of the Data Analysis Process: Interpreting the Document Data Analysis Data (prior to ARC1)

There are two main approaches to qualitative data coding when doing data analysis, deductive and inductive data coding. In inductive data coding, the data will be analysed to creates its own set of themes (Eriksson, et al., 2023) (Pearse, 2019). With deductive data coding, the data analysis subscribes to predetermined codes. In deductive data coding, it is anticipated that certain core concepts of the framework are present in the data (Azungah, 2018).

In this research, data coding for analysing the data collected was done using a deductive approach. The ETDP framework was used to build the data code book as manifested in the three frameworks encompassed in it (TPACK, Organisational learning (OL), Participant Research and Inquiry (PRI) (Pearse, 2019).

The researcher, now familiar with the data, began interpreting it, by developing data codes for the raw data, grouping the data codes into categories, and then classifying them into the predetermined data codes from the ETDP framework.

This research aimed to discover how FP teachers (in KZN) can be prepared to teach coding. The theoretical framework already guides that such requires an integration of the TPACK, OL, and PRI. The deductive data analysis aimed to show how each aspect of the ETDP framework can be practically implemented in order to be an effective PD for teaching coding. The deductive data analysis also translated whether the KZN FP teachers are prepared to teach coding as guided by the data collected.

Data codes were deductively analysed to develop clusters of data themed under either the TPACK, OL or PRI (Azungah, 2018). These data codes were also further sub-categorised under each theme, to lend an understanding of how each aspect of the framework can be realised, to better answer the research question.

Ryan and Bernard (2003) point out that deriving themes is a systematic process, as themes are derived from the literature review, approved professional definitions, intuitive constructs, and from researchers' values, theoretical understanding, and first-hand experience with the topic at hand. Therefore, the ETDP provided the initial list of themes for the data to subscribe to.

The data coding for this research was developed based on word repetitions, keywords in context, comparing and contrasting answers, and searching for missing information in the content analysed (Ryan & Bernard, 2003; Lamprou & Repenning, 2018; Noah, 2022).

The process of developing codes in this research is illustrated and explained below:

Data transcripts were copied into Microsoft Word, where data coding was developed by adding comments to the document. This can be seen in Figure 3.8-5, Figure 3.8-6, and Figure 3.8-7 below for the summarised Coding and Robotics draft CAPS document.

Figure 3.8-5 ***Developing data codes from the CAPS document***

PAGE 9:

1.4. Subjects and Time Allocation

1.4.1 Foundation Phase

(a) The instructional time in the Foundation Phase is as follows:

SUBJECT	GRADE R (HOURS)	GRADE 1-2 (HOURS)	GRADE 3 (HOURS)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Coding and Robotics	1	1	2
Life Skills: • Beginning Knowledge • Creative Arts • Physical Education • Personal and Social Well-being	6 (1) (2) (2) (1)	6 (1) 2 2 (1)	7 (2) (2) (2) (1)
TOTAL	**(24)**	**(24)**	**(27)**

sithandwayinkosi@gmail.com
Coding allocated 1 hour per week- least amount

Note. Developing data codes in the summarised coding and robotics draft CAPS document.

Figure 3.8-6 ***Developing data codes from the CAPS document***

PAGE 16:

2.4.2 Resources

- Each learner must have a textbook / workbook / e-book. Schools must utilise book retrieval policy where applicable.
- Schools are required to ensure that the necessary tools, devices, materials and consumables be available for teaching, learning and assessment. These resources should be indexed and checked each term.
- The school should subscribe to a minimum of two or more subject related magazines for the teacher to keep abreast with the latest developments in the industrial environment. These magazines could also be lent out to learners (in the same way as library books). These resources must be readily available in the classroom or in the library.
- Schools offering Coding and Robotics must have a well-equipped Coding and Robotics lab for learners to complete the Practical Assessment Tasks. The Coding and Robotics lab needs to be secured with enough storage space for resources.
- The teacher should have a variety of reference books / e-books, charts and brochures in the classroom to stimulate the learners' interest in the subject.
- The teacher should have access to the internet to be able to source

sithandwayinkosi@gmail.com
Coding involves people skills

sithandwayinkosi@gmail.com
Coding involves ict skills

sithandwayinkosi@gmail.com
Coding involves creative skills

sithandwayinkosi@gmail.com
Teachers need to be trained in TPACK of coding

sithandwayinkosi@gmail.com
Coding educators need access to new relevant information

sithandwayinkosi@gmail.com
Coding educators need access to various resources

sithandwayinkosi@gmail.com
Coding requires a well-equipped lab

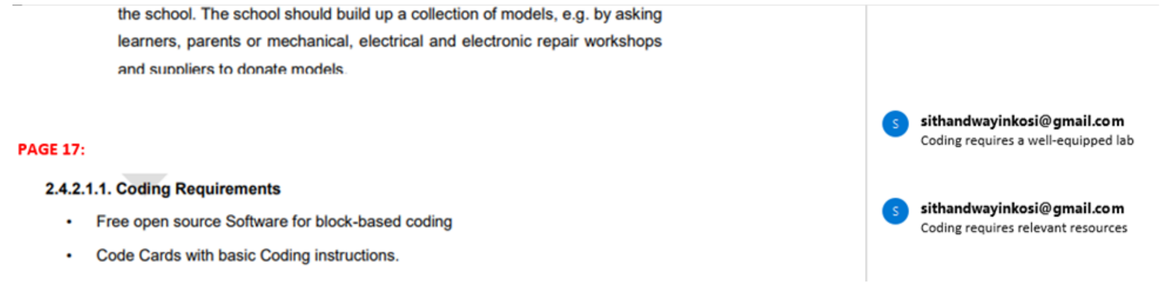
sithandwayinkosi@gmail.com
Coding requires relevant resources

Note. Developing data codes in the summarised Coding and Robotics draft CAPS document.

The comments in the document are what became the data code. It was important that they be uniform. When an idea or sentiment was interpreted as repeated, the same comment was added. An example of this is in figure 3.8.1.3_b above, where the comment "coding requires a well-equipped lab" was derived from the paragraph: "Schools offering coding and robotics must have a well-equipped coding and robotics lab for learners to complete the Practical Assessment Tasks. The coding and robotics lab needs to be secured with enough storage space for resources" (DBE, 2021, p. 16).

The same comment is seen from the data coding that arose from interpreting the paragraph outlining coding requirements in figure 3.8.1.3_c below (DBE, 2021, p. 17).

Figure 3.8-7 ***Developing data codes from the CAPS document***



the school. The school should build up a collection of models, e.g. by asking learners, parents or mechanical, electrical and electronic repair workshops and suppliers to donate models.

PAGE 17:

2.4.2.1.1. Coding Requirements

- Free open source Software for block-based coding
- Code Cards with basic Coding instructions.

sithandwayinkosi@gmail.com
Coding requires a well-equipped lab

sithandwayinkosi@gmail.com
Coding requires relevant resources

Note. Developing data codes in the summarised Coding and Robotics draft CAPS document.

Once the data coding was done for the document, the codes were transferred to an excel sheet (see Figure 3.8-8) for better analysis.

Figure 3.8-8 ***Initial data codes of the CAPS document***

1	CODE
2	Coding allocated 1 hour per week- least amount
3	Coding educators need access to new relevant information
4	Coding educators need access to various resources
5	Coding involves creative skills
6	Coding involves people skills
7	Coding involves ict skills
8	Coding involves ict skills
9	Coding is critical thinking
10	Coding is equipping learners for skills in a fast-changing world
11	Coding is pattern recognition
12	Coding is pattern recognition
13	Coding is pattern recognition
14	Coding is problem solving
15	Coding is problem solving
16	Coding is problem solving
17	Coding is problem solving
18	Coding is problem solving
19	Coding is working collaboratively
20	Coding requires a well equipped lab

Coding and Robotics CAPS Grade | Training Workshop (

Note. Initial data codes from the summarised coding and robotics draft CAPS document on an excel sheet.

Once on the spreadsheet, codes with multiple occurances had the extra occurances removed. The initial coding of the Coding and Robotics CAPS document resulted in 24 codes, which were reduced to 15 by eliminating multiple occurances.

The codes were also reorganised in an order that best explains the representation of the data as interpreted by the researcher. Basit (2003) describes this proces as analysing data "to illuminate an existent situation" that can help the reader to understand the phenomenon under scutiny (see Figure 3.8-9).

Figure 3.8-9 ***Reorganised data codes of the CAPS document***

	CODE	ASPECT OF ETPD FRAMEWORK
1	Coding is problem solving	CK
2	Coding is pattern recognition	CK
3	Coding is critical thinking	CK
4	Coding involves creative skills	CK
5	Coding is equipping learners for skills in a fast-changing world	PK, CK
6	Coding involves ict skills	TK
7	Coding requires relevant resources	TK
8	Coding requires a well-equipped lab	TK
9	Coding resource are responsibility of the school	OL
10	Educators need to be trained in TPACK of coding	CK, PK, TK
11	Coding involves people skills	OL
12	Coding is working collaboratively	OL
13	Coding educators need access to various resources	TK
14	Coding educators need access to new relevant information	PRI
15	Coding allocated 1 hour per week- least amount	CK, PK, TK

*Note. Data c*odes from the summarised Coding and Robotics draft CAPS document on an excel sheet reorganised and linked to the ETDP framework aspect they represent.

The aspect of the ETDP framework that describes the data codes was also indicated(see Figure 3.8-9). This was done in order to identify the data codes that will fit in each theme in the ETDP framework, as they will later be presented.

3.8.2 Observation Data (during ARC1)

3.8.2.1 Stage 1 of the Data Analysis Process: Preparation of the Observation Data (During ARC1)

During ARC1, the researcher attended the BOATS training course on unplugged coding.

In qualitative research, participant and non-participant observation give researchers an opportunity collect data expressed verbally and non-verbally (Barrett & Tywcross, 2018). This was applied in the research through the researcher in her role as a participant and an observer.
The observations took place during the first AR cycle. The researcher attended the training as a teacher, with the aim to observe the introduction to coding training itself

in terms of TPACK in the Assessment of ETPD. The observations were meant to support further investigation into sub research question 1(SRQ1): Which skills should teachers be prepared for to teach computational thinking through coding? SRQ1 focused on teachers' TPACK development during the training.

During each lesson, the observation instrument was completed. An example of Lesson 1's observation data has provided in the figures below.

Figure 3.8-10 ***Lesson 1 observation page 1***

Observation Instrument:

The Technology Integration Assessment Instrument (TIAI) is a rubric that can be used to assess technology integration in a lesson plan. The TIAI explores seven dimensions of planning with specific attention to levels of technology integration (Harris, Grandgenett, & Hofer, 2010).

Observations must earn a minimum score of "adequate" on all indicators

Lesson: 1 Basics of Coding Date: 11 Aug 2021

		EXCELLENT Exceeds Expectations	PROFICIENT Meets Expectations	ADEQUATE Partially Meets Expectations	UNSATISFACTORY Fails to Meet Expectations
Curriculum Goals & Technologies (Curriculum-based technology use)	use of technology skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan strongly supports the skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan supports the skills needed to teach computational thinking through coding.	Technologies selected for use in the instructional plan partially supports the skills needed to teach computational thinking through coding. ✓	Technologies selected for use in the instructional plan do not support the skills needed to teach computational thinking through coding.
	Comments: The technologies being referred to ~~for~~ the lesson plan are appropriate, but not much tech for the actual presentation.				

Figure 3.8-11 ***Lesson 1 observation page 2***

Technology Selection(s) (Compatibility with curriculum goals & instructional strategies)	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are exemplary.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are appropriate, but not exemplary.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are marginally appropriate.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are inappropriate.
	Comments: The lesson was more of a discussion rather than an introductory lesson introducing coding with the BOATS app. Maybe it was also because of my expectations				
"Fit" (Content, pedagogy and technology together)		Content, instructional strategies and technology fit together strongly within the instructional plan.	Content, instructional strategies and technology fit together within the instructional plan.	Content, instructional strategies and technology fit together somewhat within the instructional plan.	Content, instructional strategies and technology do not fit together within the instructional plan.

Figure 3.8-12 ***Lesson 1 observation page 3***

Instructional Strategies & Technologies (Using technology in teaching/ learning)	Use of offline coding technology and Boats app supports instructional strategies needed to teach computational thinking through coding.	Technology use intentionally makes it easier to understand concepts/ideas that wouldn't be possible without this technology.	Technology use intentionally makes it easier to understand concepts/ideas.	Technology use incidentally makes it easier to understand concepts/ideas.	Technology use provides limited/ no opportunities to understand concepts/ideas.
	Comments: Pattern recognition example - displayed a loopic code on scratch (maybe not for 1st lesson). Topics presented to suit a person who has done some coding! Maybe have a practical lesson on Boats first.				
	Use of offline coding technology and Boats app supports learning	Students/ teachers use technology to engage in discovery learning.	Students/ teachers use technology to extend their learning.	Students/ teachers use technology to apply prior learning.	Students/ teachers passively receive information.
	Comments: App not really used for lesson. Rather, she disscussed the lesson plan which dealt with "coding as communication" + activities to do in class to substantiate this.				

Figure 3.8-13 ***Lesson 1 observation page 4***

Comments:
* An educator commented that her Grade R and 1 learners are really confused about coding – could the issue be the method of teaching/teacher knowledge?

Adapted from (Harris, Grandgenett, & Hofer, 2010) and (Ohio Wesleyan University, 2020)

Score: Mostly Adequate

Sign: ____________

The observation instrument was presented in section 3.7.2.2. Comments were added to highlight noteworthy occurrences during the training course.

The observed course training lessons were also transcribed for the researcher to analyse the training course at a chosen pace, in more detail, and assist in summarising comments on the observation instrument. An example of a transcription is provided in Figure 3.8-14 below.

Figure 3.8-14 ***Lesson 1 transcript***

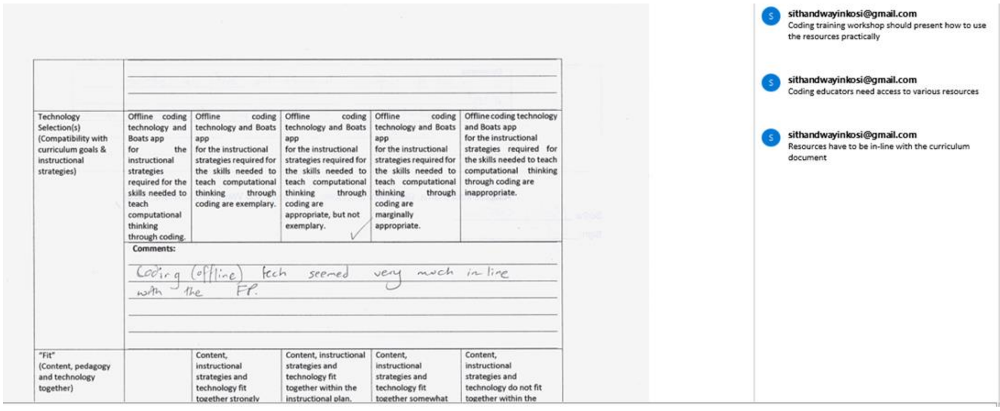
questions or discussions or anything that you want to have a look at okay so
welcome
3:00
this is a first of all introductory course just to coding and teaching coding as well as
3:09
looking through the particularly the boats kit
3:14
and the lesson plans that come with it the offline coding lesson plans
3:22
so those of you who have not yet experienced the boat boats coding app
3:27
the reason why i was really drawn to boats and tanks before that is
3:32
because i really felt when i saw this app and when i when i installed it on my
3:38
phone and used it i could see that it was developed in south africa with the african
situation in mind because a lot
3:45
of accent and websites that are developed overseas
3:51
don't necessarily understand our situation in south africa like for example there are a
lot of coding things

3.8.2.2 Stage 2 and 3 of the Data Analysis Process: Familiarity with and Interpreting the Survey Data (During ARC1)

The observation instrument for each lesson was matched with the transcribed lesson for each course training lesson, to assure reliability of the data. They were both read thoroughly to look for codes in them.
In the observation instrument, an overall score of the instrument was tallied, to give an idea of the overall score of the training course. The results of scoring the training course will be outlined in chapter 4.

The observation instrument, was also analysed for codes, which were commented in a document (see Figure 3.8-15) and transferred to an excel sheet (see Figure 3.8-16) These codes were identified through narrative analysis, the interpretation of which was guided by hermeneutic principles. In the excel sheet, the codes were listed, reorganised, and assigned to their respective ETDP framework theme (see Figure 3.8-17).

Figure 3.8-15 ***Developing data codes from the observation instrument***



Technology Selection(s) (Compatibility with curriculum goals & instructional strategies)	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are exemplary.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are appropriate, but not exemplary. ✓	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are marginally appropriate.	Offline coding technology and Boats app for the instructional strategies required for the skills needed to teach computational thinking through coding are inappropriate.
	Comments: Coding (offline) tech seemed very much in line with the FP.				
"Fit" (Content, pedagogy and technology together)		Content, instructional strategies and technology fit together strongly	Content, instructional strategies and technology fit together within the instructional plan.	Content, instructional strategies and technology fit together somewhat	Content, instructional strategies and technology do not fit together within the

sithandwayinkosi@gmail.com
Coding training workshop should present how to use the resources practically

sithandwayinkosi@gmail.com
Coding educators need access to various resources

sithandwayinkosi@gmail.com
Resources have to be in-line with the curriculum document

Figure 3.8-16 ***Initial data codes of the observation instrument***

	A
1	CODE
2	Coding educators need access to various resources
3	Coding training workshop presented in a manner that need a person who has an idea about coding
4	Coding training workshop presented in a manner that need a person who has an idea about coding
5	Coding training workshop presented in a manner that need a person who has an idea about coding
6	Coding training workshop presented in a manner that need a person who has an idea about coding
7	Coding training workshop presented in a manner that need a person who has an idea about coding
8	Coding training workshop should present how to use the resources practically
9	Coding training workshop should present how to use the resources practically
10	Coding training workshop should present how to use the resources practically
11	Coding training workshop should present how to use the resources practically
12	Educators currently teaching coding say Grade 1 learners are confused
13	Educators expected to have prepared for training workshop
14	Educators expected to have prepared for training workshop
15	Educators expected to have prepared for training workshop
16	Resources have to be in-line with the curriculum document
17	Teachers need relevance of coding to understand it
18	Teachers need to be trained in TPACK of coding

Coding and Robotics CAPS Grade | Training Workshop Observation | Surveys | Focus Group Sessic ...

Figure 3.8-17 ***Reorganised data codes of the observation instrument***

	CODE	ASPECT OF ETPD FRAMEWORK
1	Educators need to be trained in TPACK of coding	CK, PK, TK
2	Coding training workshop presented in a manner that need a person who has an idea about coding	PK
3	Educators expected to have prepared for training workshop	PRI
4	Educators need to know the coding curriculum content	CK
5	Educators need relevance of coding to understand it	CK
6	Educators currently teaching coding say Grade 1 learners are confused	PK
7	Training workshop should be conducted like the lessons educators will teach	PK
8	Educators need to be made aware of the relevant coding resources and how to use them	TK
9	Training workshop has to present how to use the relevant technologies	PK, TK
10	Resources have to be in-line with the curriculum document	TK, CK
11	Coding educators need access to various resources	TK
12	Coding training workshop should present how to use the resources practically	TK, PK

Note. Data codes from the observation instrument on an excel sheet, reorganised and linked to the ETDP framework aspect they represent.

3.8.3 Survey and Focus group Data (during ARC2)

3.8.3.1 Stage 1 of the Data Analysis Process: Preparation of the Survey and Focus group Data (during ARC2)

Surveys were collected electronically and physically from participants. An example from teacher 1A can be seen in Figure 3.8-18 below.

Figure 3.8-18 ***A survey for teacher 1A***

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Title of Research Project: Hello world: Preparing Foundation Phase teachers in KZN to teach coding

Researcher: Sithandwayinkosi Goba
Contact of Researcher: 062 585 4630

Supervisor: Professor R. Callaghan
Contact of Researcher: 012 420 5521

RESEARCH SURVEY FORM

Personal information *(For statistic purposes)*

Name	[redacted]
Surname	[redacted]
Name of School	[redacted] Primary
Province	KZN
District	Umlazi
Subject(s) taught	English HL,Mathematics,Afrikaans FAL,Life Skills
Grade(s) taught	1 and 3
Impementing Boats at School (Yes / No)	Yes

Section A
Please answer in the spaces provided.

1 How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions?

I was not very confident because I had no prior knowledge about coding and I thought it would be very difficult.

There were two focus group sessions which were transcribed (see Figure 3.8-19 below)

Figure 3.8-19 ***Focus groups transcripts***

Focus Group Session 1

Present: Educator A1, Educator A2, Educator A3, Educator A4, and researcher

Venue: School A

Date: 12 March 2022

Researcher: Okay, it started. So, hi, everyone, and thank you. As you know, I'm doing my master's in computer integrated education with my majors being coding and robotics at the University of Pretoria. So we're having like a discussion because you guys attended the BOATS training workshop on coding. These sessions are called focus group sessions, and as explained in your indemnity forms, we will have more of these in future. I just want to know your feel of the training and whether or not you feel you're ready to now teach coding after having attended the training. Remember teaching coding is officially meant to start being next year.

I'm going to go through some questions, similar to the survey first, just to get your baseline understanding.

So my first question is what was your understanding of what coding is before the workshop? So basically, like I wanted to know if you guys had ever heard of coding before the training, and what did you guys understand about coding?

So, any of your guys can just feel free to answer that.

Educator A1: Ok, I had no knowledge about coding, initially I thought it was meant to be done on the computer or something like that. Afterwards, I was introduced to TANKS by Mr (the principal of school A). He had introduced it to us using puzzle pieces. He had explained that it is not done on the computer, and everything is done using a phone, what is

Focus Group Session 2

Present: Educator A1, Educator A2 and researcher

Venue: Online (WhatsApp)

Date: 27 June 2022

Researcher: Hi there, I hope you have had time to go through that document where I summarised the Coding and Robotics draft CAPS document and the topics relating to coding in the FP were highlighted.

So, my first question is:

Having seen the Coding and Robotics draft CAPS document, or rather, part of it, how do you feel about teaching coding? Do you feel you are still ready and prepared having attended the BOATS workshop?

Educator 2A: After looking at the CAPS document, I have realised that what I though was just coding, was only a bit of it. But I think I can learn it, given the time and training.

Educator 1A: I think it's the same for me. And I also feel the BOATS training was good in terms of training us for our learners, just introducing coding, obviously not for following the CAPS document. But we learnt enough to be able to get them exposed to coding.

Researcher: What technologies do you have access to in your institution that can help or have helped with complementing the learning you have received from the training workshop?

Educator 1A: Having the BOATS kit early on, while we were still learning TANKS allowed us time to get used to it. The BOATS app as well. And also, the space to do coding in our school, the lab really helps.

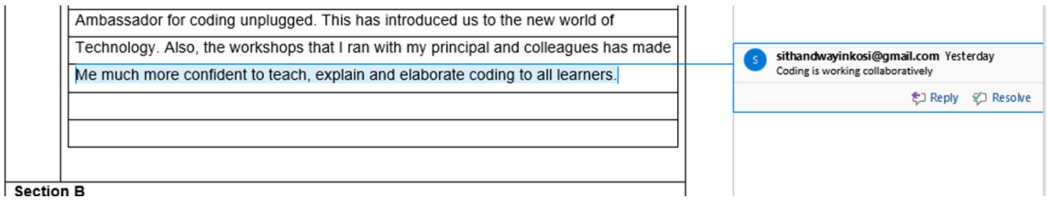
Researcher: What support systems do you have access to in your institution that can help or have helped with complementing the learning you have

3.8.3.2 Stage 2 and 3 of the Data Analysis Process: Familiarity with and Interpreting the Survey and Focus group Data (during ARC2)

The researcher familiarised herself with the survey instrument answers and their sentiments, and also the focus group transcripts. The surveys and focus groups were both read thoroughly to look for data codes present in them. Keywords were highlighted in data collected in both instruments, and noted for data coding that was used to develop themes.

An example is shown below. Figure 3.8-20 is the survey response by teacher 1B. Figure 3.8-21 is the transcript from the focus groups showing code development.

Figure 3.8-20 ***Developing data codes from the survey instruments***


Ambassador for coding unplugged. This has introduced us to the new world of Technology. Also, the workshops that I ran with my principal and colleagues has made Me much more confident to teach, explain and elaborate coding to all learners.

Section B

Figure 3.8-21 ***Developing data codes from the focus groups transcripts***

Focus Group Session 1

Present: Educator A1, Educator A2, Educator A3, Educator A4, and researcher

Venue: School A

Date: 12 March 2022

Researcher: Okay, it started. So, hi, everyone, and thank you. As you know, I'm doing my master's in computer integrated education with my majors being coding and robotics at the University of Pretoria. So we're having like a discussion because you guys attended the BOATS training workshop on coding. These sessions are called focus group sessions, and as explained in your indemnity forms, we will have more of these in future. I just want to know your feel of the training and whether or not you feel you're ready to now teach coding after having attended the training. Remember teaching coding is officially meant to start being next year.

I'm going to go through some questions, similar to the survey first, just to get your baseline understanding.

So my first question is what was your understanding of what coding is before the workshop? So basically, like I wanted to know if you guys had ever heard of coding before the training, and what did you guys understand about coding?

So, any of your guys can just feel free to answer that.

Educator A1: Ok, I had no knowledge about coding, initially I thought it was meant to be done on the computer or something like that. Afterwards, I was introduced to TANKS by Mr (the principal of school A). He had introduced it to us using puzzle pieces. He had explained that it is not done on the computer, and everything is done using a phone, what is unplugged. Also after we had done the BOATS training, by what's her

> sithandwayinkosi@gmail.com — Coding can be unplugged
>
> sithandwayinkosi@gmail.com — Coding is sequencing

Present: Educator A1, Educator A2 and researcher

Venue: Online (WhatsApp)

Date: 27 June 2022

Researcher: Hi there, I hope you have had time to go through that document where I summarised the Coding and Robotics draft CAPS document and the topics relating to coding in the FP were highlighted.

So, my first question is:

Having seen the Coding and Robotics draft CAPS document, or rather, part of it, how do you feel about teaching coding? Do you feel you are still ready and prepared having attended the BOATS workshop?

Educator 2A: After looking at the CAPS document, I have realised that what I though was just coding, was only a bit of it. But I think I can learn it, given the time and training.

> sithandwayinkosi@gmail.com — Learning to teach Coding needs more time than a workshop

Educator 1A: I think it's the same for me. And I also feel the BOATS training was good in terms of training us for our learners, just introducing coding, obviously not for following the CAPS document. But we learnt enough to be able to get them exposed to coding.

> sithandwayinkosi@gmail.com — Coding needs unstructured learning

Researcher: What technologies do you have access to in your institution that can help or have helped with complementing the learning you have received from the training workshop?

Educator 1A: Having the BOATS kit early on, while we were still learning TANKS allowed us time to get used to it. The BOATS app as well. And also, the space to do coding in our school, the lab really helps.

> sithandwayinkosi@gmail.com — Coding educators need access to various resources
>
> sithandwayinkosi@gmail.com — Coding resource are responsibility of the school

Researcher: What support systems do you have access to in your institution that can help or have helped with complementing the learning you have

In the excel sheet, the data codes were listed (se Figure 3.8-22 and Figure 3.8-24), reorganised and assigned to their respective ETPD framework theme (see Figure 3.8-23 and Figure 3.8-25)

Figure 3.8-22 ***Initial data codes of the survey instruments***

1	CODE
2	Coding is perceived as a difficult subject
3	Coding teaching strategies ae easier to grasp as there is sequencing which is taught in “normal classes”
4	Coding teaching strategies ae easier to grasp as there is sequencing which is taught in “normal classes”
5	Coding is working collaboratively
6	Coding is perceived as a difficult subject
7	Coding is working collaboratively
8	Coding is part of sequencing which is taught in normal classes
9	Coding needs new teaching and learning strategies
10	Coding needs new teaching and learning strategies

Figure 3.8-23 ***Reorganised data codes of the survey instruments***

	B	C
	CODE	ASPECT OF ETPD FRAMEWORK
1	Coding is perceived as a difficult subject	PK
2	Coding teaching strategies are easier to grasp as there is sequencing which is taught in “normal classes”	PK
3	Coding needs new teaching and learning strategies	PK
5	Coding is working collaboratively	OL

*Note. Data c*odes from the survey instruments on an excel sheet, reorganised and linked to the ETDP framework aspect they represent.

Figure 3.8-24 ***Initial data codes of the focus groups session 1 and 2***

1	CODE
2	Coding can be unplugged
3	Coding involves creative skills
4	Coding involves people skills
5	Coding is critical thinking
6	Coding is learning to give instructions
7	Coding is problem solving
8	Coding is problem solving
9	Coding is sequencing
10	Coding is working collaboratively
11	Coding is working collaboratively
12	Coding needs more time allocation
13	Learning to teach Coding needs more time than a workshop
14	Learning to teach Coding needs more time than a workshop
15	Coding needs unstructured learning
16	Coding needs unstructured learning
17	Coding requires adaptive educators
18	Coding requires involvement of all educators
19	Teachers need relevance of coding to understand it
20	Teachers need relevance of coding to understand it
21	Teachers need to know the coding curriculum content
22	Teachers need to know the coding curriculum content
23	Teachers need to know the coding curriculum content

1	CODE
2	Learning to teach Coding needs more time than a workshop
3	Coding needs unstructured learning
4	Coding educators need access to various resources
5	Coding resource are responsibility of the school
6	Coding is working collaboratively
7	Coding is working collaboratively

Figure 3.8-25 ***Reorganised data codes of the focus groups session 1 and 2***

	CODE	ASPECT OF ETPD FRAMEWORK
1	Coding involves creative skills	CK
2	Coding involves people skills	OL
3	Coding is critical thinking	CK
4	Coding is learning to give instructions	PK
5	Coding is problem solving	PK
6	Coding is sequencing	CK
7	Coding can be unplugged	PK
8	Coding needs unstructured learning	PK
9	Coding needs more time allocation	PK, CK
10	Teachers need relevance of coding to understand it	CK
11	Teachers need to know the coding curriculum content	CK
12	Coding requires adaptive educators	PRI
13	Coding is working collaboratively	OL
14	Learning to teach Coding needs more time than a workshop	OL, PRI

	CODE	ASPECT OF ETPD FRAMEWORK
1	Coding needs unstructured learning	PK
2	Coding educators need access to various resources	TK
3	Coding resource are responsibility of the school	OL
4	Coding is working collaboratively	OL
5	Learning to teach Coding needs more time than a workshop	OL, PRI

*Note. Data c*odes from the focus group session 1 and 2 on an excel sheet, reorganised and linked to the ETDP framework aspect they represent.

Stages 4 of the data analysis process, which is verifying the data by *generating themes, reviewing themes, defining, and naming themes steps; and* stage 5, is presented in the results section (Chapter 4).

3.9 TRUSTWORTHINESS

To ensure the trustworthiness of the research process and outcomes of this research, the following concepts of trustworthiness were employed:

1. Hermeneutics within interpretive research.
2. Credibility of the research's data
3. Transferability of the results
4. Dependability of the research's findings
5. Conformability in the handling of the data

3.9.1 Hermeneutics within interpretive research

Hermeneutics, the art that governed the interpretation of this research's data, was explained in section 3.2. The researcher subscribed to the seven hermeneutic principles for Interpretive Field Research suggested by Klein and Meyers (1999) to interpret the participants' data in its truest likeness. Table 3.2 presented in section 3.2 summarised the seven hermeneutic principles for Interpretive Field Research. The table will now be presented with its application in the research's data interpretation.

Table 3.9-1 *Hermeneutics within the research*

1	**The Fundamental Principle of the Hermeneutic circle** This principle suggests that all human understanding is achieved by iterating between considering the parts that form the whole, and the whole. **In this research, this is achieved by iterating between each participant (surveys) and the group as a Whole (focus groups)**
2	**The Principle of Contextualisation** This principle necessitates the critical reflection of the social and historical background of the research setting, so that the intended audience can have an understanding of the emergence of the current investigation. **In this research, there was critical reflection of the historical background of the research setting as it was first planned to be done as a physically presented course. There has been thorough explanation on the historical background of the researcher, and the research participants and the schools they are based in, in undertaking the Coding unplugged initiative.**
3	**The Principle of Interaction Between the Researchers and the Subjects** This principle necessitates critical reflection on how research data developed as a result of the communication between the researcher and the participants. **In this research, the researchers' understanding improved the more she interacted with the participants and data and started questioning her own assumptions, and seeing the participants as interpreters as well as they altered their horizons by the concepts introduced and used by the researcher when interacting with them.**
4	**The Principle of Abstraction and Generalization** The principle necessitates correlating the data interpretation resulting from the applications of the fundamental principle of the Hermeneutic circle and the principle of contextualisation to theoretical, general concepts that describe the nature of human understanding and social action. These generalisations should be prudently related to the details of the research as collected by the research. The readers need to be able to follow how the researcher arrives at his or her theoretical insights. **This research does not depend on the representativeness of cases in terms of statistics, but rather on the reasoning used in presenting the results.**
5	**The Principle of Dialogical Reasoning** The principle suggests an openness to the possibility of the expected findings according to literature being contradictory to the actual findings of the research. **This research came to revise the preconceptions that course training alone is needed for Preparing Foundation Phase teachers in KZN to teach computational thinking through coding**
6	**The Principle of Multiple Interpretations** The principle suggests an openness to the possibility of different interpretations among the participants in accordance with the narration of their experiences of the same events under investigations. **In this research, multiple viewpoints were documented with reasons for them. This was applied to confront the conflicting interpretations of the participants.**
7	**The Principle of Suspicion** The principle suggests an openness to possible bias and distorted narratives from data collected from the participants. **This research employed the methods of Forester of identifying distortions in conversations, by carefully analysing figurers of speech.**

Note: Adapted from "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems", by H.Klein & M.Myers, 1999, *MIS Quartely, 23(1),* p. 72.

3.9.2 Credibility of the research's data

Credibility is the truth and reliability in the research's findings. Credibility can be determined by the research's finding being similarly recognised by other researchers when confronted with the same data (Guba & Lincoln, 1985). It is the believability of the researches' results and findings (Nassaji, 2020).This research addressed credibility using a number of techniques suggested by Guba and Lincoln (1985). Firstly, credibility was ensured though prolonged engagement with the participants, as the participants were requested to give consent to participate in the research, then to participate in the survey, so that the questions were understood and answered without confusion. Secondly, credibility was also ensured by persistent observation of the training course. As the training course was ultimately online and video recorded, the researcher could replay it for more credible observation. The researcher was also able to conduct one of the focus groups physically, which contributed positively to credible and persistent observation. Thirdly, credibility was ensured though data collection triangulation, as the research used multiple methods of data collection on the same phenomena (Bowen, 2009), each to help answer the research question at a different layer of depth than the other. In addition, the researcher was able to visit the schools and meet the principals, to corroborate each school's dynamic. Lastly, peer debriefing was used to provide an external check on the research process against raw data.

In addition, using thematic analysis, and being transparent about the research's analysis process speaks to its credibility (Castleberry & Nolen, 2018).

3.9.3 Transferability of results

The results of this research would be transferable to the KZN population The participant sample represented the dynamics of a generalisable population and school environment demographics in KZN. The data collection instruments were devised to be simple by yet measure the attributes needed to answer the research question. The research was transferable as evident from its participant sample, which can be acceptable for a general population (Moules et al., 2017) in KZN.

In addition, by providing detailed evidence of the research content, makes it generalisable, as any reader can also rediscover if the findings are generalisable (Castleberry & Nolen, 2018).

3.9.4 Dependability of the research's findings

The research's findings are outlined in chapter 4, and their usefulness for future pedagogical development. To achieve dependability, researchers can ensure the research process is logical, traceable, and clearly documented (Moules et al., 2017). This can be demonstrated through an audit.

In addition, the thematic analysis indicates consistency in the research. This shows that the research can be repeated.

3.9.5 Conformability in the handling of data

In order to show how research is objective, especially when collecting, analysing, and interpreting the data; Moules et al. (2017) says that confirmability is established when credibility, transferability, and dependability are all achieved. Conformability is the control of bias in research, and assuring that the research is based solely on the participants' experiences. Measures of controlling bias were also mentioned in section 3.4.2. Castleberry and Nolen (2018) says that the use of thematic analysis shows that the results arose from the research's data, and thus displays a control of bias.

3.10 ETHICAL CONSIDERATIONS

Nolen and Vander Putten (2007) explain that the ethical considerations that arise when doing AR are complex in nature. They should express the applications of the principle of respect for persons in the planning and execution of AR projects.

Respect for persons, or rather ethical considerations in AR, can be applied in three ways (Nolen & Vander Putten, 2007). These are: (1) Informed consent of Participants (informing the participants, or guardians about the likely risks and consequence involved in the research, and giving their informed consent before participating), (2) Protecting the Confidentiality of Participants (maintaining security of data that may identify the individual participant), and (3) Autonomy of Participants (a persons' decision on whether or not to participate).

3.10.1 Informed Consent

An application for ethical clearance to conduct the research was made and granted by the University of Pretoria (see page ii).

The intentions of the research were disclosed to the developers of the BOATS Unplugged coding training course, and to the Kwa-Zulu Natal Department of Basic Education (KZNDOE). The KZNDOE was made aware of the schools which would be approached to be involved in the research, and a research proposal was also provided. The researcher then attained the Ethical clearance certificate to fully approach the required institutions under the KZN DoE to partake in the research (see ANNEXURE A: KZNDOE PERMISSION TO CONDUCT RESEARCH). A letter of permission was also sent to the developers of the BOATS Unplugged coding training course (see ANNEXURE B: PERMISSION FROM BOATS TRAINING ORGANISERS)

Prior to data collection, letters describing the research project, along with an invitation to participate in the research, and a consent to from participants who would be involved in the research, was made. Letters describing the research were first delivered to principals of schools taking part in the BOATS Unplugged coding training course, explaining that the teachers of their respective schools would be approached to take part in the research, given their consent to participate (see ANNEXURE C: PERMISSION LETTER TO PRIMARY SCHOOL PRINCIPAL). The participants were also provided with a letter to grant informed consent (see ANNEXURE D: INFORMED CONSENT TO PARTICIPATE IN RESEARCH). The informed consent was granted.

3.10.2 Confidentiality

In order to maintaining confidentiality, the teachers, along with their schools, were assigned codes in the data collection. They were referred by these codes in the research. The identities of the participants were also protected when data collection that was done through online communication (such as the WhatsApp group for the focus group).

3.10.3 Autonomy of Participants

It was explicitly clarified in the consent form that a participant's decision on whether or not to participate in this research was voluntary and would not affect their relationship with the Nelson Mandela University or University of Pretoria. It was also clarified that if the participant chose not to continue to participate in the research, they were free to withdraw their consent and discontinue participation at any time without prejudice.

3.11 CHAPTER SUMMARY

This chapter provided clear details about the research philosophy, approach to theory development, methodological choice, the research strategy, the time horizon, data collection, and an explanation of the sampling done. The chapter concluded with the data analysis techniques, the strategies to ensure trustworthiness, and the ethical considerations. The next chapter presents the results and findings.

4. CHAPTER 4: RESULTS AND FINDINGS

4.1 INTRODUCTION

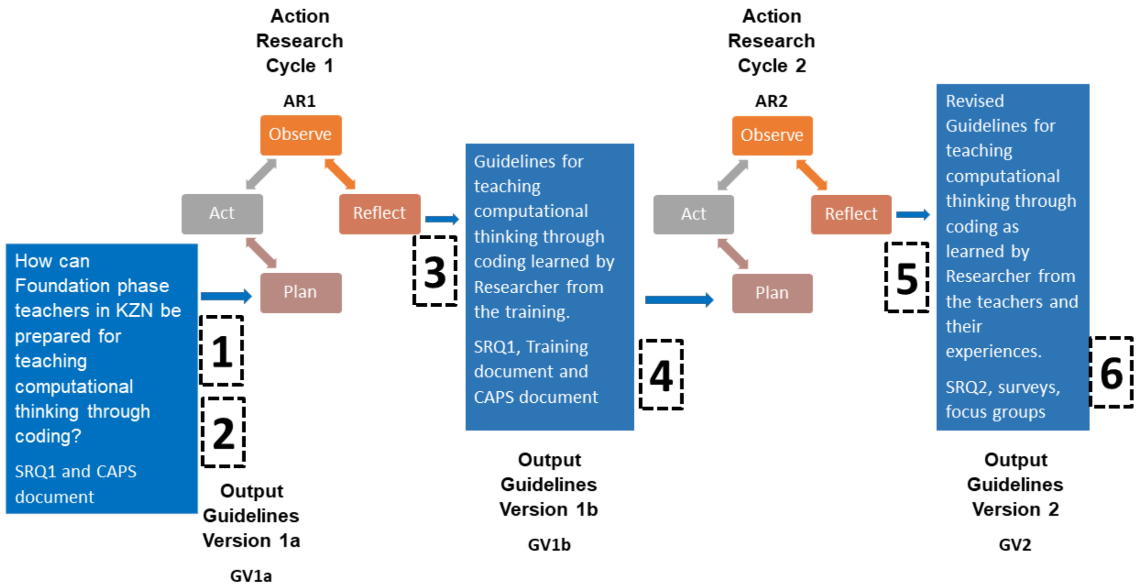
The chapter presents the results and findings as they unfolded throughout the Action Research (AR) cycles. The results and findings also represent stages 4 and 5 of the five stages involved in the analysis of qualitative data (Denscombe, 2010) presented in section 3.8. The research considered that AR research is an iterative process. As shown in figure 3.5.2_b depicting a typical AR design (McAteer, 2013) with three cycles, where cycle 1 informs cycle 2 (in the case of this research). Data analysis, results and findings were done before the first cycle, after the first cycle, and after the second cycle (see Figure 4.1-1).

1. In Section 4.2, the research will present the results of the document analysis prior to ARC1 (Stages 4 and 5 of the Data Analysis Process).
2. In Section 4.3, the findings, compiled as the Output Guidelines Version 1a, are presented. These guidelines answer the first sub-research question (SRQ1), Which skills should teachers be prepared for to teach computational thinking through coding?
3. In Section 4.4, the results of the observation of the BOATS training course alongside the training material analysed during ARC1(Stages 4 and 5 of the Data Analysis Process) are presented.
4. In Section 4.5, the findings, compiled as the Output Guidelines Version 1b, are presented. These guidelines answer the first sub-research question (SRQ1), Which skills should teachers be prepared for to teach computational thinking through coding?
5. In Section 4.6, the results of the surveys and the focus group conducted during ARC2 (Stages 4 and 5 of the Data Analysis Process) are presented.
6. In Section 4.7, the findings, compiled as the Output Guidelines Version 2, are presented. These guidelines answer the second sub-research question (SRQ2), How did teachers' preparedness change during training?

In Section 4.8, Output Guidelines Version 1a, 1b and 2 are combined and presented, to present holistic findings of the research question: How can Foundation Phase teachers in KZN be prepared for teaching coding?

The data analysis results and findings, as listed in the above-mentioned steps have illustrated as to where they occurred in the AR cycle in Figure 4.1-1 below.

Figure 4.1-1 ***Data analysis results and findings in the AR cycle***

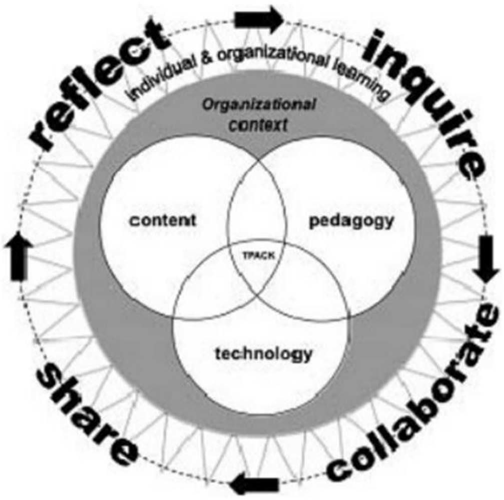


In recollection, this research aims to answer the question: How can Foundation Phase (FP) teachers in Kwa-Zulu Natal (KZN) be prepared for teaching coding? The research was based on observing an introduction to an unplugged coding course, surveying teachers through a survey instrument, and interviewing them through focus groups. The research aimed to discover if these teachers were prepared enough by the professional development (PD) course, to enter a classroom in the FP, and teach concepts of computational thinking (CT) through coding in-line with the Coding and Robotics curriculum.

The research will reveal the codes derived from the data collected from various data instruments. The research will also show how the codes were grouped to reveal the themes by revealing similar themes to the Assessment of Educational Technology Professional Development (ETPD) framework.

Remembering that the Assessment of ETPD framework consists of the Technological Pedagogical Content Knowledge (TPACK) framework as its core. The TPACK is based on the organisational context. The organisational context is dependent on the framework of individual and organisational learning (OL). OL is influenced by the framework of participant research and inquiry (PRI). The purpose of the Borthwick and Pierson model is to offer a model that explains the Assessment of ETPD through the integration of the three frameworks (Borthwick & Pierson, 2010). Figure 4.1-2 offers a reminder of the Assessment of ETPD model.

Figure 4.1-2 ***Assessment of ETPD model***

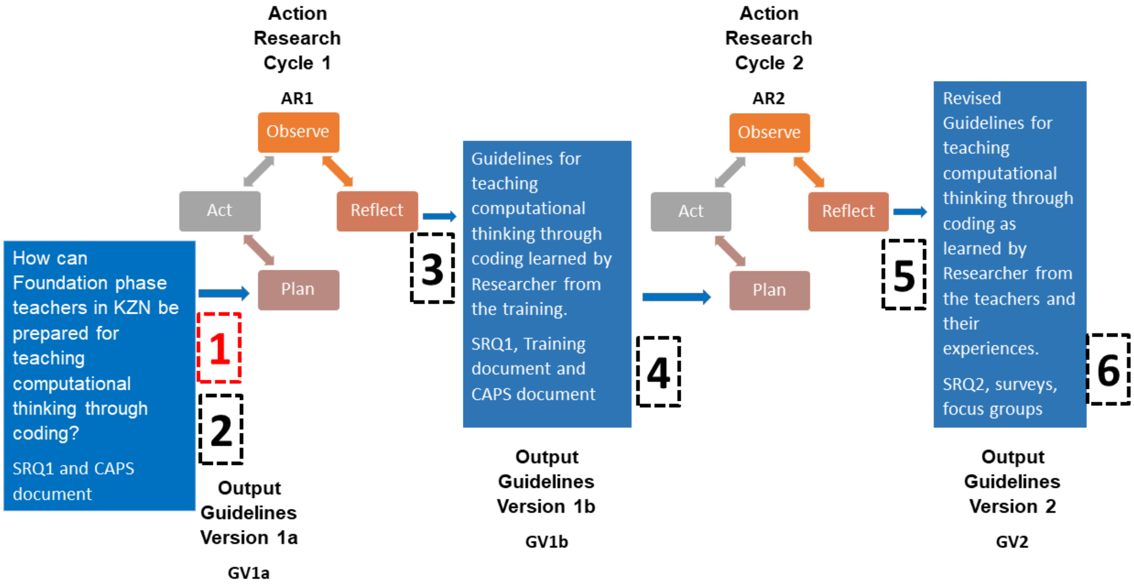


Note. From Borthwick and Pierson (2010).

The following is a presentation of the document analysis findings.

4.2 FINDINGS FROM THE DOCUMENT ANALYSIS (PRIOR TO ARC1)

Figure 4.2-1 ***Positioning of step 1 in the AR cycle***



As mentioned in section 3.8.1.3, data codes were derived from the document data. Data analysis must be represented in a transparent manner in order to conform with the conformability central to data analysis. Ensuring that data coding procedures are defined, rigorous, and consistently applied ensured the research was in line with the credibility, transferability, dependability, and conformability standards required in qualitative research.

To develop the data codes, sections of the text, “usually phrases or sentences” (Caulfield, 2022, p. 16) which convey the same sentiments, are summarised in short labels or phrases referred to as codes. Data codes describe what sentiments the phrases or sentences conveyed.

After coding the Coding and Robotics draft CAPS document, the following data codes were developed:

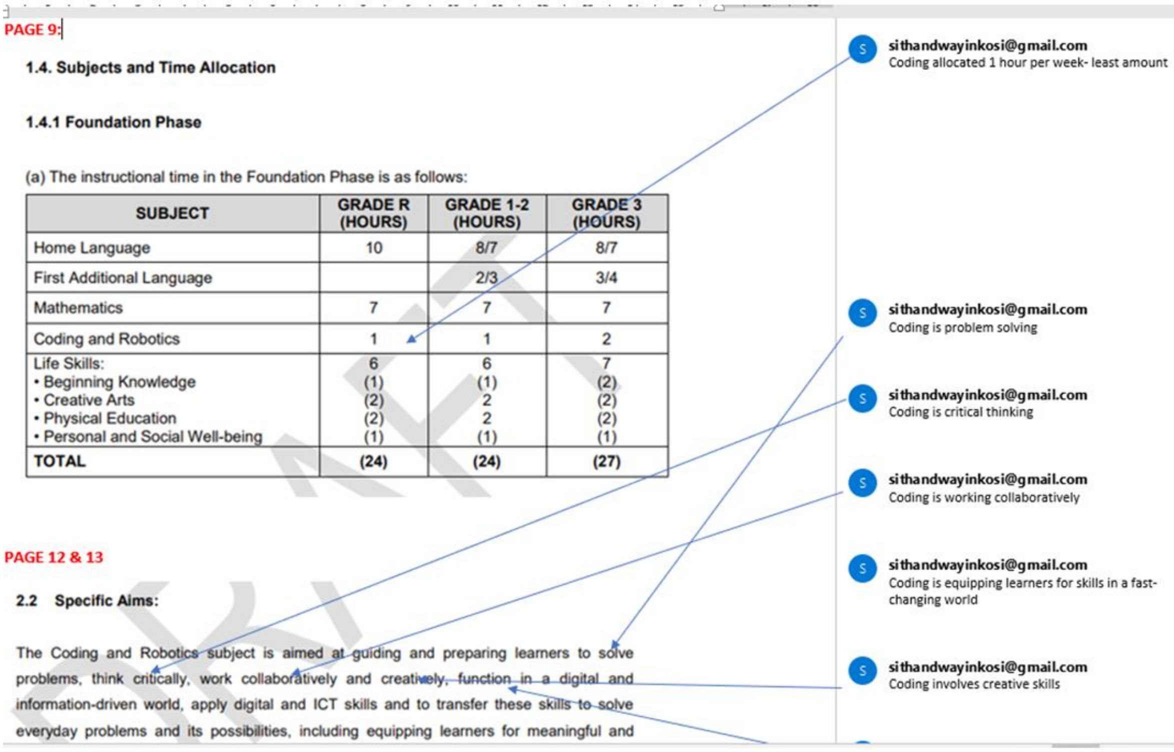
Table 4.2-1 ***Codes from the CAPS document***

Code Number:	CODE:
1	Coding is problem solving
2	Coding is pattern recognition
3	Coding is critical thinking
4	Coding involves creative skills
5	Coding is equipping learners for skills in a fast-changing world
6	Coding involves ict skills
7	Coding requires relevant resources
8	Coding requires a well-equipped lab
9	Coding resource are responsibility of the school
10	Teachers need to be trained in TPACK of coding
11	Coding involves people skills
12	Coding is working collaboratively
13	Coding teachers need access to various resources
14	Coding teachers need access to new relevant information
15	Coding needs free play
16	Coding allocated 1 hour per week- at least

The data codes are listed in an order that best explains the representation of the data as interpreted by the researcher (as mentioned in section 3.8.1.3).

An example of how few data codes were derived:

Figure 4.2-2 ***Deriving data codes from the CAPS document***


PAGE 9:

1.4. Subjects and Time Allocation

1.4.1 Foundation Phase

(a) The instructional time in the Foundation Phase is as follows:

SUBJECT	GRADE R (HOURS)	GRADE 1-2 (HOURS)	GRADE 3 (HOURS)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Coding and Robotics	1	1	2
Life Skills: • Beginning Knowledge • Creative Arts • Physical Education • Personal and Social Well-being	6 (1) (2) (2) (1)	6 (1) 2 2 (1)	7 (2) (2) (2) (1)
TOTAL	(24)	(24)	(27)

PAGE 12 & 13

2.2 Specific Aims:

The Coding and Robotics subject is aimed at guiding and preparing learners to solve problems, think critically, work collaboratively and creatively, function in a digital and information-driven world, apply digital and ICT skills and to transfer these skills to solve everyday problems and its possibilities, including equipping learners for meaningful and

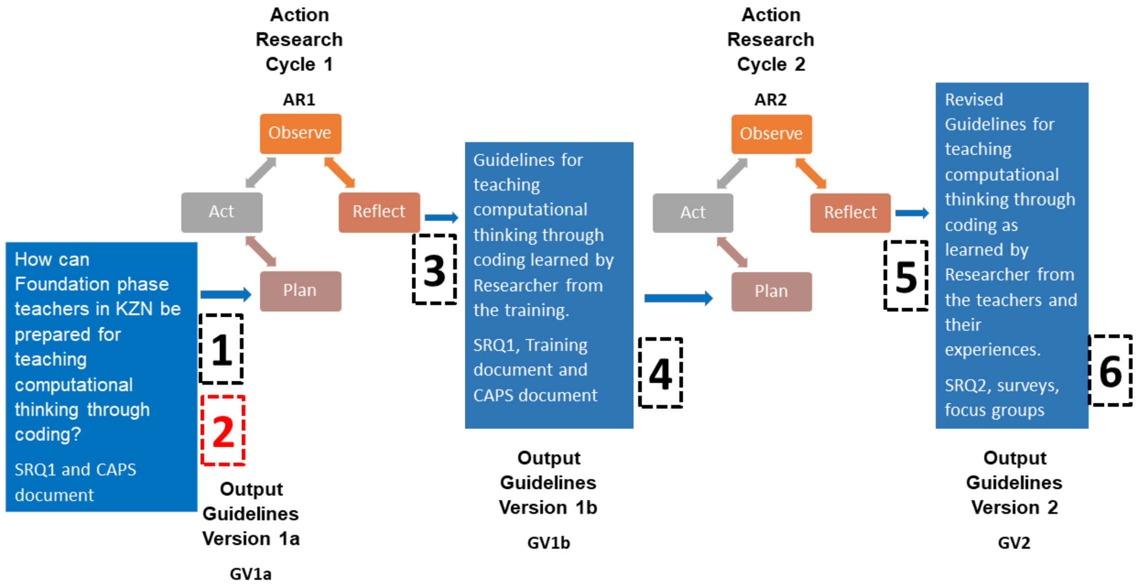
Note: Derived using MS Word.

Some data codes were determined by examining images or the data from tables, and finding keywords in context (Ryan & Bernard, 2003; Lamprou & Repenning, 2018; Noah, 2022), such as **code 16**, “Coding allocated 1 hour per week- at least”. This sentiment was observed on the table describing the instructional time for all subjects in the FP per week.

Some data codes were determined through word repetitions (Ryan & Bernard, 2003; Lamprou & Repenning, 2018; Noah, 2022) such as **code 1**, “Coding is problem solving”.

4.3 OUTPUT GUIDELINES VERSION 1A (PRIOR TO ARC1)

Figure 4.3-1 ***Positioning of step 2 in the AR cycle***



The data codes of the document data were rearranged under each aspect of the ETDP framework. They were also rephrased in a summarised manner that still retained the idea each data code convey. Rephrasing can be names that are used in the academic discipline literature, professional reading, or by the participants (Strauss & Corbin, 1990, as cited in Basit, 2003).

Figure 4.3-2 ***Codes from the CAPS document aligned with the TPACK***

	TPACK	REPHASED	ETDP ASPECT
TK	Coding involves ict skills	Technological teachability	TK
	Coding requires relevant resources	Relevant Resources	TK
	Coding requires a well-equipped lab	4IR equipped lab	TK
CK	Coding is problem solving	Analytic	CK
	Coding is pattern recognition	Sequencing	CK
	Coding is critical thinking	Strategic	CK
	Coding involves creative skills	Creativeness	CK
PK	Coding needs free play	Free-play learning	PK
TPACK	Educators need to be trained in TPACK of coding	Educators PD	PK, CK, TK
	Coding is equipping learners for skills in a fast-changing world	4IR Equipped	PK, CK, TK
	Coding allocated 1 hour per week- least amount	Effective Coding Education	PK, CK, TK

The data codes in Figure 4.3-2 were derived as the TPACK aspect of the ETPD framework in the following manner (see Table 4.3-1):

Table 4.3-1 ***Deriving data codes of the TPACK aspect of the ETPD frameworks***

Code No.:	Code:	Rephrased:	TPACK	Method of deriving
6	Coding involves ICT skills	Technological teachability	TK	Learning to teach coding needs teachers to have knowledge of ICT technology. To attend the course required an teacher who has the ability to access the internet. In addition, the BOATS app, though it is offline, requires the technological knowledge of a smart phone. Therefore, a teacher needs to either have the technological knowledge or be teachable technologically.
7 and 13	Coding requires relevant resources (and access to them)	Relevant resources	TK	Learning to teach coding needs teachers to have knowledge of about the relevant technological resources must be available to them.
8	Coding requires a well-equipped lab	4IR-equipped lab	TK	Learning to teach coding requires the knowledge of technology of a well-equipped lab in line with the 4IR requirements for effectively teaching coding.
9	Coding is problem solving	Analytic	CK	Learning to teach coding needs teachers to have knowledge of the analytical content of coding associated with problem solving.
2	Coding is pattern recognition	Sequencing	CK	Learning to teach coding needs teachers to have knowledge of the sequencing content of coding associated with pattern recognition.
3	Coding is critical thinking	Strategic	CK	Learning to teach coding needs teachers to have knowledge of the strategic content of coding associated with critical thinking.
4	Coding involves creative skills	Creativeness	CK	Learning to teach coding needs teachers to have knowledge of the creative content of coding associated with creative skills.
15	Coding needs free play	Free-play learning	PK	Learning to teach coding needs teachers to have knowledge of the pedagogical use of free-play as a teaching strategy.
10	Teachers need to be trained in the TPACK of coding	Teachers PD	PC, CK, TC	Learning to teach coding requires PD that is TPACK-aligned.
5	Coding is equipping learners for skills in a fast-changing world	4IR-equipped	PC, CK, TC	Learning to teach coding is learning to teach for the 4IR.
16	Coding allocated 1 hour per week- at least	Effective Coding Education	PC, CK, TC	Learning to teach coding knowledge effectively requires more time allocation

Figure 4.3-3 ***Data codes from the CAPS document aligned with the OL***

OL	REPHASED	ETDP ASPECT
Coding resource are responsibility of the school	Orginisational involvement	OL
Coding involves people skills	Sharing	OL
Coding is working collaboratively	Collaboration	OL

Figure 4.3-4 ***Data codes from the CAPS document aligned with the PRI***

PRI	REPHASED	ETDP ASPECT
Coding educators need access to new relevant information	Inquiring	PRI

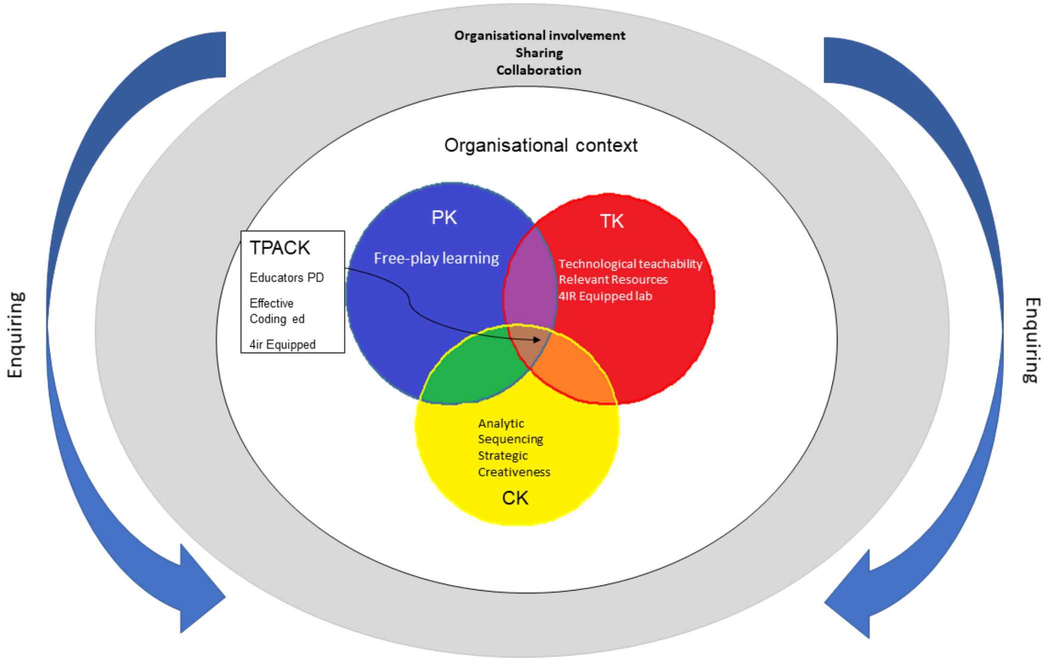
The data codes in Figure 4.3-3 and Figure 4.3-4 were derived as the OL and PRI aspects of the Assessment of ETPD framework in the following manner (see Table 4.3-2):

Table 4.3-2 ***Deriving data codes for the OL and PRI aspects of the ETPD framework***

Code No.:	Code:	Rephrased:	ETPD Aspect:	Method of deriving:
9	Coding resources are the responsibility of the school	Organisational Involvement	OL	Learning to teach coding requires the educational organisation needs to be actively involved in order for the educational needs to be met for effective learning to occur.
11	Coding involves people skills	Sharing	OL	Learning to teach coding needs teachers within an organisation to share knowledge and experiences to capacitate each other.
12	Coding is working collaboratively	Collaboration	OL	Learning to teach coding needs teachers withing and organisation to work together to capacitate each other.
14	Coding teachers need access to new relevant information	Inquiring	PRI	Learning to teach coding requires teachers need to have a personal interest in constantly researching new and relevant information to be well equipped to teach coding.

Using the data codes, alligned with each aspect of the ETPD framework, the results of the findings from the Coding and Robotics draft CAPS document informing the Output Guidelines 1a become vivid. Output Guidelines Version 1a have been graphically illustrated in the format of the framework model (Figure 4.3-5). The rephrase summary terms for each data code was used on the model.

Figure 4.3-5 ***Output Guidelines Version 1a***



Note. Depicted in the Assessment of ETPD framework model.

Gathered from the analysis of the Coding and Robotics draft CAPS document, is the Output Guidelines Version 1a which aim to answer SRQ1 asking: Which skills should teachers be prepared for to teach CT through coding? More specifically, the point: TPACK and skills (OL, PRI) is needed to teach CT through coding? (Section 1.5)

A teacher has to know the content of coding (CK), which explains coding as analytical, sequencing, strategy-based, and requiring creativeness.
A teacher has to have the technlogical aspects required to learn coding (TK). The teacher must be technologically teachable (willingness to be taught to use technology), have access to all the relevant resources reqired to learn coding, and have access to current 4IR demands for learning and teaching coding.

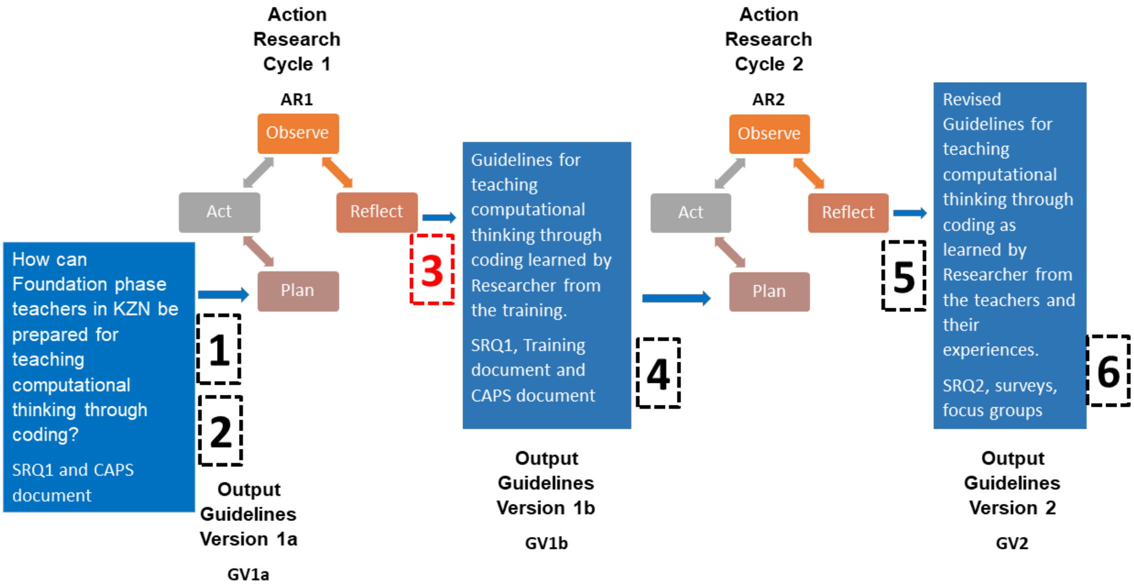
The above guidelines, according to the Coding and Robotics draft CAPS document, would ensure appropriate TPACK for a teacher to equip learners with skills necessarry for the 4IR in terms of coding.

The above guidelines (TPACK), depend on the organisational context (the white circle). Organasation context can be expanded if organisational involvement, sharing of ideas and collaboration occurs (OL).

OL is also reliant on constant inquiry by the organisation, in order to attain information and guidance that would make the organisational context conducive to TPACK, and thus, effectively helping to prepared KZN teachers to teach coding.

4.4 FINDINGS FROM THE OBSERVATION (DURING ARC1)

Figure 4.4-1 ***Positioning of step 3 in the AR cycle***



The data codes of the observation instrument were derived from the comments section in the instrument. The comment section had summarised noteworthy occurrences during the BOATS training course as shown in 3.7.2.2.

The BOATS training course observation instrument resulted in the following data codes:

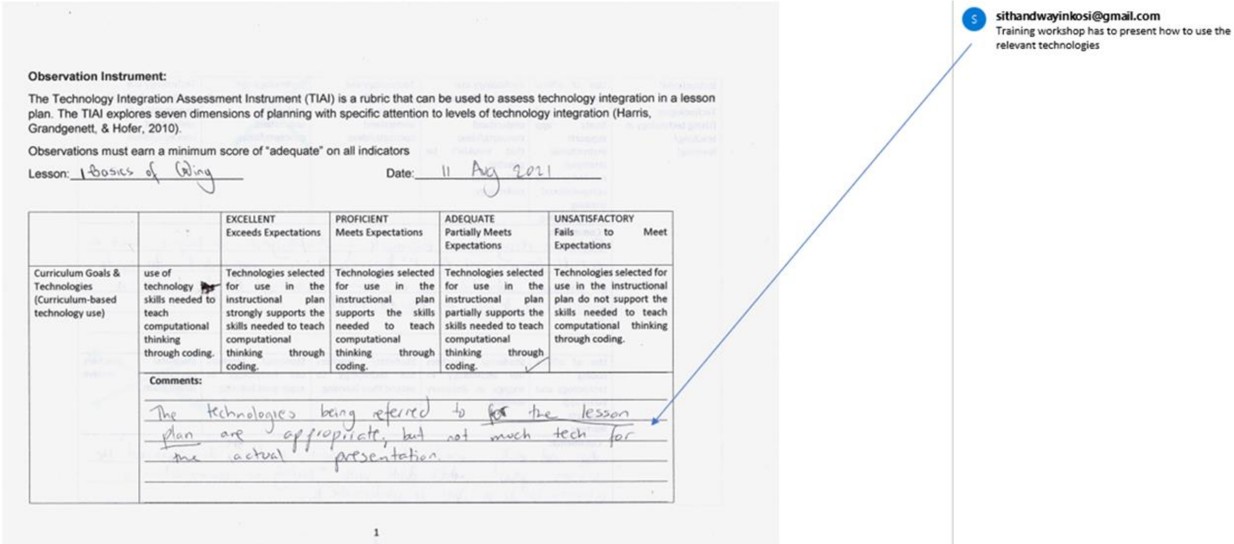
Table 4.4-1 ***Data codes from the observation instrument***

Code Number:	CODE
1	Teachers need to be trained in TPACK of coding
2	Coding training course presented in a manner that needs a person who has an idea about coding
3	Teachers expected to have prepared for training course
4	Teachers need to know the coding curriculum content
5	Teachers need relevance of coding to understand it
6	Some teachers already teaching coding in outside prescribed teaching time
7	Teachers currently teaching coding say Grade 1 learners are confused
8	Training course should be conducted like the lessons teachers will teach
9	Teachers need to be made aware of the relevant coding resources and how to use them
10	Training course has to present how to use the relevant technologies
11	Resources have to be in-line with the curriculum document
12	Coding teachers need access to various resources

The data codes are listed in an order that best explains the representation of the data as interpreted by the researcher (as mentioned in section 3.8.1.3).

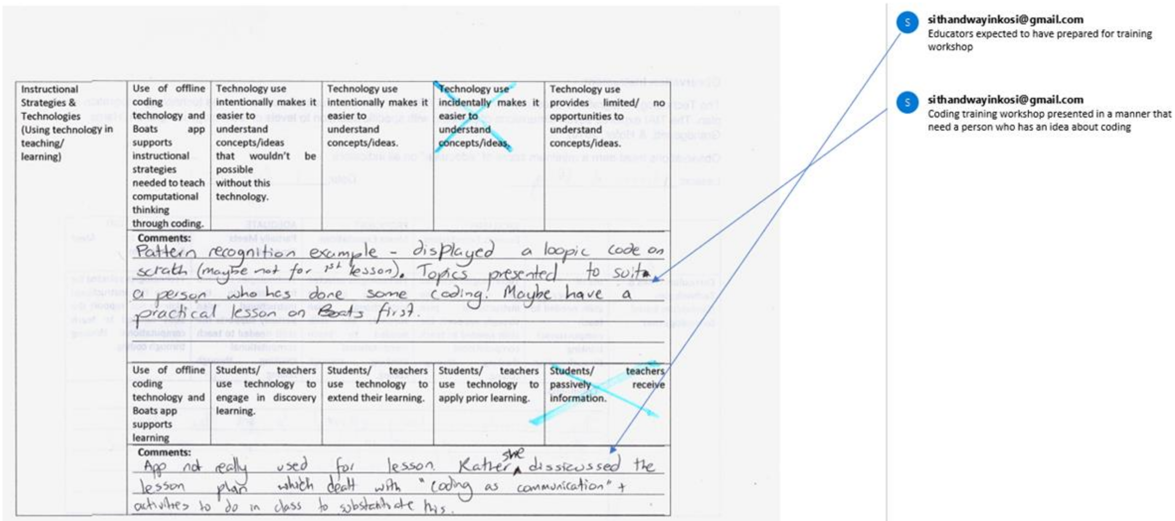
An example of how a few data codes were derived:

Figure 4.4-2 ***Deriving to a data code from the observation document***



*Note. E*xample of deriving the data code "Training course has to present how to use the relevant technologies" from the observation document.

Figure 4.4-3 ***Deriving to a data code from the observation document***



Note. Example of deriving the data codes "Teachers expected to have prepared for training course" and "Coding training course presented in a manner that needs a person who has an idea about coding" from the observation document.

Data coding comprised coming up with "shorthand labels" that described the larger content (Caulfield, 2019, p. 16).

These are examples of the data codes:

2. Coding training course presented in a manner that needs a person who has an idea about coding.
3. Teachers expected to have prepared for training course.
10. Training course has to present how to use the relevant technologies.

These data codes were derived from one or more occurrences from comments in the observation instrument of training course presentation. The examples of how the three data codes listed above (data **code 2, 3, 10**) were derived, is listed below:

An example of deriving data **code 3** above is the presenter (P) explaining that one does not necessarily need any additional resources throughout the training course presentation, but talks to the resources needed when teaching. For the BOATS training course presentation to be effective, it was of the opinion that the attending teacher should have attempted all the BOATS app coding levels. It was noticed that P made many references to activities done in the BOAT app, without going through those activities in the training course, and yet acknowledging on the first lesson that some teachers had not had exposure to the app. Therefore, the coding training was presented such that “teachers were expected to have prepared for training course”.

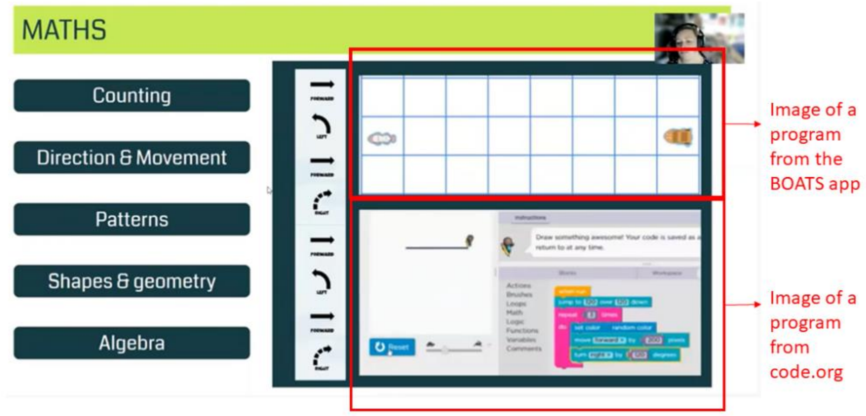
Another example of deriving data **code 3** above is in lesson 2 Presentation, when talking about debugging, P expressed how mistakes should be embraced in a coding class, as they allow for a learner to master debugging. P then referred to mistakes learners can make when working with the BOATS app.

> P: “so I often, when I'm doing an activity with learners- say we're doing a coding a big grid on the board. I'll show you an example actually when we do one of the lessons later. They give me an instruction and instead of turning me right they turn me left but you know what I just go along with it I turn left and the whole class goes ‘oh no’, but you know what it just it means that there's more problem solving to do.”

It would again seem that having worked through the BOATS app prior to the training course would have been a necessity in order for attending teachers to be advantaged in better understanding the topic presented. This would substantiate Dall'Alba and Sandberg’s (2006) suggestion for professional development (PD) to follow a developmental model "with fixed sequences of stages and levels of knowledge and skills". A teacher would have to attain the relevant content as a resource. Hence, one of the data codes discovered was, "teachers expected to have prepared for training course."

An example of deriving data **code 2** above is when P gave an overview of coding, and its use of Mathematics; also referred to a code on the BOATS app, and how counting is implemented in the programme, encompassing Mathematics. In addition, P talked about coding also incorporating Geometry in instances such as drawing of shapes, referring to an exercise on an online learning platform website, called code.org (see Figure 4.4-4 below).

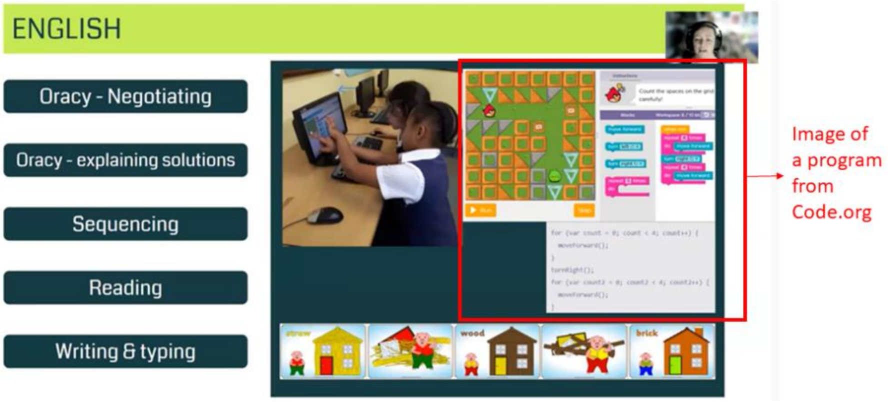
Figure 4.4-4 ***BOATS online Coding Lesson 2***



Note. Taken from BOATS online Coding Lesson 2.

References were made to the website, code.org, to explain the use Coding in English (see Figure 4.4-5 below). This gave rise to data **code 10**, "training course has to present how to use the relevant technologies."

Figure 4.4-5 ***BOATS online coding Lesson 2***



Note. Taken from BOATS online coding Lesson 2.

Working through coding websites such as code.org prior to the training course, would also be resourceful. It must be noted that the overview of these educational resources, in addition to the BOATS app, speaks to the nature of inquisitiveness that a teacher should have to be effective in implementing PD (Linn, 2006; Pierson & Borthwick, 2010). This is also noted in the data analysis coding in **code 3**, "Teachers expected to have prepared for training course".

In Lesson 4 of the presentation, P went into detail explaining the steps for solving a coding problem (the design thinking process). P explained the design thinking process using an example in the BOATS app. This is also where the **code 10** "training course has to present how to use the relevant technologies" became relevant. The design thinking process is explained based on the BOATS app, yet it was acknowledged that some teachers had not had any interaction with the app.

Figure 4.4-6 ***BOATS online coding Lesson 4***

Note. Taken from BOATS online coding Lesson 4.

4.5 OUTPUT GUIDELINES VERSION 1B (AFTER ARC1)

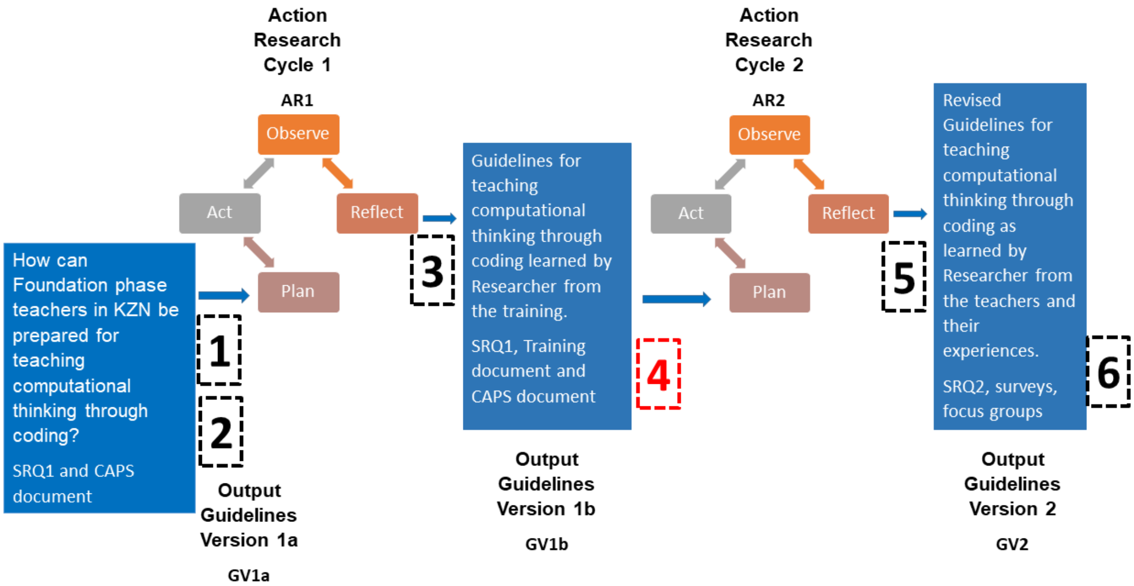
This section is outlined as follows:

4.5.1) Output Guidelines Version 1B

4.5.2) Discussion: Development of the guidelines from Output Guidelines Version 1a to Output Guidelines Version 1b

4.5.1 Output Guidelines Version 1b

Figure 4.5-1 ***Positioning of step 4 in the AR cycle***



The data codes of the observation instrument were rearranged under each aspect of the ETDP framework. The data codes were also rephrased in a summarised manner that retained the idea each code convey.

Figure 4.5-2 ***Data codes from the observation instrument aligned with the TPACK***

	TPACK	REPHASED	ETDP ASPECT
TK	Educators need to be made aware of the relevant coding resources and how to use them	Relavant Resources	TK
	Training workshop has to present how to use the relevant technologies	Resource-Based PD	TK
	Coding educators need access to various resources	Resource Access	TK
CK	Educators need to know the coding curriculum content	PD Curriculum Content	CK
	Educators need relevance of coding to understand it	Practical Curriculum Application	CK
	Resources have to be in-line with the curriculum document	Curriculum-Aligned Resources	CK
PK	Coding training workshop presented in a manner that need a person who has an idea about coding	Novice-based PD	PK
	Educators currently teaching coding say Grade 1 learners are confused	Pedagogical assisstance	PK
	Training workshop should be conducted like the lessons educators will teach	Lesson plan-based PD	PK
TPACK	Educators need to be trained in TPACK of coding	Educators PD	PK, CK, TK

The codes in Figure 4.5-2 were derived as the TPACK aspect of the Assessment of ETPD framework in the following manner (see Table 4.5-1):

Table 4.5-1 ***Deriving data codes of the TPACK aspect of the ETPD frameworks***

Code No.:	Code	Rephrased	TPACK Aspect	Method of deriving
9	Teachers need to be made aware of the relevant coding resources and how to use them	Relevant resources	TK	Learning to teach coding needs teachers to know the resources they can use to teach coding, and how to use them.
10	Training course has to present how to use relevant technologies	Resource-based PD	TK	Learning to teach coding requires PD on knowledge of how to use relevant technology resources.
12	Coding teachers need access to various resources	Resource Access	TK	Learning to teach coding requires access to various technology resources.
4	Teachers need to know the coding curriculum content	PD Curriculum Content	CK	Learning to teach coding needs teachers to have knowledge of the coding curriculum content.
5	Teachers need relevance of coding to understand it	Practical Curriculum Application	CK	Learning to teach coding needs teachers to have knowledge of the practical application of coding content in real life.
11	Resources have to be in line with the curriculum document	Curriculum Aligned Resources	CK	Learning to teach coding requires resources that are aligned with the curriculum content.
2	Coding training course presented in a manner that needs a person who has an idea about coding	Novice-based PD	PK	Learning to teach coding requires PD presentation to be aligned for teachers with novice knowledge.
7	Teachers currently teaching coding say Grade 1 learners are confused	Pedagogical Assistance	PK	Learning to teach coding needs teachers to be assisted with strategies of pedagogical knowledge.
8	Training courses should be conducted like the lessons	Lesson plan-based PD	PK	Learning to teach coding requires PD to presented aligned with the pedagogy of coding lesson plans presentation.
1	Teachers need to be trained in TPACK of coding	Teachers PD	PC, CK, TC	Learning to teach coding requires PD that is TPACK-aligned.

Figure 4.5-3 ***Data codes from the observation instrument aligned with the OL***

OL	REPHASED	ETDP ASPECT
Some educators already teaching coding in outside prescribed teaching time	Organisational Initiative	OL

Figure 4.5-4 ***Data codes from the observation instrument aligned with the PRI***

PRI	REPHASED	ETDP ASPECT
Educators expected to have prepared for training workshop	Educator Reflection	PRI

The data codes in Figure 4.5-3 and Figure 4.5-4 were derived as the OL and PRI aspect of the Assessment of ETPD framework in the following manner (see Table 4.5-2):

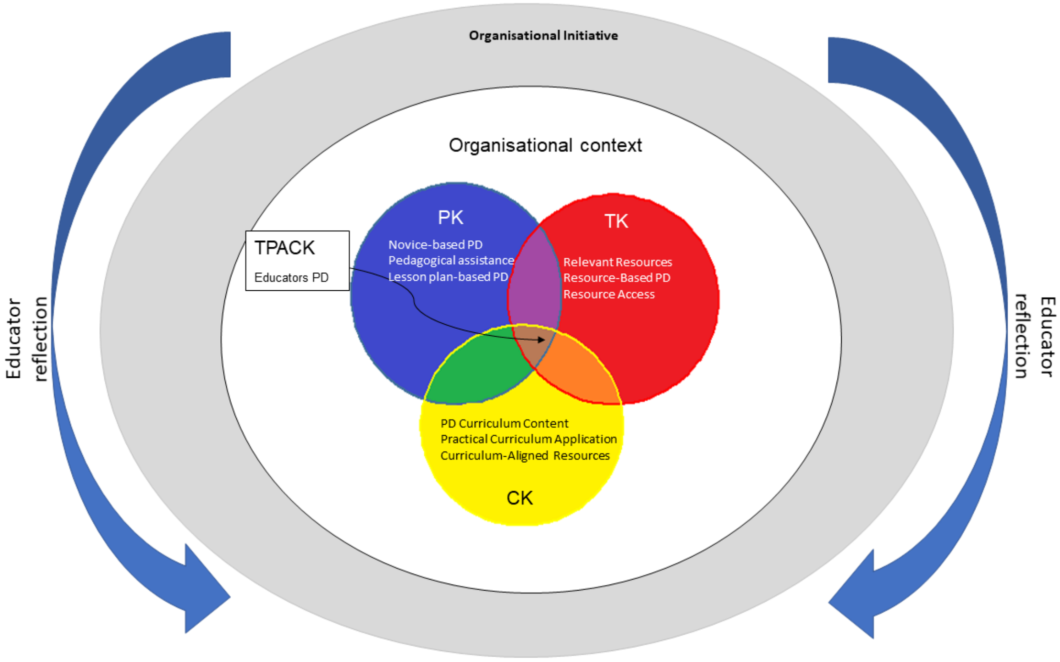
Table 4.5-2 ***Deriving data codes of the OL and PRI aspects of the ETPD frameworks***

Code No.:	Code	Rephrased	ETPD Aspect	Method of deriving
6	Some teachers already teaching coding outside of prescribed teaching time	Organisational Initiative	OL	Learning to teach coding requires the educational organisation to take an initiative in the introduction of coding.
3	Teachers expected to have prepared for training course	Teacher reflection	PRI	Learning to teach coding needs teachers within an organisation to reflect on PD content prior and post the PD.

Using the codes, now alligned with each aspect of the ETPD framework, the results of the findings from the training course observation instrument informing the Output Guidelines 1b become vivid. Output Guidelines Version 1b have been graphically illustrated in the format of the framework model (see

Figure 4.5-5). The rephrase summary terms for each code was used on the model.

Figure 4.5-5 ***Output Guidelines Version 1b***



Note. Depicted in the Assessment of ETPD framework model

Gathered from the analysis of observation data, is the Guidelines Version 1b, which also aim to answer SRQ1: Which skills should teachers be prepared for to teach CT through coding? As the Guidelines Version 1b were based on the observation data gathered from the BOATS training Course, aimed to answer the SRQ1 point: How does the BOATS training design and rollout address the TPACK, OL and PRI? (Section 1.5).

Data analysis of the BOATS training lesson plans and the course indicate that a teacher has to know the Content of coding (CK), by being professionally developed on curriculum content. The teacher must have content knowledge about curriculum-aligned resources. The teacher must also understand the practical application of coding curriculum. To elaborate on understanding the practical application of a subject's content would be an example of the content of sequencing and that of block movement taught in Grade R-3. An example of practical application of such content is a technology such as at the WeWALK Smart Cane for the blind and visually impared (Kulger, 2020). The cane is fitted with sensors that can be programmed to allow the user to avoid obstacles and move in a desired direction. Thus, the practical application of coding in everyday innovations that can be linked to the content taught in the FP, needs to be conveyed to teachers. In order for Technological knowledge (TK) to occur, data analysis suggested that there must be a knowledge of the relevant technological resources. PD must also demonstrate a practical application of all resources. Teachers must also have access to the resources. The teacher must also have Pedagogical Knowledge (PK), gained through PD, that speaks to novice teachers, offers pedagogical assistance, and demonstrate the implementation of lesson plans.

The above guidelines, according to the BOATS training lesson plans and the course, would ensure appropriate TPACK for a teacher to be professionally developed to teach coding.

The above guidelines(TPACK) depend on the organisational context (the white circle in Figure 4.5-5). Organisation context can be expanded if organisational intiative for PD occurs (OL). OL is also reliant on constant teacher reflection of PD by the organisation in order to attain information and guidance that would make the organisational context conducive to TPACK, and thus, effectively helping to prepared KZN teachers to teach coding.

4.5.2 Discussion: Development of the guidelines from Output Guidelines Version 1a to Output Guidelines Version 1b

Table 4.5-3 below shows the development of the guidelines from the Output Guidelines Version 1a, prior to ARC1 to the Output Guidelines Version 1b, after ARC1.

Table 4.5-3 ***Development of the guidelines from the GV1a, to GV1b***

ETPD Aspect	GV 1a	GV 1b	Development
TPACK- TK	Technological teachability		Technological teachability
TPACK- TK	Relevant resources	Relevant resources	Relevant resources
TPACK- TK	4IR-equipped lab		4IR-equipped lab
TPACK- TK		Resource-based PD	Resource-based PD
TPACK- TK		Resource Access	Resource Access
TPACK- CK	Analytic		Analytic
TPACK- CK	Sequencing		Sequencing
TPACK- CK	Strategic		Strategic
TPACK- CK	Creativeness		Creativeness
TPACK- CK		PD Curriculum Content	PD Curriculum Content
TPACK- CK		Practical Curriculum Application	Practical Curriculum Application
TPACK- CK		Curriculum Aligned Resources	Curriculum Aligned Resources
TPACK- PK	Free-play learning		Free-play learning
TPACK- PK		Novice-based PD	Novice-based PD
TPACK- PK		Pedagogical Assistance	Pedagogical Assistance
TPACK- PK		Lesson plan-based PD	Lesson plan-based PD
TPACK- PC, CK, TC	Teachers PD	Teachers PD	Teachers PD
TPACK- PC, CK, TC	4IR-equipped		4IR-equipped
TPACK- PC, CK, TC	Effective Coding Education		Effective Coding Education
OL	Organisational Involvement		Organisational Involvement
OL	Sharing		Sharing
OL	Collaboration		Collaboration
OL		Organisational Initiative	Organisational Initiative
PRI	Inquiring		Inquiring
PRI		Teacher reflection	Teacher reflection

The TK codes of the TPACK within the ETPD in the Output GV 1a were Technological teachability, Relevant resources, and 4IR-equipped lab. Output GV 1b also had the code Relevant resources, and the additional codes Resource-based PD, and Resource Access.

The CK codes of the TPACK within the ETPD in the Output GV 1a were Analytic, Sequencing, Strategic, and Creativity. Output GV 1b resulted in a development of codes, PD Curriculum Content, Practical Curriculum Application, and Curriculum Aligned Resources.

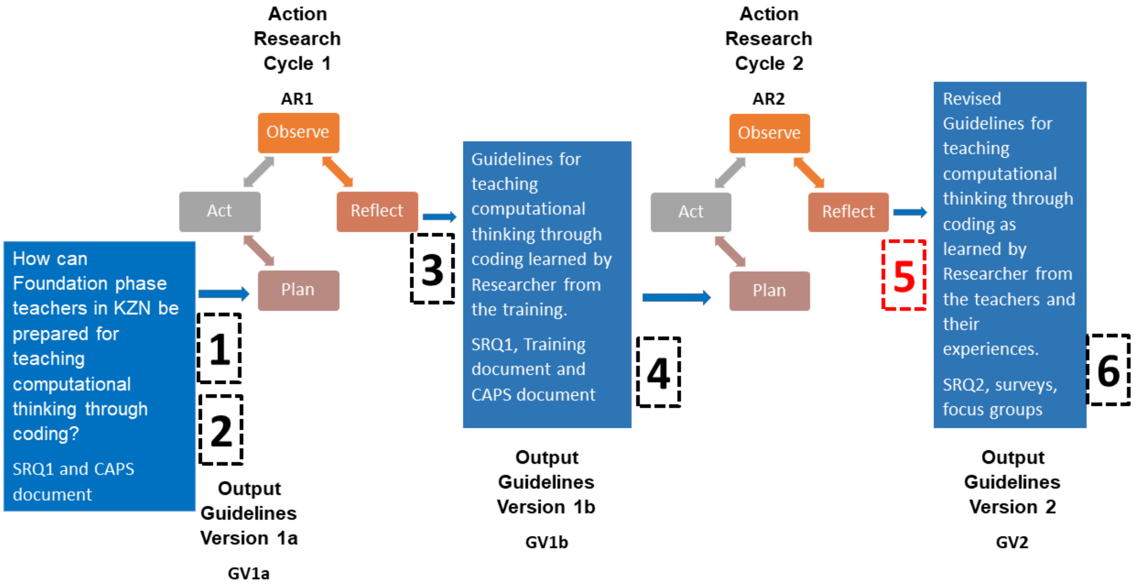
The PK code of the TPACK within the ETPD in Output GV 1a was Free-play learning. Output GV 1b resulted in the development of codes, Novice-based PD, Pedagogical Assistance, and Lesson plan-based PD.

Codes that aligned with all TPACK aspects within the ETPD in Output GV 1a were Teachers PD, 4IR-equipped, and Effective Coding Education. GV 1b also had the code Teachers PD.

The OL codes within the ETPD in Output GV 1a are Organisational Involvement, Sharing, and Collaboration. Output GV 1b resulted in a development of one code, Organisational Initiative.

4.6 FINDINGS FROM SURVEYS AND FOCUS GROUP (DURING ARC2)

Figure 4.6-1 ***Positioning of step 5 in the AR cycle***



This section combines data codes collected in three different instances during ARC2. These being from the survey, focus group session 1 and 2. To make for easier understanding in the writing, codes from the survey instrument will be referred to with a code reference, with the prefix S_. For example, data code number one from the survey instrument would be S_1. Data codes from the first focus group will be referred to with a code reference, with the prefix FG1_. For example, data code number one from the first focus group would be FG1_1. Data codes from the second focus group will be referred to with a code reference, with the prefix FG2_. For example, code number one from the second focus group would be FG2_1. The data codes were colour coded for ease of identification.

The data codes of the surveys and focus groups were derived from the comments section of answered surveys and the transcripts of the focus group.

The survey resulted in the following data codes:

Table 4.6-1 *Data codes from the survey instruments*

CODE REFERRENCE:	CODE
S_1	Teachers lack confidence in learning to teach coding
S_2	Coding is perceived as a difficult subject
S_3	Coding teaching strategies are easier to grasp as there is sequencing which is taught in "normal classes"
S_4	Coding needs new technology teaching and learning strategies
S_5	Coding requires working collaboratively with other teachers
S_6	Sharing of PD, teaching and learning strategies between teachers and organisation

Table 4.6-2 *Data codes from the Focus Group session 1 transcript*

CODE REFERENCE:	CODE:
FG1_1	Coding involves creative skills
FG1_2	Coding involves people skills
FG1_3	Coding is critical thinking
FG1_4	Coding is learning to give instructions
FG1_5	Coding is problem solving
FG1_6	Coding is sequencing
FG1_7	Coding can be unplugged
FG1_8	Coding needs unstructured learning
FG1_9	Coding needs more time allocation
FG1_10	Teachers need relevance of coding to understand it
FG1_11	Teachers need to know the coding curriculum content
FG1_12	Coding requires adaptive teachers
FG1_13	Coding is working collaboratively
FG1_14	Learning to teach Coding needs more time than a course

Table 4.6-3 ***Codes from the Focus Group session 2 transcript***

CODE REFERENCE:	CODE:
FG2_1	Coding needs unstructured learning
FG2_2	Coding teachers need access to various resources
FG2_3	Coding resource are responsibility of the school
FG2_4	Coding is working collaboratively
FG2_5	Learning to teach Coding needs more time than a course

An example of how a few codes were derived:

Question 1 of the survey asked if the participant felt confident before the training, in integrating offline coding technology in regular delivery of instructions.

Teacher 1A answered:

Figure 4.6-2 ***Deriving from data code S_1 and S_2 from the survey instrument***

Section A
Please answer in the spaces provided.

1	How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions?
	I was not very confident because I had no prior knowledge about coding and I thought it would be very difficult.

Note. Deriving from the code "Teachers lack confidence in learning to teach coding", and "Coding is perceived as a difficult subject", an example.

Teacher 2A answered:

Figure 4.6-3 ***Deriving to data code S_1 and S_2 from the survey instrument***

Section A
Please answer in the spaces provided.

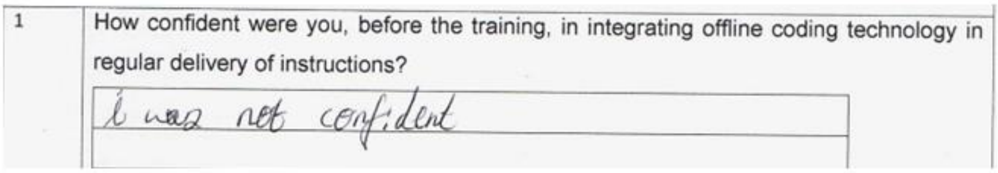
1	How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions?
	I was not so confident because I felt that coding would be really difficult.

sithandwayinkosi@gmail.com
Coding is perceived as a difficult subject

Note. Deriving from the code "Teachers lack confidence in learning to teach coding", and "Coding is perceived as a difficult subject", an example.

And Teacher 4A answered:

Figure 4.6-4 ***Deriving from data code S_1 and S_2 from the survey instrument***



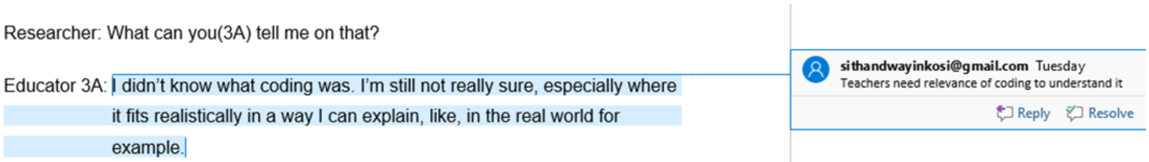
1 How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions?

I was not confident

Note. Deriving from the code "Coding is perceived as a difficult subject", an example.

It is of note that some codes for this research were developed based on word repetitions, such as in Figure 4.6-3 and Figure 4.6-4. Some codes for this research were developed based on searching for missing information in the content analysed (Ryan & Bernard, 2003; Lamprou & Repenning, 2018; Noah, 2022).

Figure 4.6-5 ***Deriving to data code FG1_10 from the focus group***

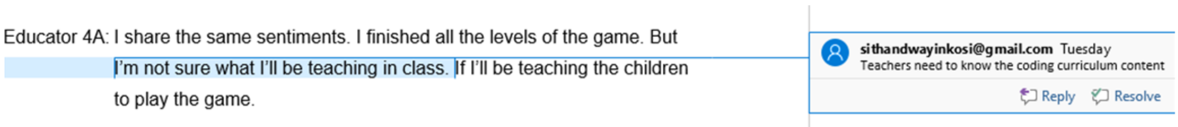


Researcher: What can you(3A) tell me on that?

Educator 3A: I didn't know what coding was. I'm still not really sure, especially where it fits realistically in a way I can explain, like, in the real world for example.

Note. Deriving from the code "Teachers need relevance of coding to understand it", an example.

Figure 4.6-6 ***Deriving to data code FG1_11 from the focus group***



Educator 4A: I share the same sentiments. I finished all the levels of the game. But I'm not sure what I'll be teaching in class. If I'll be teaching the children to play the game.

Note. Deriving to the code "Teachers need to know the coding curriculum content", an example.

Figure 4.6-5 and Figure 4.6-6 illustrate how coding was also developed based on keywords in context, comparing and contrasting answers (Ryan & Bernard, 2003; Lamprou & Repenning, 2018; Noah, 2022).

Of note, teacher 3A expressed not understanding the actual practical application of the training (see Figure 4.6-5) during the focus group session 1. This is where an example of an occurrence of the data **code FG1_10**, “Teachers need relevance of coding to understand it.”

It should be noted that Teacher 3A made the realisation of what Kember, Ho, and Hong (2008) express, of the need of establishing relevance in motivating student learning. Not understanding the practical application of a subject has also led to poor performances and lack of understanding in Mathematics and Science, according to some researchers (Mji & Makgato, 2006; Mazana, Montero, & Casmir, 2020).

This phenomenon of failing to understand coding, can be remedied by the teachers seeing it in practical “motion”, in a robot. Therefore, it seems Coding and Robotics, should be taught simultaneously in order to foster understanding (Francis, Khan, & Davis, 2016). Cuevas and Dawson (2018) also confirm this notion, and refer to Dual coding, as necessary to supplement the understanding of coding. They explain that use of Dual coding should benefit all learners as the visual superimposes the linguistic, allowing for easier understanding based on the combination of the two (Cuevas & Dawson, 2018).

From the surveys and the focus groups, codes surrounding the teachers' understanding of the basics of what coding is were discovered. Data codes derived were **FG1_5** (coding is problem solving), **FG1_7** (coding can be unplugged), **FG1_2** (coding involves people skills), **FG1_3** (coding is critical thinking), **FG1_4** (coding is learning to give instructions), **FG1_6** (coding is sequencing).
Some of the replies that led to the discoveries of the above-mentioned data codes are:

Teacher 1A: “She had told us that sequencing is important, and that was the main idea of coding. And that it had nothing to do with a computer at all. And she would use and example of the toothbrush and the toothpaste. Basically, we would be giving instructions to the little ones, or even the ones at the top. They have to follow an instruction to do something.”

Teacher 2A: “Yes, there’s a lot of planning and trying to figure out the quickest solution.”

Teachers 1B and 1C also noted what they have learnt about coding in their surveys. Teacher 1B: "We learnt about following instructions in order, and that is how a machine must be fed instructions."
Teacher 1C: "Sequencing is important in coding."

These data codes indicated that the teachers had an idea of what coding is. Other unexpected codes were discovered from the focus group. Data codes such as **FG1_1** (coding involves creative skills), and **FG1_8** and **FG2_1** (coding needs unstructured learning).

Teachers 1A, and 2A, already teaching coding in school A for an hour every day after school, noted some benefits in the learners they are teaching. The lessons are free from formal assessments, and were presented to the parents as a form of extramural.

Teacher 1A: "Yes, you know, even the learners who have problems with reading and writing in class, do very well with coding because they have a different way to express themselves without writing."

They did express that, they were taking an unstructured approach at teaching their current classes. The code was thus, "coding needs unstructured learning."

Teacher 2A: "Like I said earlier, we don't have the CAPS document or the ATP for the subject. But we can, well I can teach by going through the TANKS and the BOATS app, and Kelly's lesson plans."

Teacher 2A: "I think we obviously need a little more time to be familiar with what we'll be teaching. For now, it's fine because the class is for fun. We're not under pressure to produce results, so we are learning and also the little ones are learning with us."

The codes FG2_2 (coding teachers need access to various resources) and FG2_3 (coding resource are responsibility of the school) were coded from answers such as the following:

Teacher 1A: Having the BOATS kit early on, while we were still learning TANKS allowed us time to get used to it. The BOATS app as well. And also, the space to do coding in our school, the lab really helps.

Teacher 1A explained how school A had acquired the necessary resources for coding education, in addition to having a designated resource laboratory for ICT education. This allowed the teachers interested to familiarise themselves with the coding material prior to the training course.

Teachers 1A and 2A, in their surveys agreed that, after the course, they felt that they had the technical skills required to use the BOATS app and offline coding Technology. They admitted that they were part of the coding team at their school, and thus, attended other coding training prior to the BOATS training course. Teacher 1C mentioned that as much as the course boasted using readily available day-to-day items as resources; that required a teacher with a creative mind. 1C wished that a list of these items needed to complete the training and the lesson plans, at least be provided. Allexsaht Snider and Boz (2021) also stresses the importance of relevant resources as a necessity for teachers to effectively learn Coding and Robotics. In addition, they explained that merely having the resources was not enough, but rather teachers have to be guided on how to use them (Allexsaht-Snider & Boz, 2021). Martin (2015) also identifies that in order to increase teacher confidence, the use of technology should be specified in content and methods in a coursework.

In the focus group session two, the following question was posed:

Researcher: "What support systems do you have access to in your institution that can help or have helped with complementing the learning you have received from the training course?"

Whereby Teachers 1A and 2A answered.

Teacher 1A: "Our principal has been a great support. I was introduced, we all were introduced to coding by him."

Teacher 2A: "He is very passionate about coding, and the school coding team is preparing to train other teachers from other schools for Coding for

> Mandela day. So as that is allowing us to put what we have learnt to practice."

This is one such occurrence for the code **FG2_4** (coding is working collaboratively).

School A was able to secure a sponsorship from an Islamic Society in their area, and were able to obtain the BOATS kit prior to the training. This information was also discovered through engaging with the school's principal during a visit for the first focus group session.

Figure 4.6-7 ***BOATS offline coding kit***

Note. Image from BOATS training Lesson 2. "BOATS lesson plans", by K. Bush.

The school also has a robotics lab where learners are exposed to programmable robots, 3-d printers, virtual reality equipment, and other various advanced technology.

Figure 4.6-8 ***Computer Lab of school A***

Note. Image of the front of the Computer Lab of School A. Own Work.

With School B and C, the lack of resources was discovered through engaging with the principals. School B and C did not have furnished computer labs. School C did not have the funds to purchase the BOATS kit. School B had access to the BOATS kit, but the teacher expressed not having time to familiarise themselves with the kit.

The **code FG2_4** (coding is working collaboratively) is referring to working collaboratively in an institution, in order for teachers to learn coding. It was also used to define the collaborative working of learners who were engaged in the coding classes after school at school A.

Teacher 2A: "Especially the little ones, they are excited; because it's a lot of practical work, and they are working in groups. And they come to the front and get to act out their solutions. So, I think they are working quite well and excited to learn."

This can be seen below in Figure 4.6-9.

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Figure 4.6-9 ***Coding class in session at school A***

Note. Learners at School A engaging in BOATS lesson 2 in their coding period after school. Obtained from School A principal.

4.7 OUTPUT GUIDELINES VERSION 2 (AFTER ARC2)

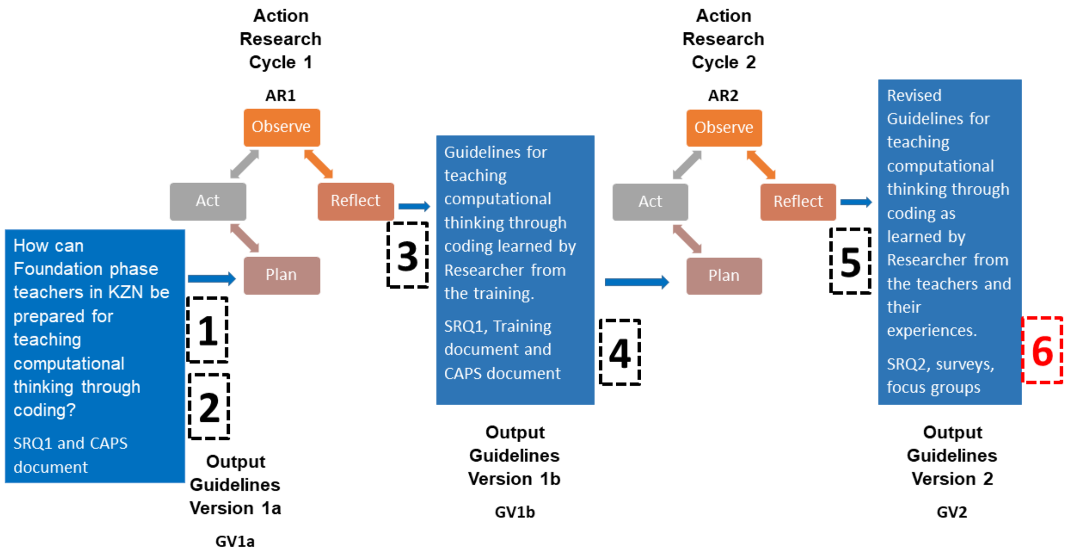
This section will be outlined as follows:

4.7.1) Output Guidelines Version 2

4.7.2) Discussion: Development of the guidelines from Output Guidelines Version 1a and 1b to Output Guidelines Version 2

4.7.1 Output Guidelines Version 1b

Figure 4.7-1 ***Positioning of step 6 in the AR cycle***



The data codes of the survey instrument and focus group sessions were rearranged under each aspect of the ETDP framework. They were also rephrased in a summarised manner that still retained the idea each data code convey.

Figure 4.7-2 ***Data codes from the survey instruments and focus groups aligned with the TPACK***

	TPACK	REPHASED	ETDP ASPECT
TK	Coding needs new technology teaching and learning strategies	Technological teaching	TK
	Coding educators need access to various resources	Relevant resources	TK
CK	Educators lack confidence in learning to teach coding	Confidence	CK
	Coding involves creative skills	Creativeness	CK
	Coding is critical thinking	Strategic	CK
	Coding is learning to give instructions	Sequencing	CK
	Coding is problem solving	Analytic	CK
	Coding is sequencing	Sequencing	CK
	Teachers need to know the coding curriculum content	Curriculum content	CK
	Teachers need relevance of coding to understand it	Practical Curriculum application	CK
PK	Coding is perceived as a difficult subject	Coding misconceptions	PK
	Coding teaching strategies are easier to grasp as there is sequencing which is taught in "normal classes"	Relating coding	PK
	Coding needs unstructured learning	Free-play learning	PK
	Coding needs more time allocation	Planning	PK
	Coding can be unplugged	Unplugged coding	PK
	Coding needs unstructured learning	Free-play learning	PK

The data codes in Figure 4.7-2 were derived as the TPACK aspect of the Assessment of ETPD framework in the following manner (see Table 4.7-1):

Table 4.7-1 ***Deriving codes of the TPACK aspect of the ETPD frameworks***

Code	Rephrased	TPACK Aspect	Method of deriving
Coding needs new technology teaching and learning strategies	Technological teaching	TK	Learning to teach coding requires the knowledge of new technologies.
Coding teachers need access to various resources	Relevant Resource	TK	Learning to teach coding requires access to various technology resources.
Teachers lack confidence in learning to teach coding	Confidence	CK	Learning to teach coding requires confident content knowledge.
Coding involves creative skills	Creativeness	CK	Learning to teach coding needs teachers to have knowledge of the creative content of coding associated with creative skills.
Coding is critical thinking	Strategic	CK	Learning to teach coding needs teachers to have knowledge of the strategic content of coding associated with critical thinking.
Coding is learning to give instructions	Sequencing	CK	Learning to teach coding needs teachers to have knowledge of the sequencing content of coding associated with giving instructions.
Coding is problem solving	Analytic	CK	Learning to teach coding needs teachers to have knowledge of the analytic content of coding associated with problem solving.
Teachers need to know the coding curriculum content	Curriculum content	CK	Learning to teach coding requires teachers to have knowledge of curriculum content.
Teachers need relevance of coding to understand it	Practical Curriculum Application	CK	Learning to teach coding needs teachers to have knowledge of the practical application of coding content in real life.
Coding is perceived as a difficult subject	Coding misconceptions	PK	Learning to teach coding requires the misconceptions of coding being difficult to be corrected through pedagogy.
Coding teaching strategies are easier to grasp as there is sequencing which is taught in" normal classes"	Relating coding	PK	Learning to teach coding needs teachers to have knowledge of making coding relatable through pedagogy.
Coding needs unstructured learning	Free-play learning	PK	Learning to teach coding needs teachers to have knowledge of the pedagogical use of free-play as a teaching strategy.
Coding needs more time allocation	Planning	PK	Learning to teach coding requires knowledge of pedagogical planning.
Coding can be unplugged	Unplugged coding	PK	Learning to teach coding needs teachers to have knowledge of unplugged pedagogical strategies.

Figure 4.7-3 ***Data codes from the survey instruments and focus groups aligned with the OL***

OL	REPHASED	ETDP ASPECT
Coding resource are responsibility of the school	Organisational involvement	OL
Coding involves people skills	Sharing	OL
Coding is working collaboratively	Collaboration	OL
Coding requires working collaboratively with other educators	Collaboration	OL
Coding is working collaboratively	Collaboration	OL
Learning to teach Coding needs more time than a workshop	Organisational initiative	OL
Learning to teach Coding needs more time than a workshop	Organisational initiative	OL

Figure 4.7-4 ***Data codes from the survey instrument and focus group aligned with the PRI***

PRI	REPHASED	ETDP ASPECT
Coding requires adaptive educators	Educator reflection	PRI
Sharing of PD, teaching and learning strategies between educators and organisation	Sharing	PRI
Learning to teach Coding needs more time than a workshop	Educator initiative	PRI
Learning to teach Coding needs more time than a workshop	Educator initiative	PRI

The data code in Figure 4.7-3 and Figure 4.7-4 were derived as the OL and PRI aspect of the Assessment of ETPD framework in the following manner (see Table 4.7-2):

Table 4.7-2 ***Deriving data codes of the OL and PRI aspect of the ETPD frameworks***

Code	Rephrased	ETPD Aspect	Method of deriving
Coding resources are the responsibility of the school	Organisational Involvement	OL	Learning to teach coding requires the educational organisation needs to be actively involved in order for the educational needs to be met for effective learning to occur.
Coding involves people skills	Sharing	OL	Learning to teach coding needs teachers within an organisation to share knowledge and experiences to capacitate each other.
Coding is working collaboratively	Collaboration	OL	Learning to teach coding needs teachers withing and organisation to work together to capacitate each other.
Learning to code needs more time than a course	Organisational Initiative	OL	Learning to teach coding requires the educational organisation to take an initiative in the PD of teachers.
Coding requires adaptive teachers	Teacher reflection	PRI	Learning to teach coding needs teachers who can reflect and take the initiative to adjust the fast-changing teaching demand.
Sharing of PD, teaching and learning strategies between teachers and organisation	Sharing	PRI	Learning to teach coding needs teachers who can reflect and take the initiative to learn from another teacher's PD.
Learning to code needs more time than a course	Teacher initiative	PRI	Learning to teach coding requires teachers need to have a personal interest to take an initiative in constantly capacitating themselves beyond PD..

Using the codes, now alligned with each aspect of the ETPD framework, the results of the findings from the survey instrument and focus group informing the Output Guidelines 2 become vivid. Output Guidelines Version 2 have been graphically illustrated in the format of the framework model (see Figure 4.7-5). The rephrase summary terms for each code was used on the model.

4.7.2 Discussion: Development of the guidelines from Output Guidelines Version 1a and 1b to Output Guidelines Version 2

Table 4.7-3 below shows the development of the guidelines from the Output Guidelines Version 1a and 1b, to the Output Guidelines Version 2, after ARC2.

Table 4.7-3 ***Development of guidelines from GV1a and 1b to GV2***

ETPD Aspect	GV 1a and 1b	GV 2	Development
TPACK- TK	Technological teachability	Technological teaching	Technological teachability
TPACK- TK	Relevant resources	Relevant Resource	Relevant resources
TPACK- TK	4IR-equipped lab		4IR-equipped lab
TPACK- TK	Resource-based PD		Resource-based PD
TPACK- TK	Resource Access		Resource Access
TPACK- CK	Analytic	Analytic	Analytic
TPACK- CK	Sequencing	Sequencing	Sequencing
TPACK- CK	Strategic	Strategic	Strategic
TPACK- CK	Creativeness	Creativeness	Creativeness
TPACK- CK	PD Curriculum Content	Curriculum content	PD Curriculum Content
TPACK- CK	Practical Curriculum Application	Practical Curriculum Application,	Practical Curriculum Application
TPACK- CK	Curriculum Aligned Resources		Curriculum Aligned Resources
TPACK- CK		Confidence	
TPACK- PK	Free-play learning	Free-play learning	Free-play learning
TPACK- PK	Novice-based PD	Coding misconceptions	Novice-based PD
TPACK- PK	Pedagogical Assistance	Planning, Unplugged coding, Relating coding	Pedagogical Assistance of planning, unplugged coding and relating coding
TPACK- PK	Lesson plan-based PD		Lesson plan-based PD
TPACK- PC, CK, TC	Teachers PD		Teachers PD
TPACK- PC, CK, TC	4IR-equipped		4IR-equipped
TPACK- PC, CK, TC	Effective Coding Education		Effective Coding Education
OL	Organisational Involvement	Organisational Involvement	Organisational Involvement
OL	Sharing	Sharing	Sharing
OL	Collaboration	Collaboration	Collaboration
OL	Organisational Initiative	Organisational Initiative	Organisational Initiative
PRI	Inquiring	Sharing	Inquiring and taking and initiative to learn from others
PRI	Teacher reflection	Teacher reflection	Teacher reflection

Of note only 5 new data codes that result from Output Guidelines Version 2. In , codes are highlighted in yellow. There they were in fact codes, those not equally phrased, but aligned with the code they are place next to from Guidelines Version 1a and 1b.

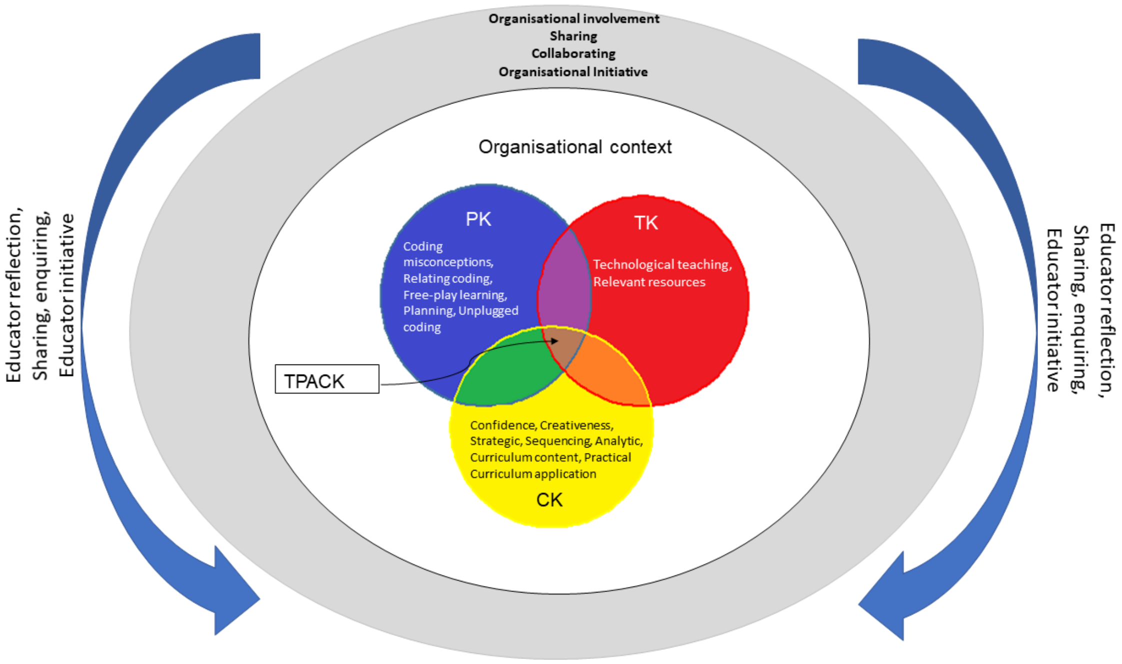
PK of Coding misconceptions from GV 2 speaks to the requirement for coding to be taught through Novice-based PD to dispel the idea that coding is difficult.

PK of Planning, unplugged coding and relating coding from GV 2, speaks to the need for pedagogical assistance in order to learn to teach coding.

ETPD Aspect	GV 1a and 1b	GV 2	Development
TPACK- TK	Technological teachability	Technological teaching	Technological teachability
TPACK- TK	Relevant resources	Relevant Resource	Relevant resources
TPACK- TK	4IR-equipped lab		4IR-equipped lab
TPACK- TK	Resource-based PD		Resource-based PD
TPACK- TK	Resource Access		Resource Access
TPACK- CK	Analytic	Analytic	Analytic
TPACK- CK	Sequencing	Sequencing	Sequencing
TPACK- CK	Strategic	Strategic	Strategic
TPACK- CK	Creativeness	Creativeness	Creativeness
TPACK- CK	PD Curriculum Content	Curriculum content	PD Curriculum Content
TPACK- CK	Practical Curriculum Application	Practical Curriculum Application,	Practical Curriculum Application
TPACK- CK	Curriculum Aligned Resources		Curriculum Aligned Resources
TPACK- CK		Confidence	
TPACK- PK	Free-play learning	Free-play learning	Free-play learning
TPACK- PK	Novice-based PD	Coding misconceptions	Novice-based PD
TPACK- PK	Pedagogical Assistance	Planning, Unplugged coding, Relating coding	Pedagogical Assistance of planning, unplugged coding and relating coding
TPACK- PK	Lesson plan-based PD		Lesson plan-based PD
TPACK- PC, CK, TC	Teachers PD		Teachers PD
TPACK- PC, CK, TC	4IR-equipped		4IR-equipped
TPACK- PC, CK, TC	Effective Coding Education		Effective Coding Education
OL	Organisational Involvement	Organisational Involvement	Organisational Involvement
OL	Sharing	Sharing	Sharing
OL	Collaboration	Collaboration	Collaboration
OL	Organisational Initiative	Organisational Initiative	Organisational Initiative
PRI	Inquiring	Sharing	Inquiring and taking and initiative to learn from others
PRI	Teacher reflection	Teacher reflection	Teacher reflection

Sharing in PRI from GV 2 speaks to the need for teachers' inquiry through taking initiative to learn from another teacher's PD.

Figure 4.7-5 ***Output Guidelines Version 2***



Note. Depicted in the Assessment of ETPD framework model.

Gathered from the analysis of the survey and focus group data, is the following guidelines for helping to prepare KZN teachers to teach coding:

Teachers require enough content knowledge to be confident in teaching coding. This content knowledge includes gaining creative, analytical, and sequencing skills required for coding. In addition, the Coding curriculum content, and the practical application of Coding curriculum.

Teachers also require resources, as they need to engage in technological teaching, and thus, must be technologically teachable.

Pedagogically, the misconceptions of coding being a difficult subject should be encouraged. In fact, coding can be related to currently taught subjects. Unplugged coding should be used to enourage the ease of learning coding, as well as strategies of free-play learning.

The above guidelines (TPACK) depend on the organisational context (the white circle). According to the survey and forcus groups data, organisational context can be expanded if there is organisational involvement, whereby the organisation ensures resources are available for effective coding education. There has to be sharing of skills learned and collaboration. The organisation has to take an initiative to professionally develop teachers beyond just a course (OL).

OL is also reliant on constant teacher reflection of knowledge acquired by teachers, and in turn, the organisation. Reflection requires sharing and taking an initiative to attain more knowledge on coding in order to make the organisational context, conducive to TPACK, and thus, effectively helping to prepared KZN teachers to teach coding.

4.8 CHAPTER SUMMARY

This chapter presented the main results and findings with regard to the preparedness and development of KZN FP teachers for teaching coding. The results and findings were obtained through different processes in AR cycles. The first was through a document analysis of the proposed Coding and Robotics CAPS document, then observation of a BOATS training course, then surveys conducted with attending teachers, and also focus group sessions with those teachers.

Each process revealed findings that were presented in line with the research framework, the Assessment of ETPD. A consolidation of all the findings from each stage in the AR cycles was then ultimately presented, answering the overall research question: How can FP teachers in KZN be prepared for teaching coding?

5. CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This research this research aimed to answer the question: How can Foundation Phase (FP) teachers in Kwa-Zulu Natal (KZN) be prepared for teaching coding? and to make recommendations for better preparedness. This was done through an Action Research (AR) strategy.

Qualitative data of available documents (CAPS document and literature) that guide the teaching of coding were analysed for guidelines on how (FP teachers should implement coding education. The BOATS training course was observed and analysed for qualitative data on its guidelines on how FP teachers should implement coding education. Willing participants were surveyed using a survey instrument and also engaged with in focus groups, in order to determine their readiness as FP teachers to teach coding.

This research was situated in an interpretive philosophical paradigm, incorporating the seven hermeneutic principles to ensure an interpretation by the researcher that reflected the true experiences of the participants. A deductive approach to theory development resulted in findings that were in line with the Borthwick and Piersons' (2010) Assessment Education Technical Professional Development (ETPD) Framework, represented as a model, that this research ultimately reinforced.

The research findings in each output part of the AR cycle were represented following the Assessment ETDP Framework model, in order to show the findings as encompassed within the framework.

The conclusions are presented in section 5.2. The research was not without limitations, and these are presented in section 5.3. The strengths and contributions of the research are presented in section 5.4, the recommendations in section 5.5, suggestions for future studies in section 5.6, and the final conclusion of the study in section 5.7.

5.2 DISCUSSION OF THE RESEARCH CONCLUSIONS

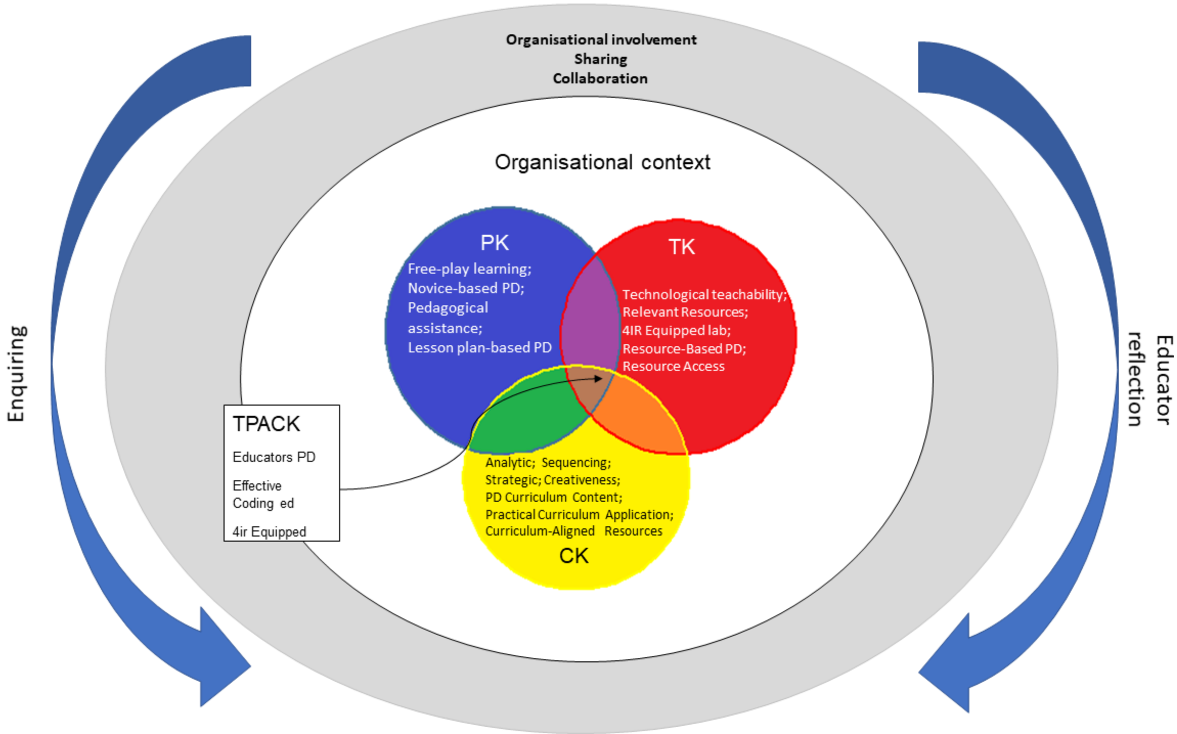
The research conclusions are presented according to the research questions, and in accordance with the output guidelines resulting from the action research. Sub-research question 1, and Sub-research question 2 are discussed prior to deliberations on the main research question.

5.2.1 SRQ1: Which skills should teachers be prepared for to teach computational thinking through coding?

Output Guidelines Version 1a and 1b (chapter 4) combined, guided the discussion of SRQ1. These findings emanated from the document analysis (CAPS and the BOATS training documents) and the observation data analysis.

Output Guidelines Version 1a and 1b have been combined in the model below to accommodate the discussion of SRQ1.

Figure 5.2-1 ***Output Guidelines Version 1a and 1b***



Note. Combined in the Assessment of ETPD framework model

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5.2.1.1 TPACK

Within an organisational context, there are TPACK aspects that teachers should be prepared for in order to teach coding. Section 2.6.1.2 provided a schematic definition of the three bodies of knowledge suggested by the TPACK framework. The research conclusions strengthen and expand on the specific nature of each of the three bodies of knowledge as provided by literature on preparing to teach coding.

a) *Technological knowledge (TK):*

According to Koehler and Mishra (2005, p.133), TK in the TPACK is knowledge of the technologies to be used. This was true for the research findings in answering SRQ1; with the findings showing the requirements for TK to occur.

The research findings revealed that *relevant resources are a necessity* for TK to occur, to foster the preparedness to teach coding. A well-resourced 4IR lab, such as the lab in school A, is necessary to provide space where technological knowledge can take place. This allows teachers space, and assurance that it is possible to easily learn and make use of technologies.

In order for teachers to have the knowledge of resources to use, *resource-based professional development (PD)* is needed. Such a PD should *standardise the specific resources* teachers can use for specific concept learning. Indicating examples of informal resources helps teachers to be resourceful, but can lead to confusion for teachers who are in the infancy stage of preparing to teach coding, if the informal resources are not standardised.

The research findings showed that teachers *need access to all necessary resources prior, during, and post* the PD in order to be effectively prepared to teach coding.

A finding that offered a different view from the research literature review, and not highlighted in the theoretical framework is that teachers should be *technologically "teachable"* in order for TK to occur. A *positive attitude* towards learning about new technologies will promote the preparedness to teach coding, while a negative one will not allow a teacher to be prepared effectively to teach coding. The research found that the technological teachability of a teacher can support development on the TK in the TPACK aspect of the Assessment of ETPD framework.

b) *Pedagogical Knowledge (PK):*

According to Koehler and Mishra (2005, p.133), PK in the TPACK is knowledge of the method and practice of teaching. This was true for the research's conclusions in answering SRQ1; with the findings identifying the requirements for FP coding PK to occur.

The research findings revealed that teachers need to understand *how to implement free-play learning*. Coding requires constructive free-play learning as a teaching process in the FP.

Findings that offered a different view from the research literature review and were not highlighted in the theoretical framework is that, PD should be presented to teachers in a way that assumes teachers *have no knowledge about the concept of coding*. Teachers should be presented with a novice-based PD for their preparedness to teach coding to occur effectively.

The research findings indicated that teachers should be prepared through pedagogical *assistance that is detailed and tailored to the curriculum*. This could be chieved through lesson plan-based PD, with lesson plans in line with the curriculum.

c) *Content Knowledge (CK):*

According to Koehler and Mishra (2005, p.133), CK in the TPACK is knowledge about the subject matter to be learned or taught. This was true for the research conclusions in answering SRQ1, with the findings extending on the requirements for CK to occur.

The research findings revealed that teachers should be prepared to learn *analytical (problem solving), and sequencing knowledge*. Teachers should understand that coding is the learning of skills, and strategies and creativity associated with problem solving and sequencing. This is because teachers often associate coding with only the writing code on a computer, and see it as a skill reserved for the elite, and shy away from professional development associated with coding.

Teachers should be prepared to teach coding by being granted access to a *simplified version of the curriculum content*. CK about curriculum-aligned resources should be promoted to empower teachers in their preparedness to teach coding.

A finding that provides a different view from the literature review and not highlighted in the theoretical framework is that, in order to remove the stigma of exclusiveness associated with coding, teachers should be taught about *the practical application of coding in everyday life*. This should allow better understanding of the content knowledge required to teach coding.

In addition, the research findings indicated that TPACK will then be promoted when there is conducive PD for teachers occurring. Learners should then be on track with being equipped for the fast-changing world in the fourth industrial revolution.

5.2.1.2 Organisational learning

The organisational context is subject to organisational learning (OL).

OL, as mentioned in section 2.6.1.3.1 describes a process where learning experienced by the individual is also shared with the organisation (Really Learning, 2013) will occur if there is *organisational involvement,* as discovered in the research's findings. Teachers need the involvement of an organisation in order to teach computational thinking through coding. This entails the complete involvement of the schools' management team. As demonstrated in school A, the principal also attended the training course, allowing invested and informed interest in implementing the introduction of coding. Such involvement will also allow for informed procurement of resources that will be of benefit to the teaching of coding. This finding also expands on the literature. Simon (1991) says one of the ways in which learning can occur in the workplace is by learning from the members as they develop themselves. What is different in the research findings from the literature is that *OL* has to occur *at the level of the School Management Team as well as the teacher.*

Contrary to the literature reviewed in section 2.6.1.3.1, there is no specific explanation on how the organisation will learn from its members (Hariharan & Vivekanand, 2017). The research findings revealed that teachers should be *prepared to share and collaborate with each other*, not just strategies, but also experiences within an organisation in order to expand the organisational context. A greater understanding of the organisational context outside of peripheral view, could open to all teachers, leading to a more combined effort of the organisational context.

To spark organisational involvement, education should have skills for constant research and inquiry into providing education which is 4IR aligned.

5.2.1.3 Participant research and inquiry

Participant research and inquiry (PRI), as mentioned in the literature section 2.6.1.3.1, allows teachers to evaluate their practice as a form of PD (Linn, 2006; Borthwick & Pierson, 2010).

The research findings revealed ways to strengthen what was explained in the literature; that *teacher access to new and relevant information* fosters skills such as *reflection and enquiring,* that encourage research and inquiry.

In addition, research findings that offered a different view from the literature review, is that *teachers should be given access to the content and technology to prepare for PD* prior to attending to accommodate participant research and inquiry.

5.2.2 SRQ2: How do teachers' preparedness change during unplugged coding training?

According to the findings in chapter 4, Output Guidelines Version 2 provided the findings of SRQ2. These findings are a result of the interview and focus group data analysis.

5.2.2.1 TPACK

Within an organisational context, there are TPACK aspects that changed, or rather were brought into awareness, during the BOATS training course, for teachers. This allowed to analyse if they were prepared to teach coding. Section 2.6.1.2 provided us with a schematic defining the three bodies of knowledge suggested by TPACK framework. The research findings strengthen and expand on the specific nature of each of the three bodies of knowledge as provided by literature in preparing to teach coding in the following manner:

a) *Technological Knowledge:*

Participants revealed that teaching coding requires *new technological teaching and learning strategies*. Teaching coding is teaching critical thinking, and therefore, needs the *learner to be engaged and actively participating*.

They also noted that teaching coding calls for a teacher to *utilise various resources* for concept illustration. These findings strengthen the literature as substantiated by Brennan and Resnick (2012), and Allexsaht-Snider and Boz (2021) that coding is linked to self-expression, creativity, and innovation, needed by students' creators and innovators (section 2.2.2).

b) *Pedagogical Knowledge:*

Findings that offered a different view from the literature review and not highlighted in the theoretical framework is that the participants' views on being prepared to teach coding changed during the BOATS coding training course as they debunked the misconceptions of coding being difficult. The teachers felt *coding concepts can be related to concepts taught in other subjects*, for example, sequencing in English. The research's findings indicate that this would strengthen pedagogical knowledge needed to teach coding in FP.

Findings that correspond to literature include *that teaching coding in FP requires free-play learning*, as advised by the draft CAPS document (DBE, 2021). In lieu of that, the teachers felt that *coding needs extensive planning to be taught*, and more time allocation for teachers to teach coding given its pedagogy. They also felt that *unplugged coding means coding could eventually be easily learnt*.

c) *Content Knowledge:*

Findings that offered a different view from the literature review and not highlighted in the theoretical framework are that it was noted that participants *lacked confidence* *to teach coding as a result of a lack of content knowledge* for teaching coding. This finding speaks to Kong and Wong's (2017) 4th point in the competencies representing what Dall'Alba and Sandberg's (2006) termed successively higher levels of knowledge and skills acquisition. It explains that teachers need to have the ability to overcome non-cognitive factors such as lack of confidence or anxiety in teaching coding (section 2.4.2).

The teachers noted the concepts they have learned from the course, which are the main themes in coding, such as critical thinking, creativity, learning to give instructions, sequencing, and problem solving. These findings are supported by the literature (Angeli et al., 2016; DBE, 2021; DoE England, 2013; Fowler, Hansen, & Vegas, 2021) as depicted in globally practiced coding (and robotics) curriculums in section 2.3.2, in intended South African coding (and robotics) curriculum in section 2.3.3, and in section 2.4.2 (Dall'Alba & Sandberg, 2006; Kong & Wong, 2017). The teachers still felt they needed to have *knowledge of the* actual *curriculum content* (such as the CAPS document) and be aided with *aligned lesson plans*.

The findings revealed that there was still *confusion as to what coding really is*, as the scope of understanding its practical component was not one the participants had witnessed. This finding substantiated the idea that computational thinking involves three key dimensions as explained by Brennan and Resnick (2012); and Haseski, Ilic and Tugtekin (2018) in section 2.2.1. The third dimension, as explained by Wing (2014), is computational perspectives, where computational thinking is realised through automation and modelling; in order to be fully understood. Thus, research findings correspond to the literature, providing evidence of CK not fully occurring without the presence of all three dimensions mentioned in section 2.2.1. The teachers continued to refer to the BOATS application as a game, rather than a concept for teaching basic coding skills because they had not yet implemented coding skills practically.

5.2.2.2 Organisational learning

Teachers 1A and 2A from school A noted in the surveys that the involvement of management encouraged their confidence with learning to teach coding, and also teaching it extramurally. Decisions about teaching coding in school A were taken through sharing, collaborating, and organisational initiative. These findings indicate a form of *constant PD* in school A, as explained by Bain, et al. (2019) in section 2.5.1, where it is explained that informal consultations with colleagues, and conducting research should also be considered as PD. This finding strengthens two of the three Organizational Learning theories mentioned by Leavitt (2011) in the literature section 2.6.1.3.1. First is the Adaptive and Generative Learning Theory which lists personal mastery that builds shared vision, team learning, and systems thinking as the traits required for organisational learning to occur. Research findings display *building shared vision, team learning, and systems thinking* as being present in school A. The second is the Assimilation which believes organisational learning will occur in the three stages of *acquiring knowledge, sharing knowledge, and using that knowledge*, as observed in the finding.

5.2.2.3 Participant research and inquiry

Emerging from the data is that the teachers realised from the training course that teaching coding requires teacher reflection. A teacher needs to be adaptive to the fast-changing world and technologies. The instructor made references to various coding platforms even though the training was about the BOATS application. This indicated the *knowledge of multiple platforms of coding* required for the coding teacher to understand. Thus, *constant sharing* is needed *between teachers*. Teachers 1A and 2A were in-sync with one another in terms of information sharing in the focus group. The two teachers were also part of a coding team in school A with the principal. Being part of the team was voluntary. Data indicates the *initiative* was a result of research and inquiry as teachers from school A had attended a coding course prior to the BOATS training course, and the school thereafter, initiated the coding team. These findings confirmed the literature. As explained in section 2.6.1.3.1, PRI allow teachers to have a variety of ways in which they look at their practice, as a form of PD (Linn, 2006; Borthwick & Pierson, 2010). Teachers 1A and 2A did so by collaborating with one another to inform future teaching plans.

The teachers' preparedness during unplugged coding training didn't quite change, but data rather suggests that they became more aware of the scope of change they need to undergo in their TPACK and that needs to occur within their organisations in order to teach coding.

What the BOATS unplugged coding training changed for the teachers is the PRI, as the course sparked teacher reflection, sharing, enquiring, whether positive or negative, into their readiness to teach coding. The course sparked teacher realisation that *learning to teach coding requires more than just a course* for teachers alone.

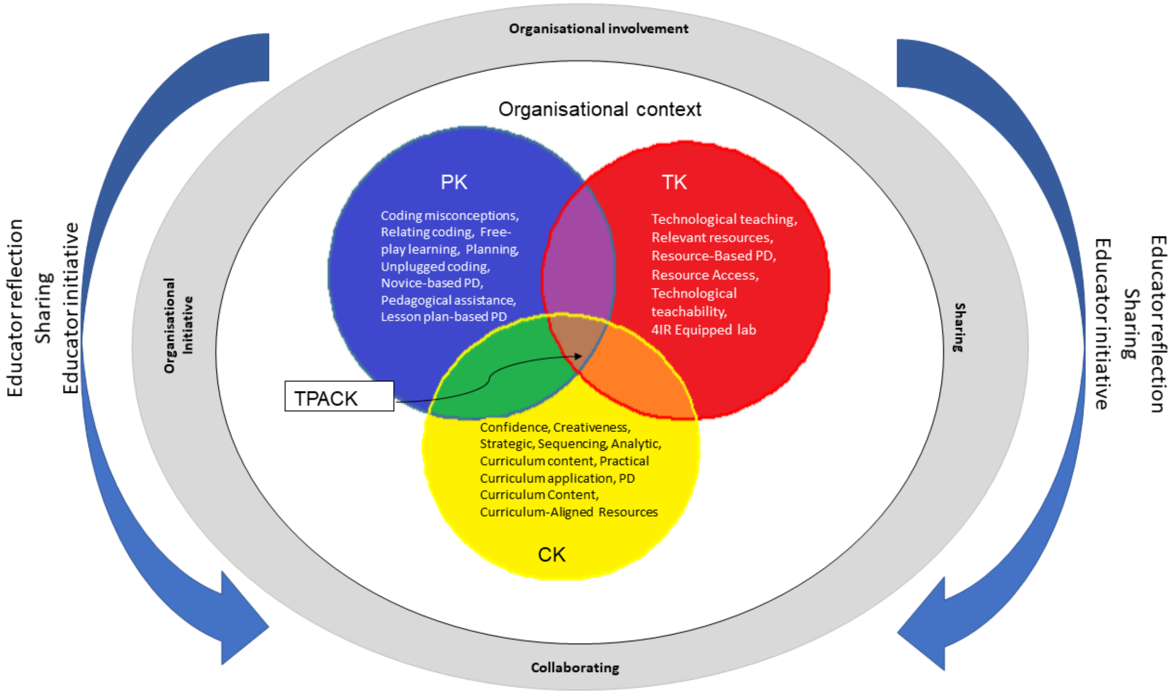
5.2.3 Main research question: How can Foundation Phase teachers in KZN be prepared for teaching computational thinking through coding?

The research findings suggest that the ETDP framework rather works as an oscillating process as growth occurs. The process begins by moving from the outer layer (PRI), to the inner layer (TPACK), explaining how organisations can prepare FP teachers in KZN for teaching coding. It also then moves from the inner layer (TPACK) to the outer layer (PRI) explaining how FP teachers in KZN can be prepared for teaching coding and influence the organisation.

Data findings suggest that the ETDP framework works in an oscillating process, first from the outer layer (PRI), to the inner layer (TPACK) and then from the inner layer (TPACK) to the outer layer (PRI). This analogy can be used to answer the main research question.

According to the research findings, FP teachers in KZN can be prepared for teaching coding by applying Output Guidelines holistically in what the research has termed the Final Output Guidelines below. The Final Output Guidelines combined the Output Guidelines version 1a, 1b, and 2.

Figure 5.2-2 ***Final Output Guidelines***



Note. Final Output Guidelines are a combination of Version 1a, Version 1b, and Version 2 as depicted in the format of the Assessment of ETPD framework model.

The finding will be presented in the oscillating motion:

- 5.2.3.1 Participant research and inquiry
- 5.2.3.2 Organisational learning
- 5.2.3.3 TPACK
- 5.2.3.4 Organisational learning
- 5.2.3.5 Participant research and inquiry

<u>Moving from the outer layer to the inner layer:</u>

5.2.3.1 Participant research and inquiry

Constant PD of FP teachers in KZN, teaching them how to teach coding, is necessary to invoke teacher initiative, sharing and reflection.

5.2.3.2 Organisational learning

This constant professional development should include the school's management team so that complete organisational involvement can occur. Such organisational involvement would be accompanied by collaborating, sharing, and organisational initiatives that allow FP teachers in KZN to be prepared for teaching coding.

5.2.3.3 TPACK

With the above, TPACK should then fall into place.

a) *Technological knowledge:*

Capacitation of teachers with technological teaching, relevant resources, resource-based PD, resource access, become technological teachable, have 4IR equipped lab.

b) *Pedagogical knowledge:*

Disproving of coding misconceptions, relating coding easily to other subjects, constructive free-play learning, planning of lessons, teaching through unplugged coding, novice-based PD, lesson plan-based PD within the organization, and pedagogical assistance.

c) *Content Knowledge:*

Boosting teachers' confidence for each coding, the creativity, possession of strategic sequencing and analytical skills needed in coding, knowing the curriculum content, practical curriculum application, using curriculum-aligned resources, and developing each other in curriculum content.

<u>Moving from the inner layer to the outer layer:</u>

Constant professional development of FP teachers in KZN in the TPACK of teaching coding would entail the knowledges discussed below.

a) *Technological knowledge:*

Capacitation of teachers with technological teaching, relevant resources, resource-based PD, resource access, becoming technological teachable, and 4IR equipped lab.

b) *Pedagogical knowledge:*

Disproving of coding misconceptions, relating coding easily to other subjects, constructive free-play learning, planning of lessons, teaching through unplugged coding, novice-based PD, lesson plan-based PD within the organisation, and pedagogical assistance.

c) *Content Knowledge:*

Boosting teachers' confidence for each coding, creativity, possessing of strategic, sequencing and analytical skills needed in coding, knowing the curriculum content, and the practical curriculum application, using curriculum-aligned resources, and developing each other on curriculum content.

This above constant professional development in TPACK should include the school management team.

5.2.3.4 Organisational learning

Organisational involvement then occurs. Such organisational involvement would be accompanied by collaborating, sharing, and the breading organisational initiatives that allow FP teachers in KZN to be prepared for teaching coding.

5.2.3.5 Participant research and inquiry

Constant professional development of FP teachers in KZN (including the involvement of the organisation), teaching teachers how to teach coding is necessary to invoke initiative, sharing, and reflection. The PRI invoked would be that of the organisation as a whole.

5.3 LIMITATIONS OF THE RESEARCH

Although one seeks perfection when conducting research, shortcomings are unavoidable. "All research has limitations" (Drisko, 2005, p 592). This research does not come without its own shortcomings. These limitations are discussed in this section.

5.3.1 Research design limitations

Upon reaching the conclusion and re-examining the research design, the breadth of the research objectives was noticed. The research objectives are listed in section 1.6 as:

a) To determine the necessary technology, pedagogy and content knowledge and skills that FP teachers need to teach coding.

b) To determine possible guidelines for preparing teachers for teaching computational thinking through the introduction to coding.

The objectives revealed the assumption that all FP teachers, their organisational context and TPACK are malleable enough to introduce a new technical curriculum. Nonetheless, such realisation can help narrow down the scope for further research.

5.3.2 Data limitations

The BOATS training course was not a mandatory one, and therefore, the number of schools that took part could not yield a large enough population, and large enough sample as the researcher would have desired.

The research could then have been less population-specific. The surveys could also have been reformulated to extract a larger amount of information from all the attendees of the course, rather than the KZN teachers alone.

5.3.3 Time limitations

The timing of the course during the peak of the COVID pandemic added further time limitations to the research. However, though time was limited, extensive research was possible with the small sample to allow for true findings.

5.4 CONTRIBUTIONS OF THE RESEARCH

The contributions of deductive research should go beyond just linking the findings to prior theories (Drisko, 2005). This section discusses the contributions of this research, beyond its link to the ETPD framework.

The research has offered a detailed explanation of the *complex issues surrounding* whether or not KZN teachers are ready to implement the introduction of coding in the FP. The research provided a deeper explanation of the aspects that surround the complexity of the phenomenon.

This research has contributed guidelines to determine readiness of teachers to implement coding, based on PRI of an individual, organisational context and TPACK. This can help to identify pilot schools and teachers within those schools.

This research has contributed to a guideline to assess schools' readiness (PRI, OL and TPACK) to identify aspects and gaps that need to be improved before the introduction of coding.

5.5 RECOMMENDATIONS

Based on the findings of this research, several factors that lead to the preparedness of FP teachers to teach coding were discovered.

The research uncovered that constant PD is needed to invoke teacher initiative, sharing, and reflection necessary to prepare FP teachers to teach coding. In addition, constant PD should include the school's management team so that complete organisational involvement can occur. All TPACK resource needs should be acquired for the implementation of PD to be effective.

It is therefore, recommended that firstly, when PD is planned, it should be attended by the teachers and the School Management Team. Secondly, such PD should be aligned with the school for a long enough time as to be able track its successful implementation in that school. Thirdly, schools should be assessed for strategies of sharing, collaboration, organisational initiative and involvement within the school. This could be a strategy such as a coding team, as initiated in school A. Lastly, schools that take on coding as a subject should be conditioned to the submission of a financial plan that will acquire and sustain the necessary TPACK resource needs for the implementation of the PD to be effective.

5.6 SUGGESTIONS FOR FUTURE STUDIES

In this section, how various future research can build on this research is presented This research only collected data concerning the coding documents and the views of teachers that attended the BOATS training course through surveys and focus groups. Future studies that could build on this research can include following teachers into the classroom, and assessing the implementation of coding by observing the classroom application.

Assessing the views of learners who are introduced to coding could also be suggested as another research that builds on this research. Quantitative longitudinal research could look into the performance of learners who do coding as a means of assessing its effective implementation.

As the research's findings have revealed that FP teachers can lack confidence in introducing a technical subject such as coding, this research may also be applicable to higher education institutions investigating the training of coding to students researching to teach in the FP. This research acts as a motivation for universities to develop coding curriculums for FP enrolled students, which could be a subject for further studies.

As mentioned in section 1.7, the research focused on analysing the main concepts of the TPACK (TK, PK, and CK), and not the Technology Content Knowledge (TCK), Technology Pedagogy Knowledge (TPK), and Pedagogy Content Knowledge (PCK). Future research can have more detailed analysis on all 8 TPACK intersections. This can be done by including the investigation of how coding is introduced, and how learning outcomes of the coding component in FP are achieved in the Coding and robotics curriculum (PCK), how relevant technology can be utilised to train teachers to teach the learners (TPK), and which technology works best to train the teachers the specific coding content.

5.7 CONCLUSION

The world is changing fast, and learners have to be equipped for the fast-changing world. Coding is a subject that can sustain learners' development for the future. Educators may not be fully prepared to undertake the teaching of coding. However, a first step has to be taken as this research has concluded in a set of guidelines.

The environment for teacher preparedness to teach coding and support learner is present. As with the traditional first programme marking an introduction to coding, this research asserts "Hello World: FP teachers in KZN can be prepared to teach coding".

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7. ANNEXURES

7.1 ANNEXURE A: KZNDOE PERMISSION TO CONDUCT RESEARCH

KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE HEAD OF DEPARTMENT

Private Bag X9137, PIETERMARITZBURG, 3200
Anton Lembede Building, 247 Burger Street, Pietermaritzburg, 3201
Tel: 033 392 1063
Email: Phindile.duma@kzndoe.gov.za

Enquiries: Phindile Duma **Ref.**:2/4/8/4025

Ms SBC Goba
30 Essex Road
Glenwood
DURBAN
4001

Dear Ms Goba

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"HELLO WORLD: PREPARING FOUNDATION PHASE TEACHERS IN KZN TO TEACH CODING",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 22 March 2022 to 02 March 2025.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers above.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

UMLAZI DISTRICT

Mr GN Ngcobo
Head of Department: Education
Date: 22 March 2022

GROWING KWAZULU-NATAL TOGETHER

7.2 ANNEXURE B: PERMISSION FROM BOATS TRAINING ORGANISERS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Permission from the BOATS training organisers to observe the participants during the training session.

Title of Research Project: Hello world: Preparing Foundation Phase teachers in KZN to teach coding

I am Sithandwayinkosi B.C Goba, a Masters Student at the University of Pretoria. The title of my study towards my Master's degree is "**Preparing Foundation Phase teachers in KZN to teach coding.**" The aim of the study is to investigate KZN foundation phase teachers' preparedness for teaching computational thinking through coding and to make recommendations for better preparedness.

I am working under the supervision of Professor R Callaghan from the Department of Computer Science Education at the University of Pretoria.

I would like to request your permission to observe the participants during the training session you have organised.

There are three parts to this research. The first part will involve the participants being observed for the duration of their attendance of the training. In the second part, the participants will be required to complete a quick survey outlining the change in their preparedness during training. Lastly, they will also be requested to join a WhatsApp group discussion, focusing on discussions that will ultimately answer on the state of Foundation Phase teacher preparedness to teach computational thinking through coding.

Participation in this study is voluntary and confidential. The participants have the right to withdraw at any point during the research study without any consequences or explanations. They can be assured that their decision will be respected. Confidentiality and anonymity will be guaranteed always by using pseudonyms to the participants during the transcription phase. **No participant names or personal information will be reported in my findings.** All data collected will only be used for academic purposes.

You may ask questions before or during the time of participation. If you have any concerns regarding the data collection procedures, please notify me or my supervisor. As an organizer of the training, you will have the opportunity to access and verify the recorded views and the transcriptions of interviews made in case there is a need to do so.

1

We would also like to request your permission to use the data collected, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

Due to COVID-19 pandemic, and to avoid the spread of the virus, the surveys and observations may be done virtually. Different virtual platforms may be used, that you are familiar. This will be discussed with you prior to the virtual meeting.

Please indicate by signing your understanding of information shared above, the purpose being to grant your permission for me to use the training you have organised to observe the participants during the training session.

CONSENT YOU ARE MAKING A DECISION WHETHER OR NOT TO GRANT PERMISSION TO USE THE TRAINING YOU HAVE ORGANISED TO OBSERVE THE PARTICIPANTS DURING THE TRAINING SESSSION. YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE DECIDED THAT THEY CAN BE OBSERVED AND PARTICIPATE IN THE RESEARCH. AFTER READING ALL OF THE INFORMATION ABOVE AND YOU UNDERSTAND THE INFORMATION IN THIS FORM, HAVE HAD ANY QUESTIONS ANSWERED AND HAVE RECEIVED A COPY OF THIS FORM FOR YOU TO KEEP.

Kind regards

____________________ Date: 15 November 2021

Researcher: Miss SBC Goba

E-mail address: sithandwayinkosi@gmail.com

Contact number: 062 585 4630

____________________ Date:__________________

Supervisor: Professor R. Callaghan

E-mail address: ronel.callaghan@up.ac.za

Contact number: 012 420 5521

Signature ______________________________ Date __________________

BOATS Training organiser

2

7.3 ANNEXURE C: PERMISSION LETTER TO PRIMARY SCHOOL PRINCIPAL

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Informed Consent to Participate in a Research

Title of Research Project: Hello world: Preparing Foundation Phase teachers in KZN to teach coding

Dear Principal

I am Sithandwayinkosi B.C Goba, a Masters Student at the University of Pretoria. The title of my study towards my Master's degree is "**Preparing Foundation Phase teachers in KZN to teach coding.**" The aim of the study is to investigate KZN foundation phase teachers' preparedness for teaching computational thinking through coding and to make recommendations for better preparedness.

I am working under the supervision of Professor R Callaghan from the Department of Computer Science Education at the University of Pretoria.

As the participants are teachers in your institution, I kindly invite they to participate in this study. There are three parts to this research. The first part will involve the participants being observed for the duration of their attendance of the training. In the second part, the participants will be required to complete a quick survey outlining the change in their preparedness during training. Lastly, they will also be requested to join a WhatsApp group discussion, focusing on discussions that will ultimately answer on the state of Foundation Phase teacher preparedness to teach computational thinking through coding.

The participants' participation in this study is voluntary and confidential. They have the right to withdraw at any point during the research study without any consequences or explanations. They can be assured that their decision will be respected. Confidentiality and anonymity will be guaranteed always by using pseudonyms to the participants during the transcription phase. **No participant names or personal information will be reported in my findings.** All data collected will only be used for academic purposes.

They may ask questions before or during the time of participation. If they have any concerns regarding the data collection procedures, please notify me or my supervisor. As a participant, they will have the opportunity to access and verify the recorded views and the transcriptions of interviews made in case there is a need to do so.

We would also like to request their permission to use their data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property

1

of the University of Pretoria. Further research may include secondary data analysis using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

Due to COVID-19 pandemic, and to avoid the spread of the virus, the surveys and observations may be done virtually. Different virtual platforms may be used, that they are familiar. This will be discussed with them prior to the virtual meeting.

Please indicate by signing that you understanding of information shared above, the purpose being to give their consent to participate.

CONSENT YOU ARE MAKING A DECISION WHETHER OR NOT FOR TEACHERS TO PARTICIPATE IN THIS RESEARCH. YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE DECIDED THAT THEY CAN PARTICIPATE IN THE RESEARCH. AFTER READING ALL OF THE INFORMATION ABOVE AND YOU UNDERSTAND THE INFORMATION IN THIS FORM, HAVE HAD ANY QUESTIONS ANSWERED AND HAVE RECEIVED A COPY OF THIS FORM FOR YOU TO KEEP.

Kind regards

____________________ Date: 15 November 2021

Researcher: Miss SBC Goba

E-mail address: sithandwayinkosi@gmail.com

Contact number: 062 585 4630

____________________ Date:____________________

Supervisor: Professor R. Callaghan

E-mail address: ronel.callaghan@up.ac.za

Contact number: 012 420 5521

Signature: ________________________________ Date ____________________

Principal

2

7.4 ANNEXURE D: INFORMED CONSENT TO PARTICIPATE IN RESEARCH

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Informed Consent to Participate in a Research

Title of Research Project: Hello world: Preparing Foundation Phase teachers in KZN to teach coding

Researcher: Sithandwayinkosi Goba | Supervisor: Professor R. Callaghan

Contact of Researcher: 062 585 4630 | **Contact of Researcher:** 012 420 5521

A. PURPOSE AND BACKGROUND

Sithandwayinkosi Goba is conducting research on KZN foundation phase teachers' preparedness for teaching computational thinking through coding. The purpose of your participation in this research is to help the researcher gather participant data. You were selected as a possible participant in this study because you will be attending the Introduction to coding training hosted by Nelson Mandela University.

B. PROCEDURES

If you agree to participate in this research, the following will occur:

You will be observed for the duration of your attendance of the training.

You will be required to complete a survey outlining the change in your preparedness during training.

You will also be requested to join a WhatsApp group discussion, focusing on discussions that will ultimately answer on the state of Foundation Phase teacher preparedness to teach computational thinking through coding.

This data collection will be done after the completion of the training. Only a WhatsApp contact number will be required for the group discussion.

C. RISKS

We acknowledge the time you will be taking to provide us with this data, and are aware of the risks of exposing your personal number for a WhatsApp group.

D. CONFIDENTIALITY

The records from this research will be kept as confidential as possible. No individual identities will be used in any reports or publications resulting from the research.

All surveys, transcripts from the group discussions, and observations will be given codes and stored separately from any names or other direct identification of participants. Research information will be kept in locked files at all times. Only the research and her supervisors will have access to the files and data. After the research is completed, by June 2032, all data with personal information will be destroyed.

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E. BENEFITS OF PARTICIPATION

The anticipated benefit of your participation in this research will be the contribution to the studied that will contribute to the conducive implementation of the Coding and Robotics Curriculum in South Africa as a whole.

F. VOLUNTARY PARTICIPATION

Your decision on whether or not to participate in this study is voluntary and will not affect your relationship with the Nelson Mandela University or University of Pretoria. If you choose not to continue to participate in this research, you can withdraw your consent and discontinue participation at any time without prejudice.

G. QUESTIONS

If you have any questions about the study, please contact Sithandwayinkosi Goba by calling 062 585 4630.

H. NOTE

We also would like to request your permission to use your data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria and, where relevant, project funders. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

CONSENT THAT YOU ARE MAKING A DECISION WHETHER OR NOT FOR TO PARTICIPATE IN THIS RESEARCH. YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE DECIDED THAT YOU HAVE READ ALL OF THE INFORMATION ABOVE. IT ALSO SERVES TO INFORM THAT YOU UNDERSTAND THE INFORMATION IN THIS FORM, AND HAVE HAD ANY QUESTIONS ANSWERED, AND HAVE RECEIVED A COPY OF THIS FORM FOR YOU TO KEEP.

I……………………………………………… [name of teacher] agree/do not agree to participate in the study [circle one option]. I have read and understood the contents of this letter.

Signature ______________________________ Date 12 October 2021

Researcher

Signature ______________________________ Date ______________

Supervisor

2

7.5 ANNEXTURE E: PRELIMINARY CODING AND ROBOTICS CAPS GRADE R-3 CURRICULUM SUMMARISED WITH CODES

PAGE 9:

1.4. Subjects and Time Allocation

1.4.1 Foundation Phase

(a) The instructional time in the Foundation Phase is as follows:

SUBJECT	GRADE R (HOURS)	GRADE 1-2 (HOURS)	GRADE 3 (HOURS)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Coding and Robotics	1	1	2
Life Skills: • Beginning Knowledge • Creative Arts • Physical Education • Personal and Social Well-being	6 (1) (2) (2) (1)	6 (1) 2 2 (1)	7 (2) (2) (2) (1)
TOTAL	(24)	(24)	(27)

Commented [s1]: Coding allocated 1 hour per week- least amount

PAGE 12 & 13

2.2 Specific Aims:

The Coding and Robotics subject is aimed at guiding and preparing learners to solve problems, think critically, work collaboratively and creatively, function in a digital and information-driven world, apply digital and ICT skills and to transfer these skills to solve everyday problems and its possibilities, including equipping learners for meaningful and successful living in a rapidly changing and transforming society.

Through Coding and Robotics learners are exposed to a range of knowledge, skills and values that strengthen their:

- aesthetic, creative skills and cognitive development, knowledge through engaging in dance, music, drama and visual art activities
- knowledge of digital and ICT skills supported by the technological process and computational thinking skills;
- understanding of the relationship between people and the environment, awareness of social relationships, and elementary science;
- physical, social, personal and emotional development.

Commented [s2]: Coding involves people skills

Commented [s3]: Coding involves ict skills

Commented [s4]: Coding involves creative skills

Commented [s5]: Coding is equipping learners for skills in a fast-changing world

Commented [s6]: Coding is working collaboratively

Commented [s7]: Coding is critical thinking

Commented [s8]: Coding is problem solving

PAGE 16:

2.4.2 Resources

- Each learner must have a textbook / workbook / e-book. Schools must utilise book retrieval policy where applicable.
- Schools are required to ensure that the necessary tools, devices, materials and consumables be available for teaching, learning and assessment. These resources should be indexed and checked each term.
- The school should subscribe to a minimum of two or more subject related magazines for the teacher to keep abreast with the latest developments in the industrial environment. These magazines could also be lent out to learners (in the same way as library books). These resources must be readily available in the classroom or in the library.
- Schools offering Coding and Robotics must have a well-equipped Coding and Robotics lab for learners to complete the Practical Assessment Tasks. The Coding and Robotics lab needs to be secured with enough storage space for resources.
- The teacher should have a variety of reference books / e-books, charts and brochures in the classroom to stimulate the learners' interest in the subject.
- The teacher should have access to the internet to be able to source, download and print relevant and new information, as the industry environment is a dynamic industry continuously incorporating new trends and developments. The teacher should also have an e-mail, cloud storage facilities, as new information from subject advisors and other sources can be shared on digital platforms.
- The teacher needs to be trained in the context, content and pedagogy of the subject.
- Resources to offer Coding and Robotics as a subject are the responsibility of the school. The school should build up a collection of models, e.g. by asking learners, parents or mechanical, electrical and electronic repair workshops and suppliers to donate models.

Commented [s11]: Coding resource are responsibility of the school

Commented [s12]: Teachers need to be trained in TPACK of coding

Commented [s13]: Coding educators need access to new relevant information

Commented [s14]: Coding educators need access to various resources

Commented [s15]: Coding requires a well-equipped lab

Commented [s16]: Coding requires relevant resources

PAGE 17:

2.4.2.1.1. Coding Requirements

- Free open source Software for block-based coding
- Code Cards with basic Coding instructions.

Commented [s17]: Coding requires a well-equipped lab

Commented [s18]: Coding requires relevant resources

PAGE 25:

SECTION 3: OVERVIEW OF TOPICS AND ANNUAL TEACHING PLANS

3.1 Overview of Topics

Listed below are the topics per grade with a short explanation of the focus. Note that some topics are continued from Grade R to 3 showing progression and increasing in complexity from year to year, whilst other topics cease at some stage. This is not due to its importance diminishing, but rather due to the integration thereof.

TERM 1				
Topics	**Grade R**	**Grade 1**	**Grade 2**	**Grade 3**
Pattern Recognition and Problem Solving	• Identify different patterns • Pattern Recognition - patterns repeating up to 2 times. • Complete a Pattern - Minimum of 2 repetitions.	• Pattern Recognition - patterns repeating up to 3 times. • Complete a Pattern - Minimum of 3 repetitions • Debugging in a sequence - 2 patterns and 3 repetitions • creating patterns	• Creating patterns	• Continue with Encode and Decode from Grade 2. - 2 Sentences consisting of 7 -words.
Algorithms and Coding	• Introduction of what Computers are. • Identify Computing devices • Decomposition. • Sequences	• Block-based programming interface • Introduce block movement: ○ forward, ○ back, ○ right, ○ left	• Introduce the Basic features of programming interface: ○ Create a project ○ Move blocks into the scripting area ○ Select a block category ○ Selecting character/agent or objects. ○ Looks Block ○ Use blocks in scripting area as buttons ○ Changing the size of the Characters/Agent or object. ○ Save a project ○ Close the Application • Continue with sequences	• Introduce basic coding terms. • Introduce the Basic features of programming interface: ○ Selecting Characters/Agents or objects. ○ Loading a program ○ Create a customised object ○ Right Click to get information from a block. ○ Motion (movement / turning) ○ Move blocks into the code area ○ Select a block category ○ Looks Block ○ Use blocks in scripting area as buttons • Sequences • Introduction to algorithms

PAGE 27:

TERM 2				
Topics	**Grade R**	**Grade 1**	**Grade 2**	**Grade 3**
Pattern Recognition and Problem Solving	• Identify different patterns • Pattern Recognition - patterns repeating up to 2 times. • Complete a Pattern • Minimum of 2 repetitions. • Movement as a Pattern.	• Explain pattern sequences. - patterns of 3 shapes and 3 repetitions. • Complete a pattern - patterns repeating up to 3 times. • Debugging in a sequence - patterns of 3 shapes and 3 repetitions.	• Introduction to Algorithmic thinking • Continue Creating patterns	• Algorithmic Thinking.
Algorithms and Coding	• Decomposition. • Sequences. • Code Cards with the following basic instructions: ○ Move forward ○ Go back ○ Turn left ○ Turn right	• Introduction to Loop functions (Loop block).	• Introduce new features of the interface: ○ Changing backgrounds ○ Event triggers (Begin/End) ○ Change speed of Character/Agent or Object (Speed block) • Introduce that more than one sequence of programming can take place at once in a single program. • Introduce more than one Character/Agent or Object.	• Introduction to: ○ Repeat and repeat forever block ○ Creating a custom object ○ Use the switch/next costume block ○ Pen block / stamp block

Commented [s19]: Coding is pattern recognition

Commented [s20]: Coding is problem solving

PAGE 29:

TERM 3				
TOPICS	**Grade R**	**Grade 1**	**Grade 2**	**Grade 3**
Pattern Recognition and Problem Solving	• movement as a pattern • Continue Pattern Recognition - patterns repeating up to 2 times. • Continue Complete a Pattern - Minimum of 3 repetitions.	• Pattern Recognition - patterns of 4 objects/shapes and 2 repetitions. • Continue to explain pattern sequences. - patterns of 4 objects/shapes and 2 repetitions. • Continue to complete pattern sequences. - patterns of 4 objects/shapes and 2 repetitions. • Continue to debug pattern sequences. - patterns of 4 objects/shapes and 2 repetitions.	• Algorithmic thinking • Creating number patterns • Following instructions to make a pattern according to numbers.	• Continue with algorithmic thinking • Continue with debugging
Algorithms and Coding	• Code Cards • Swapping items	• Introduction to Input events • Introduce input events in a block-based interface.	• Introduce new features of the interface: ○ Pen Block ○ Infinite Loop (Repeat forever block) ○ Speech bubbles ○ Delays (delay block) ○ Counter Control Loop (repeat Block) ○ Insert sound (sound block)	• Introduction to event driven programming ○ sensory triggers ○ keyboard/mouse triggers

Commented [s21]: Coding is pattern recognition

Commented [s22]: Coding is problem solving

PAGE 31:

TERM 4				
TOPICS	**Grade R**	**Grade 1**	**Grade 2**	**Grade 3**
Pattern Recognition and Problem Solving	• Movement as a pattern • Pattern Recognition - patterns repeating up to 3 times. • Complete a Pattern - Minimum of 3 repetitions.	• Pattern Recognition - patterns of 5 objects/shapes and 3 repetitions. • Explain pattern sequences. - patterns of 5 objects/shapes and 3 repetitions. • Debugging in a sequence - patterns of 5 objects/shapes and 3 repetitions. • Complete a Pattern - patterns of 5 objects/shapes and 3 repetitions	• Encode and Decode - 3 to 4 letter words in 5-word sentence • Continue with Algorithmic thinking	• Continue with Algorithmic Thinking.
Algorithms and Coding	• Code Cards ○ Debugging	• Continue with Debugging • Introduction Pair Programming	Concept that are introduced: • Creating multiple characters • Continue with the following features: ○ Customising characters ○ Looping functions ○ Event triggers ○ Add sounds ○ Change the Background. ○ Pen block	• Introduction to ○ event triggers – Broadcasting ○ sounds

Commented [s23]: Coding is pattern recognition

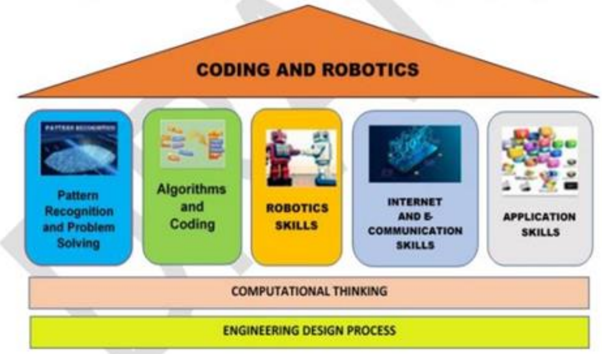
Commented [s24]: Coding is problem solving

2.3 Focus Content Areas:

The Coding and Robotics Foundation Phase subject consist of the following Knowledge Strands:

- Pattern Recognition and Problem Solving
- Algorithms and Coding
- Robotic Skills
- Internet and E-Communication skills
- Application Skills

The Strands co-exist and overlap in their application, knowledge and skill levels. The Subject methodology is based on Computational Thinking and the Engineering Design Process.



Commented [s9]: Coding involves ict skills

Commented [s10]: Coding is problem solving

7.6 ANNEXTURE F: A SURVEY INSTRUMENTS WITH CODES

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

Title of Research Project: Hello world: Preparing Foundation Phase teachers in KZN to teach coding

Researcher: Sithandwayinkosi Goba
Contact of Researcher: 062 585 4630

Supervisor: Professor R. Callaghan
Contact of Researcher: 012 420 5521

RESEARCH SURVEY FORM

Personal information *(For statistic purposes)*

Name	[redacted]
Surname	[redacted]
Name of School	[redacted]
Province	KZN
District	Umlazi
Subject(s) taught	English HL, afrikaans FAL, isizulu SAL, life skills, n.s/tech, arts, history, geography, Technology.
Grade(s) taught	3,4,5,7
Impementing Boats at School (Yes / No)	Yes

Section A
Please answer in the spaces provided.

1	How confident were you, before the training, in integrating offline coding technology in regular delivery of instructions?
	I was not so confident because I felt that coding would be really difficult.

Commented [s1]: Coding is perceived as a difficult subject

2	How confident are you in integrating offline coding app/s utilized in the training in regular delivery of instructions?
	Now I am fairly confident because I understand the basis of offline coding.
3	How confident were you in your knowledge of teaching and learning strategies, prior to the training?
	I had great knowledge of the normal classroom context. Therefore, I was fairly confident Because to my understanding, coding needed to be taught as part of sequencing Which was done in the normal classroom whilst teaching and learning.
4	How confident are you in your knowledge of teaching and learning strategies?
	I am very confident.
5	How confident are you to organise your lessons to interest students of varying abilities in your classes?
	Fairly good.

Commented [s2]: Coding is part of sequencing which is taught in normal classes

6	How confident were you that you knew and understood the Introduction to coding that you are going to teach, prior to the training? I was extremely confident as sequencing was a priority for coding and this was already Taught in the classroom to learners.
7	How confident are you that you know and understand the Introduction to coding that you are going to teach? Very confident as I am in the coding team of my school and have already ran two Workshops on coding. One to educators and the other to learners. hence, I am fully Aware of the basis of coding.
8	How confident are you that you can answer all students' questions on the introduction to coding you are going to teach and give meaningful explanations? I am very confident. Apart from playing the game myself, the virtual assistance by prof Greyling and Kelly bush have really helped. Furthermore, my principal is the Ambassador for coding unplugged. This has introduced us to the new world of Technology. Also, the workshops that I ran with my principal and colleagues has made Me much more confident to teach, explain and elaborate coding to all learners.
Section B *To select an answer, place your mouse over the word in bold, click once. An arrow will appear on the right-hand side click on the arrow to select an answer from the list that will drop down.*	
9	I have the technical skills I need to use the Boats app and offline technology.

Commented [s3]: Coding is part of sequencing which is taught in normal classes

Commented [s4]: Coding is working collaboratively

7.7 ANNEXTURE F: FOCUS GROUP SESSION 1 CODED

Focus Group Session 1

Present: Educator A1, Educator A2, Educator A3, Educator A4, and researcher

Venue: School A

Date: 12 March 2022

Researcher: Okay, it started. So, hi, everyone, and thank you. As you know, I'm doing my master's in computer integrated education with my majors being coding and robotics at the University of Pretoria. So we're having like a discussion because you guys attended the BOATS training workshop on coding. These sessions are called focus group sessions, and as explained in your indemnity forms, we will have more of these in future. I just want to know your feel of the training and whether or not you feel you're ready to now teach coding after having attended the training. Remember teaching coding is officially meant to start being next year.

I'm going to go through some questions, similar to the survey first, just to get your baseline understanding.

So my first question is what was your understanding of what coding is before the workshop? So basically, like I wanted to know if you guys had ever heard of coding before the training, and what did you guys understand about coding?

So, any of your guys can just feel free to answer that.

Educator A1: Ok, I had no knowledge about coding, initially I thought it was meant to be done on the computer or something like that. Afterwards, I was introduced to TANKS by Mr (the principal of school A). He had introduced it to us using puzzle pieces. He had explained that it is not done on the computer, and everything is done using a phone, what is unplugged. Also after we had done the BOATS training, by what's her name… Kelly. She had told us that sequencing is important, and that

Commented [s1]: Coding can be unplugged was the main idea of coding. And that it had nothing to do with a computer at all. And she would use and example of the toothbrush and the toothpaste. Basically, we would be giving instructions to the little ones, or even the ones at the top. They have to follow an instruction to do something.

Commented [s2]: Coding is sequencing

Commented [s3]: Coding is learning to give instructions

Researcher: So basically, you are saying that coding in the Foundation Phase is more about teaching learners computational thinking and not really about programming on a computer as such. Does anyone else have anything to add?

Educator 2A: Yes, there's a lot of planning and trying to figure out the quickest solution.

Commented [s4]: Coding is problem solving

Educator 1A: And moving from recognising simple patterns, like just moving forward in the game, to doing repeats, helps with getting comfortable with the concepts of patterns. Same with TANKS.

Commented [s5]: Coding is critical thinking

Commented [s6]: Coding is problem solving

Researcher: What can you(3A) tell me on that?

Educator 3A: I didn't know what coding was. I'm still not really sure, especially where it fits realistically in a way I can explain, like, in the real world for example.

Commented [s7]: Teachers need relevance of coding to understand it

Researcher: Could you explain more on that. How would you explain those subjects that fit in the real world.

Educator 3A: Maybe It's because I don't know the jobs where coding, like the coding we learnt at the workshop. Like where you'll code to move forward and turn right. Or maybe it's for telling robots.

Commented [s8]: Teachers need relevance of coding to understand it

I understand that you need to know Biology or Life science to be a doctor, and I know what a doctor does. I don't know where these games will help in real life.

Educator 4A: I share the same sentiments. I finished all the levels of the game. But I'm not sure what I'll be teaching in class. If I'll be teaching the children to play the game.

Commented [s9]: Teachers need to know the coding curriculum content

Researcher: Thank you for you input. I'd like to know, how did you guys feel about teaching coding before the workshop?

Educator 2A: Yes, we were nervous. We didn't know what we'll be teaching. There's no ATP, no lesson plans or CAPS. But we went for the TANKS training for grade 4-7, we've been doing TANKS, I think from since last year. With the small children, grade r-3; we started with BOATS last year, just touched on it a little bit. And we are doing it at the moment.

Commented [s10]: Teachers need to know the coding curriculum content

Researcher: Oh wow, how do these classes work? When are they taught? What content are you teaching?

Educator 2A: The lessons are held everyday after school for 1 hour. For the TANKS, they were going though the levels. For the BOATS, we go through the lesson plans from Kelly, and also the levels of the game.

Commented [s11]: Coding needs more time allocation

Researcher: How do you feel the learners are receiving it?

Educator 2A: Especially the little ones, they are excited; because it's a lot of practical work, and they are working in groups. And they come to the front and get to act out their solutions. So I think they are working quite well and excited to learn.

Commented [s12]: Coding is working collaboratively

Commented [s13]: Coding involves people skills

Educator 1A: Yes, you know, even the learners who have problems with reading and writing in class, do very well with coding because they have a different way to express themselves without writing.

Commented [s14]: Coding involves creative skills

Researcher: Do the lessons require different teaching styles than what you are used to? Or can you adapt the teaching styles in these lessons with the teaching styles you use in your other subjects as well?

Educator 1A: We generally adapt. The children are more of less as how they are in the class. Like you said...Like mam said, they are in groups; so even in the bigger grades, grade 4-7, they are in groups as well.

Commented [s15]: Coding requires adaptive educators

Commented [s16]: Coding is working collaboratively

Researcher: Can I ask, who teaches these lessons from the four of you guys?

Educator 2A: Mam and I. I take grades 4 to 7 and she takes grade R to 3. The principal also assists.

Commented [s17]: Coding requires involvement of all educators

Researcher: Um, you guys? (3A and 4A)

Educator 3A: I've just started. The principal only recently told me to attend the BOATS workshop.

Researcher: So after attending the workshop, how do you feel about constructing lesson plans for coding? Do you guys feel you have all the resources you would need?

Educator 2A: Like I said earlier, we don't have the CAPS document or the ATP for the subject. But we can, well I can teach by going through the TANKS and the BOATS app, and Kelly's lesson plans.

Commented [s18]: Teachers need to know the coding curriculum content

Commented [s19]: Coding needs unstructured learning

Researcher: Would you (4A) be able to constructing lesson plans for coding, or how do you (4A) feel about it.

Educator 4A: I still need more time to understand it.

Commented [s20]: Learning to teach Coding needs more time than a workshop

Researcher: Do you guys feel you'd be able to teach coding as a formal subject, with formal assessments etc…?

Educator 1A: Um…maybe

Educator 2A: I think we obviously need a little more time to be familiar with what we'll be teaching. For now it's fine because the class is for fun, we're not under pressure to produce results, so we are learning and also the little ones are learning with us.

Commented [s21]: Learning to teach Coding needs more time than a workshop

Commented [s22]: Coding needs unstructured learning