Facilitating online learning for authentic real-life challenges in a MakerSpace environment

by

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Submitted in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in the

FACULTY OF EDUCATION

at the

UNIVERSITY OF PRETORIA

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PRETORIA

May 2021

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DEGREE AND PROJECT	PhD Facilitating online learning for authentic real-life challenges in a MakerSpace environment
INVESTIGATOR	Mr Jaco Joubert
DEPARTMENT	Humanities
APPROVAL TO COMMENCE STUDY	23 August 2018
DATE OF CLEARANCE CERTIFICATE	12 June 2020

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by

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28 August 2020

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Acknowledgements

As a man whose academic career has been paved with grace, I firstly acknowledge the manyfold blessings of my Heavenly Father on this study over all the years that built up to its completion:

Non nobis Domine, Domine

Non nobis Domine

Sed nomini, Sed nomini

Tu o da gloriam!

(Shakespeare, 1599)

I would also like to thank all the people who were integral in the completion of this thesis:

- Thank you to the noblest of colleagues: Mr. Pierre le Roux, Mr. Francois Enslin and Mr. Wayne van Zyl.
- As a human being faced with the emotional toll of conducting a PhD, I am also indebted to my family and friends who supported me through the entire process. Many thanks to my loving wife Ineke and darling girl Kira. Thanks also to my dear sister, Louise du Plessis, for her wonderful and diligent editing of the manuscript and my brilliant mother, Prof. Ina Joubert, for her advice and guidance throughout my academic career.
- A word of gratitude goes to my supervisor, Prof. J.A. Slabbert. Thank you for showing me what it means to be a teacher. I have no higher praise to give than that.
- Lastly, I want to dedicate this thesis to my earthly father, Dr. Jaco Joubert. Where Mom showed us the academic heights to which we should aspire, you laid a foundation for us all from which to start our academic ascent.

By being the first Doctor in a family that has since produced four Doctoral candidates (so far), we are all living testimonies of your legacy. You have our boundless appreciation and all our love.

Abstract

In an increasingly digitised world, the pedagogy of education is at risk of being dictated by technological advancement. As fragments of teaching practice left over from previous curricula are adapted and amalgamated into new curricula, the educational landscape becomes a sea of learning terminologies used interchangeably. In many cases these terminologies are then disconnected from an underlying understanding of what learning is and how the best possible form and quality of learning can be brought about. Two recent technological advancements in the field of education is Computer Supported Collaborative Learning (CSCL) and the MakerSpace movement. However, these fields need to be engaged with as avenues of investigation in the pursuit of the highest possible learning quality outcome required by a world that is super-complex. Through comprehensive literature research, the researcher first presented an in-depth argument detailing what learning is, what the highest quality of learning is and how this learning quality can be measured. The literature revealed a particular professional practice of “facilitating lifelong authentic learning” of which the sole purpose is achieving exactly that. In this mixed method research project, an attempt was made to re-connect the technological advancement of online learning with the theoretical framework of the learning process as laid down by Vygotsky, particularly through the Zone of Proximal Development. Within the context of a MakerSpace subject, the researcher attempted to determine how the identified practice of facilitating lifelong authentic learning would ensure the increase in the quality of learning in online groups where MakerSpace learners were required to resolve a real-life challenge. An experiment then followed where a professional facilitator of learning was present in the experimental groups, while the control groups attempted to resolve the challenge un-facilitated. A comparison of the analysis of chat transcriptions indicated that on average the quality of learning was higher in facilitated groups. Interview data collected after the experiment shed light on this finding and suggested that the quality of learning in an online group increases when a facilitator of learning increases the level of difficulty of the real-life challenge as perceived by the group’s dominant

participant (the person who contributes the most to the group dialogue). This not only indicated the value of *Facilitating Learning* in an online learning evnvironment, but also highlighted its necessity in terms of *improving the quality of the learning*.

Keywords

Facilitating Learning, online learning, MakerSpace, Computer Supported Collobarative Learning, authentic learning, real-life challenge, Zone of Proximal Development, highest quality of learning, Microsoft Teams, STEM

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CHAPTER 1: ORIENTATION AND PROBLEM STATEMENT

1.1 Introduction

"Dark matter is present with a much greater density than luminous matter."

(Fritz Zwicky,1937)

Renowned Swiss astronomer and scientist, Fritz Zwicky, penned the ground-breaking finding that the mass of a galaxy could not be measured by what can be seen (Zwicky, 1937). Studying the Coma cluster of stars, he concluded that the greater part of its mass was in fact dark. Similarly, I maintain that the kind of education that is conducive to resulting in the best possible education within a formalised learning space is the 'dark matter' [1]of education. It is the unmentioned backdrop against which all debates concerning the scope of a curriculum take place. It is the unseen foundation on which every choice concerning the way in which education is delivered to learners in a classroom environment is made. It lies at the very heart of the educational landscape and yet it is dark, hidden and overshadowed by a vast amount of research concerning the most current and effective modes of knowledge delivery and assessment. In seeking out these modes, the educational profession is in a race to assimilate the most recent technologies and practices present in the world of work. We find the roots of such a workplace driven teaching practice as far back as the 20th century era, which fathered our current educational system (Slabbert, De Kock & Hattingh, 2009).

Since the dawn of formal schooling in the industrial era the goal has always been to deliver, as an end-product, young people capable of fulfilling the demands of the workplace on an industrial scale. As explained by Popkewitz and Lindblad (2004, p. 231), education can be viewed historically as: "an entity contributing to the making of the future citizen." As the place of work, social landscapes and political landscapes of countries evolve, the attributes or abilities of these future

[1] Single quotation marks will be used to highlight important words or phrases in this document.

citizens also changed, requiring a rapid and continual update of curricula. It is, however, particularly the technological advancements in the 21st century that led to new forms of practice within society and industry that had prompted reforms in educational teaching methods (Marsh, Kumpulainen, Nisha, Velicu, Blum-Ross, Hyatt, Jónsdóttir, Little, Marusteru, Ólafsdóttir, Sandvik, Scott, Thestrup, Arnseth, Dýrfjörð, Jornet, Kjartansdóttir, Pahl, Pétursdóttir & Thorsteinsson, 2017). Ironically, amidst a drive to fulfil these shifting external demands, I maintain that the heart of the educational endeavour has been left behind.

We know that learning in human beings takes place virtually all the time. We also know that the quality of the learning outcomes may be severely jeopardised – even under good educational conditions, thus requiring some sort of educational support. The type of teaching, which we can also refer to as the pedagogical intervention, that ultimately determines the true quality of the learning does not answer the question of "How much do you know?" but rather "How well can you learn?." The answer to this question will reveal how the learning process needs to be interrogated continuously. Only then, when the educational community has identified the corresponding pedagogical intervention which will bring about the highest possible quality of learning, can we (as teachers) hope to consistently deliver young people who will be able to flourish in an unknown future (Claxton, 2007; 2008; Barnett, 2007; 2012).

Unfortunately, instead of focusing on the pedagogical intervention which would lead to the highest quality of learning, educational reform is currently driven by economic needs. This can be seen in the implementation of the STEM (Science, Technology, Engineering and Maths) curriculum spearheaded by the United States of America (USA) (The committee on STEM education of the National Science & Technology Council, 2018). The rationale behind this curriculum is described by Croak (2018, p. 2) as follows:

> "Emerging research suggests that education specifically related to science, technology, engineering and mathematics (STEM)

> disciplines is a better measure of human capital because it considers the importance of education that stimulates innovation and produces workers able to drive and respond to technological advancement, which lies at the centre of economic prosperity."

According to Reider, Knestis, Kirk, Malyn-Smith and Joyce (2019, p. 1) the STEM curriculum was implemented after USA "policymakers … challenged US K-12 education systems to help young people develop the STEM capabilities necessary to fulfill these [STEM related] workforce needs." In order to meet this challenge, classroom pedagogy was informed by "seminal research on career development, helping to shape current understandings of how people develop not only an awareness of but also an interest in specific careers, as well as how they prepare for those careers" (2019, p. 2).

To put it plainly, STEM aims to generate interest in the vocations that are currently understaffed in the USA. Herein lies a dilemma however: The required outcomes of external stakeholders (like the government) become the focal point of the learning endeavour, instead of rather focusing on the format of learning which will lead to the highest possible quality of learning outcome irrespective of current economic, political or societal demands. Yet, we can only hope to institutionalise the highest possible quality of learning outcome if we are prepared to ask a question which can be seen as a form of educational hubris: How or when or under which conditions are the learning competences of human beings enhanced optimally? This question attempts to shift the focus of the learning endeavour from the needs of the economy, to the highest possible learning quality outcome, which can refer to any outcome as required by external educational stakeholders (Slabbert, et al., 2009).

Technically, investigating the pedagogical intervention that will bring about the required quality of learning outcome can only take place if we have a consensus on the epistemological nature of reality. As teacher and researcher, I constantly dwell on the following questions: Should we as teachers believe that reality is a

constant, objective, immutable fact that we perceive through our senses? Or should we rather believe that as human beings we construct our own realities based on our understanding of what we perceive? Should learners be expected to be passive receivers of objective, observable facts (Positivism[2]), or should they construct their own understanding of reality (Constructivism[3])? With the possibility of differing opinions at its most basic level, it is no wonder that the debate on best teaching practices can often "more resemble clashes of opposing political factions than reasoned educational arguments" (Servent-Miklos, Virginie, Norman & Schmidt, 2019, p. 3). Having taught at three different schools over the past decade, I have seen the great extent in which teachers differ in terms of best teaching practice. However, irrespective of the personal views of teachers on the nature of reality, there has been a noticeable shift towards constructivism in educational policy around the world as was particularly evident in the adoption of Outcomes-Based Education (Berlach & McNaught, 2007) where the construction of outcomes were the primary focus. The later advent of technology and its increased use in the classroom has also seen a rise in the implementation of constructivist practices, as can be seen in the following quote by Makewa, Ngussa and Kuboja (2019, p. XIV):

> "The use of technology as an instructional tool goes hand in hand with Vygotsky's quality instructional impact. Building further on the constructivist's theory that students construct knowledge through accommodation and assimilation …"

Even the Situated Cognition Theory (Kelley & Knowles, 2016), which is the theoretical base for STEM learning, is based on "problem solving and Constructivism" (Motta, 2016). This is evident in a focus on concepts like "self-constructed identity formation … and … exploratory skills" (Reider, et al., 2019, p. 3) which can only manifest where learners are confronted with constructivist

[2]An epistemological view that states that reality is fixed, unchanging and objective.
[3]An epistemological view that states that reality is constructed by each person's own subjective understanding of reality.

tenets such as ‘authentic learning experiences’. Coeval this general shift towards constructivist tenets and building on an epistemological foundation of Constructivism, researchers like Slabbert, et al. (2009) have articulated education as a holistic constructivist practice.

They maintain that education is, by nature, a practice and that its theory has (should have) been constructed from observing, experiencing and analysing the phenomenon as it naturally occurs in the informal real-world. But it is their revelation that education pivots around learning that is significant. For that reason, it is important to identify the kind of learning that occurs naturally in humans. After investigating the authentic nature of the human learning phenomenon Kolb (1984, p. 41) described human learning as “the process whereby knowledge is created through the transformation of experience.” He calls this experiential learning, which occurs in a cycle of four steps: concrete experience, reflective observation, abstract conceptualisation and active experimentation, which correlates with the natural structure and function of the brain (Zull, 2011). The best learning would consequently result when the pedagogical intervention is directed towards a learner’s natural learning process. However, the quality of the learning will be determined by the quality of the execution of each step by the learner in this cyclical learning process. This, in addition to Vygotsky’s theoretical framework describing how a child learns (Vygotsky, 1938; 1967), has given me a lens through which I can analyse literature that aims to address the current pressures placed on education by a world which is becoming increasingly digitised.

The ability to critically analyse educational reforms is even more important in a world where technology has fully permeated every aspect of teaching pedagogy, bringing the rapid pace of technological advancement into the classroom, as explained by Crews (2015, p. 87):

> “Technology in education is a concept whose time has come. Technology as part of teaching and learning is now a pervasive part

> of course delivery. Technology was not only a factor in expanding ground, brick and mortar, courses, but also helped break the shackles of conventional teaching to enable quick dissemination of knowledge and information while providing anytime, anywhere education through various technology devices to enhance online education. Today, online learning spans all educational levels."

The speedy pace of technological advancement into the classroom enhanced various initiatives. Unfortunately, the use of technology in education is fraught with controversy: "If ever there were a case to be made that more research can cloud rather than clarify an issue, technology use and learning seems to fit the bill" (Vamsidhar, 2019, p. 1). What is of educational concern is that international studies have indicated that technology use in schools had raised "too many false hopes" (Coughlan, 2015, p. 1). What remains important though, is that the *learning* process determines the most appropriate pedagogical intervention for optimal learning and that this, in turn, determines the best suited *educational* technology to be employed. It seems as though attractive technologies and associated factors sometimes override the selection of the more fundamental educational considerations with a detrimental effect on the students' learning outcome (Wexler, 2019, p. 1).

This has also been implied during the launch of the Programme of International Assessment (PISA) 2018 results in reading, science and mathematics where the main focus was on reading literacy in the digital environment. According to the Organisation for Economic Co-operation and Development (OECD), these skills are key to engaging in social and civic life, participating in the labour market and undertaking further education in the 21st century. The following general remark about the students' achievements in the test was made: "These results are worrisome" (Gurria, 2019, p. 1), which is a reflection of the quality of the students' learning within a digital environment. It is within the context of this awareness and the unavoidable utilisation of technology without which we cannot exist that I was introduced to the grass roots educational movement that is emerging all over the

world. It is the MakerSpace movement where technology is fostering experiential learning in various forms (Marsh, et al., 2017).

The MakerSpace environment provides the 'dark matter' of an ideal educational environment within which experiential learning can be created within its authentic context, where the technology of online learning is challenged to bring about the highest possible quality learning outcome. The focus of my study is high school learners, which stems from the fact that I have been a high school teacher for the better part of nine years, as is discussed in my rationale for the study.

1.2 Purpose of the study

1.2.1 Rationale for the study

The process of learning fascinates me. It inspires me to learn more about the mystery of how human beings shape themselves, especially when faced with seemingly insurmountable challenges. I first discovered my interest in this field while completing a Postgraduate Certificate in Education (PGCE) at an established South African higher education institution. The first part of the rationale for this study pertains to my experience when I studied to become a teacher. The second part concerns my interest in becoming a teacher-researcher.

1.2.1.1 Becoming a teacher

Having just completed a bachelor's degree in Multi-Media at the same institution, I was thrilled to enrol in a PGCE programme in order to enter the world of education – a world that pivoted around a question essential to human thriving: How do we learn best? The PGCE programme differed radically from any form of education that I had experienced before, and I was challenged to discover what it means to be a professional teacher confronted with the aim of getting the best out of learners in order for them to reach their full potential (Slabbert, et al., 2009).

The programme was a professional development programme in the truest sense of the word. From the moment we entered the programme we were told that we will be compiling a professional development portfolio which will contain all the

evidence of the work that we, each individual student, had done to continually construct an ever-increasing improved 'practice theory' of and for education. The premise was that all of us had a good idea of what education is because we had all attended school for at least twelve years in addition to at least another three years of higher education. All of us were, therefore, able to construct our general idea of education as we had experienced it in practice. Since this constituted our practice theory (a theory derived from practice) of education we could also use that theory as the foundation for how we would execute our teaching in practice. Soon after some confidence settled in we were confronted with the following challenge about our first constructed practice theory: "Will your practice theory ensure that it will produce the highest possible quality of learning from the learners? That is the purpose of the programme."

From that point forward, we were challenged in many different ways to implement our most recently constructed practice theory, assess the implementation thereof through critical reflection, explore existing educational theories, practices and possibilities through which ours can be improved, and then use our improved practice theory experimentally. Thus we followed an experiential learning cycle. Needless to say, my initial confidence was quickly replaced with the uncertainty induced by the novelty of the challenge posed to me. I realised that I was not going to be given lectures. Instead, I was going to construct my evidence-based and substantiated professional practice of and for education. Assessment in this PGCE programme would be an evidence-based defence of the quality of the practice theory that we had constructed during the year in front of a panel of examiners (Slabbert, et al., 2009).

Like all the other students, I was confronted with a mammoth task that was actually my real-life challenge as a student teacher. The lecturer's intensive, personalised intervention ensured that I did not underestimate the gravity of the challenge and at the same time it ignited the incredible virtue of resilience through which I could accomplish this achievement. It slowly dawned on me that I was experiencing a significantly skilful lecturer who was also inadvertently fulfilling the proposition that teachers should be taught in the way that they are expected to

teach – except that the 'taught' and the 'teach' was nothing that I was familiar with in an educational setting.

Although the expectations placed upon us were daunting, they conveyed the lecturer's confidence in us that we were capable of accomplishing what is required (Joubert & Slabbert, 2017). Like my fellow students, realising how much I needed to grow to be able to achieve the desired outcome in order to be certified as a teacher, evoked a powerful intrinsic motivation within me to fulfil all the requirements as best I could. In the ensuing months this motivation drove me to unpack the education profession, break through barriers of uncertainty and grow as a human being. It was a difficult process, especially as the authentic challenge posed by the programme was uncompromising in terms of my internalisation of what was being learnt.

Throughout the angst, however, there was my facilitator of learning whose primary goal was to engage with me in such a way that my learning (or growth) took place at an optimal rate. The nature of our engagements shifted dynamically as I grew throughout the year, taking the form of encouragement at times or at other times becoming a challenging voice of critique. My fellow students who were also struggling with this novel approach to learning encouraged me and compulsory group interaction sessions showed me that I was not alone in my uncertainty. These interactions became an underlying safety net, constantly ensuring me that the uncertainty I was experiencing was part of a process that would ultimately help me become the best possible teacher that I needed to become (Joubert & Slabbert, 2017). Finally, I graduated with distinction in a programme completely at odds with (different from) my own primary, secondary and tertiary education experiences up until that time.

1.2.1.2 Becoming a teacher-researcher

After I completed the PGCE programme I embarked on a career in education. Having found my feet within the South African context of the teaching profession after some years, at primary and secondary school levels in both the public and private sectors, I felt satisfied with the inroads I had made in the profession. I was

then compelled to continue my own professional development and thus started my postgraduate studies by enrolling for an honour's and then a master's degree in education. I was still intrigued with my PGCE teacher education programme and the impact it had on my perception of education, especially regarding the way in which we were essentially thrown in the deep end, but instead of being left to swim, we were actively compelled to dig deep into ourselves to ignite the qualities for coping with the challenges of adversity (Joubert & Slabbert, 2017). The research required for my master's study directed me to acquire an intimate understanding of Vygotsky's Zone of Proximal Development (ZPD) that had, unbeknown to me at the time, served as the theoretical framework for the PGCE programme (Vygotsky, 1978). I interviewed alma maters of the programme as well as its designers and lecturers. At the end of the study, I concluded that the amount of learning that takes place relies heavily on the actions of the teacher, especially those actions when learners were engaging with a real-life challenge. I had also come up with my own visual metaphor to explain Vygotsky's ZPD in such a manner that it indicates the influence of pedagogical interventions on the learning process.

After completing my master's degree, I attended several teaching conferences in Asia and the Middle East where I presented on the effectiveness of using digital textbooks. At these conferences I got a glimpse of the international teaching landscape. A tour in 2016 to the public MakerSpace in Hong Kong made me realise that, at grass roots level, the international education community was moving towards authentic, experiential learning experiences within the emerging realm of the 4th Industrial Revolution.

This 4th revolution is already "fundamentally changing the way we live, work, and relate to one another" (Schwab, 2016, p. 7). In the process of being brought about by advances in the digital realm, this revolution moves at the speed of technological development and we are already experiencing the effect of emerging technological breakthroughs like "artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing"

(Schwab, 2016, p. 7). In terms of education, more and more institutions are making use of either models of hybrid/blended learning or distance-learning (Adams, 2007; Andert & Alexakis, 2015; Burgess, 2015; Crews, Tena, Wilkonsin, Kelly, Neill & Jason, 2015; Armellini, 2016; Florian, 2015; Petrovic-Dzerdz & Trépanier, 2018), and other emerging technologies are making their way into classrooms, as is the case with MakerSpaces (Schwab, 2016, p. 148).

Seeing the high quality of learning embedded within the experiential nature of MakerSpaces, I realised that I had to find a way to bring this movement to the school I was teaching at. I started to petition external stakeholders of the school for funds until, one year later, I had enough money to re-purpose an unused classroom into a school MakerSpace. Once I had acquired the basic materials and equipment, I conferred with the school management and found a place in the existing curriculum where the MakerSpace could be utilised during school time hours. Using what I had learnt in Hong Kong and researching popular MakerSpace movements in the USA, I was able to offer MakerSpace as a choice subject for Grade 9 learners (aged 15) during their 'Technology' subject periods. Shortly after I had established the MakerSpace subject at my school, I decided to continue my studies towards a Doctor of Philosophy Degree (PhD) that accommodates this field.

Having developed an interest in the contribution of technology towards the quality of education and the technological influences stemming from the 4th Industrial Revolution, I began researching studies concerning educational paradigms within technology driven contexts. Ultimately I came upon the work of Manu Kapur (2008). Based on an experiment conducted in his home country of Singapore, Kapur had published a paper on Productive Failure (2008) which is a form of learning where the teacher poses a problem to learners that is too difficult for them to solve. In his experiment he challenged triads of high school learners with a mathematics problem in an online chat environment. Some of the triads (the control groups) had been instructed in the mathematical theory and formulas needed to solve the problem beforehand, while other triads (the experimental groups) were not given this information. His research shows that learners who

first struggle, unaided, with ill-structured mathematical problems are better equipped to understand the theories needed to solve the problem when the theory is 'taught' to them *after* they have struggled un-assisted. This was opposed to learners who were first taught the mathematical theories and then asked to apply them. To have learners apply content that they have just been 'taught' is a 20th century mode of teaching which, when stripped from all the educational window dressing and technological paraphernalia, is still persistently dominating our education practices. This is evident even on higher education levels to the extent that Summerlee and Murray (2008) are questioning the right of existence of the contemporary university. Kapur's Productive Failure (2008) addressed the hidden efficacy of the experimental groups that had to first struggle with the un-scaffolded, ill-structured mathematical problem.

I instantly saw similarities between the problems posed to learners in Kapur's (2008) study and the type of challenge I had to resolve during my PGCE education and those that I am confronting my learners with. These similarities reveal an alignment between his work and my interest in determining learning quality when resolving challenges – in his case online. There are also other similarities. The failure of students described in his work also implied an intense emotional struggle which, according to my own experiences and my understanding of Vygotsky (1978), constitutes the very essence of learning. Kapur's research also resonated with the work done Holmes, Day, Park, Anthony, Bonn and Roll (2014), who state that "attempting to repair failures during the invention process requires students to evaluate their failed attempts" (p. 526). These similarities combined with the fact that Kapur's (2008) experiment was done in a technological setting (online chat groups) gave me a model with which to conduct my own studies. There were, however, some serious points of discrepancy; the most glaring one being how Kapur (2008) and myself view the role of the teacher.

Where Productive Failure posits that learners struggle without any form of pedagogical intervention, I believe that the action of a facilitator of learning, especially as learners are attempting to resolve a challenge, is the key to

unlocking the highest possible quality of learning outcome throughout the learning process. I do, however, empathise with Kapur (2008) in terms of the reasoning behind having learners learning completely un-scaffolded, as he reasonably concludes that any form of help may rob learners of potential growth. Personally, I also have qualms with overly scaffolded learning events where learners merely move from one provided scaffold to another until they fulfil a learning outcome.

Basically, the term 'scaffolding' can be defined as "a concept used to describe how learning is mediated by interactions with more expert others" (Moschkovich, 2015). Teasley (2008) states that by scaffolding small-group discussions the optimal learning outcomes will be achieved. When taken at face value, this definition seems to suggest something akin to the pedagogical intervention while learners are struggling to resolve a challenge. In practice, however, the nature of scaffolding is typically a form of pre-meditated support designed by anticipating challenges that learners will be faced with. Herein lies a risk that possible opportunities for struggle would be anticipated and negated, which would decrease the quality of the learning. Thus, in line with Kapur (2008) and in contrast to Teasley (2008) I also believe that scaffolding can be a threat to the quality of learning in small groups.

Within this context Ludvigsen, Cress, Law, Rosé, Stahl and Gerry (2016, p. 259) state that the Computer-Supported Collaborative Learning (CSCL) community has both the mandate and the means to "contribute with models for learning" in an online collaborative environment with the opportunity to provide the most appropriate scaffolding. From their investigation where learners were confronted with ill-structured problems, Kapur, Voiklis and Kinzer (2008) wrote an article titled: "Sensitivities to early exchange in synchronous computer-supported collaborative learning (CSCL)", which discusses how the first part of an online chat group discussion (consisting of text messaging over a computer network) determines the subsequent level of interaction of participants. In his study, Kapur refers to participation in-equity (PI) as the measure for participant interaction. The term refers to a scenario where the contributions made by participants in an

online chat setting are not equal in number. This inequality typically takes the form of one participant making a greater amount of comments (in effect dominating the discussion) while other participants retract from the discussion, allowing teammates to solve the problem without their input. An online chat with a high level of PI refers to such a scenario, while a low level of PI refers to an online chat where the participants generally contributed equally to the discussion. To put it in the words of Kapur et al. (2008, p. 58):

> "Early lock-in of PI is significant, for it suggests that the impact of early exchange on group performance is much greater than what comes later."

Acknowledging the importance of participation in groups and the threat posed to the quality of the learning by participation inequity, other researchers then questioned how the 'natural' participation inequities highlighted by Kapur (2008) could be addressed.

My research formed part of a response to Kapur's call for further studies to be done in this field and is a respectful rebuttal of un-scaffolded learning as proposed by Kapur. In order to make my case, I conducted a study of Kapur's theory of Productive Failure (Kapur, 2008). Once this was done I was be able to reconcile the work of Kapur (2008) with an appropriate pedagogical intervention which was, in fact, a purposeful learning quality enhancing form of scaffolding. This enabled me to adapt Kapur's original experiment in order to determine a learning quality measurement in an online, collaborative learning setting.

1.2.1.3 My rationale taking a significant turn

After being convinced that I have expressed the rationale for my study to its ultimate conclusion in the preceding paragraphs, I was confronted with a challenge imbedded in the very nucleus of my intended research. It was the revelation of an inherent obstacle in the field that was to be the pivot on which the success of my investigation depends. Stahl and Hesse (2010, p. 137) formulate this challenge as follows:

> "Our field of Computer-Supported Collaborative Learning necessarily struggles to integrate contributions and perspectives from a diverse set of disciplines, technologies, practices, methodologies, and theories. First, based on its very name, CSCL must bridge the professional disparity between computer science and learning science. Then it has to function within the multiplicity of approaches to conducting research about computer support technologies and collaborative-learning interactions."

This necessitated me to contemplate the rationale of my research in terms of its ultimate focus on a singular particularity (CSCL) already exposing an inherent challenge. This challenge refers to the incredible progress that has been made towards a 21st century education together with the exponential advancement of technology in the wake of the 4th Industrial Revolution. It has resulted in a world, which includes that of education, that has truly become too big to know, as so well portrayed by Weinberger (2012). If this challenge exists within the context of one of many 'end-of-the-line' educational techniques, how much more would it not be valid for education as a whole? Even before this incalculable expansion education was perceived by many as a conglomerate of separately existing philosophies, theories, methods and techniques with the abundance of Smart technologies that could be selected according to the criterion of 'what works for you'. Even when the term 'integration' is used, this seldom refers to anything more than an 'adding-on'-practice characterised by expressions like 'bringing in X, and bringing in Y, and bringing in Z'. Today, even the best attempt at integration may be jeopardised because the resultant condition of the current exponential expansion "produces a multiplication of incompatible differences of interpretation" of the world which Barnett (2004, p. 249) calls "supercomplexity."

Within the exploration of the interrelatedness of the particularities and its potential advantages for this research mentioned in the preceding paragraphs, the encompassing rationale for this study was to, as far as is humanly possible under the conditions of supercomplexity, rid education of being subjected to a

randomised ideological, commercial and populist eclecticism with an ever-illusive clarity of purpose.

1.2.2 Aim of the study

The aim of this study was, therefore, to revisit the foundations of education to search for a generic, comprehensive, holistically integrated and internally cohesive 21st century pedagogy. A corresponding professional practice can then be constructed from this pedagogy that pursues the highest possible educational quality outcome. Although this might be seen as a rather ambitious endeavour it is, after all, the ethical imperative of education - and within the context of supercomplexity, the clarity of focus on an unambiguous aim of education is primary.

Within this framework, this study aimed to utilise identified professional education practice that has been construed as the pedagogical intervention that is proposed to result in the highest possible learning quality. The aim is to use the work of Kapur (2008) as the basis for this purpose. His work was based on problem-solving and his differentiation between well-structured and ill-structured problems prompted the relationship with the role of MakerSpace in resolving demanding real-life challenges. It provided the opportunity to incorporate MakerSpace as the creative environment of my research. Kapur found that when students are challenged with solving ill-structured problems in small groups online, the amount of participation of students (in their endeavour to solve the problem), determine the learning quality outcome. Although Kapur's experiment influenced the design of my experiment, there were key differences. One of these differences was that the experimental groups would be exposed to the proposed pedagogical intervention, while the control groups would be deprived of such intervention. The participation equity, as well as other measures, was employed to determine the learning quality of the distinctive groups and thus the learning quality result of the pedagogical intervention. Other qualitative mechanisms were harnessed to corroborate results to eventually determine the outcome of the proposed pedagogical intervention on the learning quality achievement of the students – which was the aim of this study.

Thus, to achieve this aim within the context of the demanding challenges of 21st century education in practice, resolving authentic real-life challenges in a corresponding milieu which is contemporarily best represented by a MakerSpace education environment, requires an equally authentic pedagogical intervention like that of Facilitating Learning which explicitly pursues the highest possible quality of individual and cooperative learning on an online platform.

1.2.3 Problem statement

This study attempted to determine the extent to which a teacher can pursue the highest possible quality of learning through having learners resolving demanding real-life challenges in small groups. This was done by means of an online discussion through a pedagogical intervention specially designed for that purpose.

1.3 Research questions

From the outset of this research I perceived a potential complexity. I realised that to address the problem statement listed above I would be faced with two research challenges. Firstly I had to indicate the effect of an educational intervention on the learning quality of small groups. Secondly, I would have to analyse this effect. A main research question along with several subsidiary questions allowed me to structure the research in such a manner that these two challenges were resolved. The research questions are listed below.

1.3.1 Main research question

> What kind of pedagogical intervention is best suited to pursue the highest possible quality of learning outcome from Grade 9 learners when resolving authentic real-life challenges on a CSCL online platform in a MakerSpace environment?

1.3.2 Subsidiary questions

The first two subsidiary questions helped me to resolve the first research challenge where I needed to measure the effect of a pedagogical intervention on

an online discussion by laying the groundwork for such an experiment's design and are listed below:

1. How can I utilise Kapur and Kinzer's (2007) experiment on participation in-equity to determine the learners' learning quality when they resolve authentic, real-life challenges on a CSCL online platform?

2. What would represent the theoretical and conceptual framework of/for a pedagogical intervention that explicitly pursues the highest possible quality of individual and collaborative learning that results in its corresponding intended outcome in practice?

Answering these two subsidiary questions allowed me to design an experiment where I could then test the effect of a pedagogical intervention on the learning quality of online chat groups. With experimental groups where a pedagogical intervention was introduced and control groups where no intervention was introduced, the hypothesis for this experiment was as follows:

a. H_0: If the online CSCL educational experience of my learners in resolving a demanding authentic real-life challenge is not intervened by the professional practice of facilitating learning, the quality of their learning process will not be enhanced.

   H_1: If the online CSCL educational experience of my learners in resolving a demanding authentic real-life challenge is intervened by the professional practice of facilitating learning, the quality of their learning process will be enhanced.

Once a had resolved the first challenge, I had to then analyse the effect of the pedagogical intervention on the learning quality of the discussions as indicated by the experiment. Subsidiary research questions 3 and 4 were designed to this effect and are listed below:

3. What are the experiences of participants in all of the chat groups when being confronted by a demanding, authentic, real-life challenge that they need to resolve?

4. How did participants experience Facilitating Learning in the experimental chat groups while being confronted by a demanding, authentic, real-life challenge that they need to resolve?

1.4 Overview of the study

1.4.1 Chapter 1: Orientation and problem statement

In Chapter 1 I endeavoured to explain the study in terms of the rationale behind it and what I aimed to achieve by conducting it. It should also be noted that the aim and problem statement for this study was elaborated upon to a much greater degree than was common in examples of PHD theses which I researched in preparation for this study. This elaboration was done in an attempt to guide the reader along the same path that ultimately led me to the discovery of the topic of this research and in doing so help the reader to locate this study between the seemingly disparate fields like pedagogy, technology and curriculum.

1.4.2 Chapter 2: Literature review

Chapter 2 provided the scientific context of the study by locating it within the existing literature. In order to address the different facets of the study, the literature review included discussions on:

- Constructivism as the epistemological lens used by the researcher whilst conducting this research,
- my understanding of ‘authentic learning’ based on the existing literature,
- a brief overview of the MakerSpace movement including its history and how it has started to permeate formal education,

- a discussion on Vygotsky's Zone of Proximal Development as the theoretical framework for the study,
- an overview of the different formats of online learning most prevalent in the current educational landscape,
- an in-depth analysis of one specific form of online learning which pertains to the study, and finally
- a detailed (if concise) exploration of the pedagogical intervention designed especially for pursuing the highest possible quality of learning.

1.4.3 Chapter 3: Research design

The research methodology for the study was presented and explained in Chapter 3. With a mixed methods approach, the study comprised of both quantitative and qualitative phases, each with its own set of data collection tools and data analysis techniques. An effort was made to keep the presentation of the research design systematically ordered according to the different phases in order for the reader to be able to confidently follow the planned research process. The complexity of the study and the explorative manner in which the different aspects of the research were uncovered did, however, necessitate that I approach the study as a "research assemblage" (Martin, 2018, p. 9). In that sense there was bound to be some deviation from the conventional reporting style that accommodated a more personal, experiential and affective first person communication in the presentation of this study.

1.4.4 Chapter 4: Empirical research

In this chapter, an effort was made to order the presentation of the data collected in the study in such a way that the reader is cognisant of its nature, be it quantitative or qualitative. The way the different types of data were reconciled is also systematically laid out to highlight the interplay between the different data sets.

1.4.5 Chapter 5: Findings

Chapter 5 presented the findings of the study by analysising the collected data. In this chapter both of the research challenges were effectively resolved as the hypothesis for the experiment was addressed and then also analysed.

1.4.6 Chapter 6: Conclusions and recommendations

Based on the presented findings in Chapter 5, conclusions were drawn and finally the research questions of the study were answered. Limitations in this study were also discussed as well as suggested recommendations for future research.

1.5 Conclusion

Over the course of the six chapters listed above, I hoped to shed some light on what I perceived to be the ‘dark matter’ of education. A visual metaphor for this goal can be seen where a photo taken by the Hubble Space Telescope shows the galaxy cluster MCS J0416.1-2403 (European Space Agency, 2014).

Figure 1.1: Galaxy Cluster MCS J0416.1-2403 without an indication of dark matter (European Space Agency, 2015)

The photo above shows the galaxy as perceived with the human eye. Currently, no ‘dark matter’ is present within this photograph. To be able to view the ‘dark matter’ present in this galaxy cluster, the incremental overlaying of a ‘dark matter map’, which simulates the distribution of dark matter, is required. Progress made in the research on the dark matter of education within this study was indicated by such a proverbial “dark matter map” (European Space Agency, 2015). So, as the study shed light on the type of teaching that will bring about the highest quality of learning within an online environment, the dark matter became more visible as the study progressed. This process of illumination was advanced with the literature review conducted in the following chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The question that Chapter 1 left us with as researchers in general was: How do we frame our research under the conditions of supercomplexity? Although this process might not be completely different from how this was done in the past, usually in the chapter that deals with the research design, I believed it was becoming increasingly critical to remain authentic, and as researcher to reveal my dispositions towards my research unequivocally right from the start of this study.

The theories that I chose to lean on already revealed my tentative assertions about the problem I wanted to solve irrespective of whether they were 'correct' or widely accepted. It is, according to Popper (1963), the commitment to making my theories explicit that they become useful in guiding any research process as well communication with you as the reader. Since they were my assertions and thus my proposed tentative solutions to the challenges I was resolving in this research, I aimed to develop enough trust in them to base my actions upon them as an immediate consequence of this research (Polkinghorne, 1983).

Therefore, regarding each aspect of my research from this point forward, I made carefully informed assertions based on a purposefully selected, manageable number of associated theories which I explicated as best as I could, in the most appropriate way within the context and limited space at my disposal towards a tentative resolution to my research challenge. I need to emphasise that this was my construction, one of many other possible constructions of its kind which I was not even aware of. I, therefore, make no claim towards the exhaustion of resources nor completeness of the task, but rather a commitment to appropriate explicitness instead of 'correctness'. Most importantly, this research is here for your scrutiny, not to be judged as a proof of truth or securing your agreement but, as participants in this endeavour "to part as wiser men" (Popper, 1974, p. 325).

With this introduction in mind, one of the first concepts in education that came to mind is ‘knowledge’ because it seemed as though this is what education is all about. Thus it also seemed to be an appropriate point of departure.

2.2 Epistemology

Epistemology is the study (the Greek root word being ‘logos’) of knowledge (the Greek root word being ‘episteme’). The study of knowledge is a very wide and deep field which describes the nature and different types of knowledge. However, a clear definition of knowledge still eludes us today (Bolisani & Bratianu, 2018). What is appropriate to know about knowledge in this research is encapsulated in a definition that is probably still the most quoted one provided by Davenport and Prusak (1998, p. 5): “Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information.”

This definition exposes some significant misconceptions about knowledge. It indicates that knowledge is ‘not’ information and vice versa, although there is a relationship. The definition further indicates that knowledge is indeed ‘much more’ than information. It is the culminating result of ‘everything’ that has been involved when a human being has been immersed in an authentic (contextually uncompromised) challenging experience that demands the harnessing of all human faculties (holistic) to resolve (make or construct meaning of) the challenge. In fact, knowledge is the instrument and the ‘expert insight’ for ‘evaluating and incorporating’ new information. Most importantly, knowledge is not superficial but it fundamentally possesses “qualities of personal insight and understanding” (Barnett, 2007, p. 164). This means that effectively only the ‘creator’ of knowledge possesses knowledge. Everything else is at most information – void of essential personal qualities.

Having indicated what the nature of knowledge is in terms of this research, it becomes clear that something else is becoming the pivot of education: how knowledge is ‘constructed’ – this is learning.

2.3 The learning sciences

Learning sciences is an interdisciplinary field that was established in the 1990's. It works to further our understanding of learning and the consequential design, implementation, and innovation for the improvement of learning environments and pedagogical interventions. Some major fields that are contributing to this interdisciplinary endeavour are cognitive science, educational psychology, neuroscience, anthropology and computer science. Some of the most prominent researchers are Stahl (2006), Sawyer (2014) , Pea (2016), Fischer, Hmelo-Silver, Goldman and Reimann (2018) and with many more scholars from different disciplines (Coffman, 2017; Holden, 2017; Oakley, 2017, 2018; Blakemore, 2018a, 2018b; Martinez, 2018; Dehaene, 2018, 2019; Agarwal, 2019; Willingham, 2019a, 2019b; Bunge, 2018; Watson, 2019; Davidow, 2019; Laur, 2019; Stobauch, 2019).

The large membership of the International Society of the Learning Sciences (ISLS) is also affiliated with two international journals: the Journal of the Learning Sciences and the International Journal of Computer Supported Collaborative Learning, the latter being a key aspect of this research. This research, imbedded in the learning sciences, was concerned with learning as it occurs in real-world situations and how to better facilitate learning in these environments. Since learning sciences research is primarily guided by constructivist theories, this will be the object of our exploration in the upcoming paragraph.

2.4 Constructivist and associated epistemologies

During the Age of Enlightenment, the theory of Positivism emerged "as a science … pointing … to a crisis scenario predicated on the decrease of religion's significance" (Ballano, 2019, p. 56). This theory rejected all forms of theism and only recognised that which can be scientifically verified. According to Positivism, reality is objective and can thus be scientifically observed. This was the foundation of schooling in the 20th century, where the task of the teacher was to transmit the objective knowledge of reality presented in textbooks into the minds of students. Based on the work of Jean Piaget, John Dewey, Jerome Bruner, Lev

Vygotsky, Ernst von Glasersfeld and many others a new alternative epistemology later emerged called Constructivism, which is so aptly described by Heyligen (2013, p. 1):

> "According to the constructivist epistemology, knowledge is not passively received either through the senses or by way of communication, but it is actively constructed by the individual through interactions with the environment … When learners are in interaction with their environment attempting to make sense of the world, they are constructing knowledge through their experiences which constitutes the construction of meaning."

This definition prompts a closer look at the environment it mentions. We are constantly in relation with two major environments. The one environment is our own personal, internal environment and the other is the external environment. The external environment may be divided into the non-human environment and the human environment, which is an environment of which individual human beings are constructing meaning or knowledge. There is a perception that human beings construct meaning 'together', but what is happening inadvertently within a social context is that individuals 'share' their individually constructed meaning(s) with others while each individual has the opportunity to utilise the shared meanings of others and the context of their interaction with one another, to construct a new individual and personal meaning even though it may result in the rejection of the meaning(s) of others. This is called Social-Constructivism and is fundamental to this research.

The key to Constructivism and Social-Constructivism is Von Glasersfeld's (2008, p. 33) short but profound statement that clears up a fundamental misconception about education in terms of our proposed definition of knowledge in a previous paragraph: "Knowledge is not a transferable commodity and communication not a conveyance." However, Constructivism has been heavily criticized, and its criticism originates mainly because of a perception that it is a teaching theory

(method/approach/strategy). One of these criticisms is that utilising constructivism in classroom practices usurps too much time. Fortunately, Smilkstein (2011, p. 61) clarifies the inevitable time required for the way in which we naturally learn:

> "Learning takes time because it requires growing new dendrites, synapses, and neural networks. These are physical structures, and physical structures ordinarily do not grow instantaneously."

Another criticism comes from the cognitive load theory (CLT) developed by Sweller (1988). Cognitive load theory pertains to the limitation of the amount of information the working memory can contain and process at a time before it is overloaded with an obvious detrimental effect on learning. The criticism is that Constructivism causes cognitive overload through confronting students with an abundance of information even at the start of a learning event. Truth is that all of us are naturally bombarded with experiences of an unsolicited amount of information every moment of our lives. However, it seems as though we have a natural control over, and filtering of, the abundant amount of information that we are confronted with in our daily lives – even as small children (Zull, 2011). Cognitive overload is much more likely to occur when students have no control over the amount of particularly structured information that is transferred during teaching. This is particularly important when we also consider the next criticism towards Constructivism.

The criticism lodged by the proponents of the sociology of knowledge like Young (2008; 2009) and his co-workers is that Constructivism is discriminatory within the realm of diversity. They argue that there is a difference between knowledge that students acquire in everyday life and the specialist (powerful) knowledge they should acquire in school. Since Constructivism is proposed to be reliant on students' experiences of everyday life (real-life) as a priority for the acquisition of prior knowledge for specialist knowledge, the knowledge thus acquired may differ vastly among students with different abilities, cultures and socio-economic

circumstances. Because of the consequential detrimental disadvantage of some students (in some cases the vast majority), they submit that "the goal of schools is to 'transmit powerful knowledge'" (2009, p. 10). Unfortunately, as indicated by Von Glasersfeld (2008, p. 48) knowledge cannot be transmitted (because of its intrinsic relationship with experience), thus only information (the constructed knowledge – understandings – of others) can be communicated though still largely dominated by the tell/show/talk transmission and acquisition of knowledge. We may need to take note of the serious accusation of Kersson-Grieb (2006, p. 6):

> "Teaching is an unnatural act, an incursion on another person's learning-in-progress. Each persuasive attempt to get students learning [through teaching]… comes with a built in demand that they stop thinking [because of] the teach/tell/talk belief that defines 'learning' as 'students memorizing my understandings' instead of constructing their own … teaching is no doubt an imposition, a sustained redirection of other curious creatures' voracious cogitation."

Constructivism, by contrast, suggests that students should be confronted by the most powerful learning environment which is real-life in its uncompromising complexity (as it authentically exists or re-structured if necessary) through which students will be able to construct the required powerful, dynamic knowledge. In fact, the exemplary work of Paulo Freire with his advocacy of critical education, described so well by Slattery (2006, p. 232), is testimony to this achievement:

> "When the illiterate peasants of Freire's Third World classrooms, as well as uncritical students of First World schools, begin to participate in problem-posing and problem-solving educational experience, they begin to develop a new awareness of self, a new sense of dignity, and ultimately an experience of hope."

Newman, Marks, and Gamoran (1995, p. 1) identify this constructivist problem-posing and problem-solving education as authentic education and confirms the results of Freire's work: "As to the effects of authentic pedagogy on students with different backgrounds: We found that authentic pedagogy helps all students substantially."

Perhaps one of the more subtle questions that remain lingering about the constructivist epistemology may be when and how do human beings express their inherent constructivist epistemology. Fuller (2010, p. 169) provides an answer:

> "Children are born true scientists. They spontaneously experiment and experience and re-experience again. They select, combine, and test, seeking to find order in their experiences – 'which is mostest? Which is leastest?' They smell taste bite and touch – test for hardness, softness, springiness, roughness, smoothness, coldness, warmness; they heft, shake, punch, squeeze, push, crush, rub, and try to pull things apart."

Ackofff and Greenberg (2008, p. 29) testifies to this in terms of the standard of children's natural capacity of executing constructivist epistemology:

> "Complex problem solving is natural to children. From the moment of birth, nearly all their activity relates to a vast number of interrelated real-life problems. With each passing month the number and complexity of the problems they face increase."

Through these two quotes, it is evident that human beings are born to learn in this authentic manner (Smilkstein, 2011; Zull, 2011).

One of the most revealing descriptions of the spontaneity of the process of constructivist learning through to its final conclusion is epitomised by that of the mathematical genius, Blaise Pascal, as it is related by Cox (1926, p. 304):

> "Pascal used to mark with charcoal the walls of his playroom, seeking a means of making a circle perfectly round and a triangle whose sides and angles are equal. He discovered these things for himself and then began to seek the relationship between them. He did not know any mathematical terms and so he made up his own … Using these names he made axioms and finally developed perfect demonstrations … until he had come to the thirty-second proposition of Euclid."

This is not only an example of the potential of constructivist epistemology, but also an example of the capacity of children to actually construct knowledge that has not existed before. The question may be asked, however, that if children need to learn things that already exist, why is it necessary for them to reinvent the wheel through a constructivist epistemology. The answer to this question is that it will, of course, be senseless to have children learn what they already know. The reality is that there are many things that children need to learn because it is yet unknown to them. Buscaglia (1986) explains why learning through constructivist epistemology is necessary when he says that the wisest people live their lives perpetually (lifelong) learning because the most important thing about learning is not so much the knowing but the seeking. That is why Piaget (1972, p. 27) insists:

> "Children should do their own experimenting and their own research. Teachers, of course, can guide them by providing appropriate materials, but the essential thing is that in order for the child to understand something, he must construct it himself, *he must re-invent it*. Each time one prematurely teaches a child something he could have discovered himself, that child is kept from inventing it and consequently understanding it. On the other hand that which we allow him to discover by himself will remain with him" [own emphasis].

It is the potential of the inherent, natural disposition of the child (curiosity) and the subsequent essential human qualities (like courage, motivation, initiative, responsibility, perseverance, resilience and more) that are ignited to flourish

through the learning process – the adventure of seeking during the journey – of the constructivist/social-constructivist epistemology.

This brings us to the mental processes of learning as it is entailed in the learning theory of cognition. This is also popularly known as the brain's learning process. It is the field that has intersections with other disciplines like the neurosciences and neuro-psychology (Zull, 2002; 2011; Smilkstein, 2011; Venter, 2016; Almarode & Daniel, 2018; Blakemore, 2018a; Dehaene, 2018; Willingham, 2019b). The following hyper-simplistic model of cognition and its associated disciplinary contribution is an attempt to reveal its centrality for the explication of its interconnectedness as it is relevant to this research through Sternberg's theory of intelligence (2018).

Raw stimuli emanating from the environment (internal and external) are received by the senses and is then transported to the working (or short-term) memory that transforms the random data bits into organised, comprehensible categories of information. Since the working memory has limited capacity, the information has to be transferred to the long-term memory which is the cognitive structure that stores the information. It is a process-searching process of finding a match for the information to be stored. If the brain recognises the incoming information it strengthens its pathway to storage, its existence and how it has been used, like filling up a container with more of the same ... If the information is new and a fitting container is not found, tension caused by uncertainty arises with a consequent excretion of hormones like endorphins and adrenaline that energises our entire being to take action to release the tension. However, to avoid the risk of engaging with the unknown, the safest path is the one with the least resistance. Quitting the search releases the available energy to keep the existing, well-known cognitive structure and its content intact. The status quo is maintained and no learning takes place. The other option is to *force fit* the new information into a place where other already existing well-known information has already found its home (assimilation). The consequence of not using the available energy to take the risk of learning something new is humoristic-violently expressed by Palmer (2007, p. 113):

> "So we grab an old idea, a conceptual club we know how to use because we have swung it many times before, and we beat the surprise to death – or we run away before it can make a mark on our minds. Startled by otherness, reacting out of fear, we destroy the possibility of learning anything new by allowing the ancient fight or flight syndrome to have its way …"

Thus we seek refuge in the illusionary security of our comfort zone. However, we may also use the energy to transfer the information and all its contextual contributors into knowledge, which will require the container occupying the existing knowledge to be strengthened because it now has to accommodate not only the existing knowledge but also the incoming knowledge in a fully integrated higher level. This effortful achievement is rewarded by the brain with the excretion of an appropriate amount of good-mood enhancing hormones like dopamine and serotonin. If the new information can not be accommodated in this way, the increased tension provides the associated increase in the amount of hormone excretion, the energy and effort to construct a completely new container customised to envelop new knowledge in its own right. In all cases, this results in a correspondingly higher feel-good reward which provides the impetus to put the new knowledge to its ultimate test of utility.

This limited description discussed above highlights, amongst others, the following about cognition:

a. The brain is a self-rewarding system.
b. The brain produces knowledge that differs in levels that may be equated to quality.
c. The bigger the effort, the bigger the quality of the knowledge construction.
d. Emotion is fundamental to the process of learning.
e. The neuroscientific and psychological dimensions of Cognitivism are indispensable.

What is perhaps the most significant revelation of the cognitivist epistemology in this regard is that learning is *holistic* in nature. Many researchers, including those from the not so readily accepted interrelated fields like philosophy, Enlightenment, neurology, embodiment, transpersonal psychology, evolutionary psychology and computer sciences, have contributed to the construction of what may constitute the human being in its holistic essence (Maturana & Varela, 1992; Zohar & Marshall, 2000; Dimitrov & Wilson, 2002; Covey, 2004; De Quincey, 2005; Bar-On, et al., 2007; Palmer, 2007; Pandya, 2011; Buss, 2015; Claxton, 2015; Friedman & Hartelius, 2015).

From these and many more contributors, we can conclude that body, mind, soul, and spirit are the four vital, inseparable constituents of our human nature that is responsible for the integrity of our human individuality. They are also called domains of intelligence:

a. Body: Physical intelligence (PQ).
b. Mind: Mental intelligence (IQ)
c. Soul: Emotional intelligence (EQ) – which includes will and social intelligence.
d. Spirit: Spiritual intelligence (SQ) – the source of our authentic potential: who we really are, what we are actually capable of and what our ultimate purpose is.

When a demanding real-life challenge compels a constant, dynamic interaction with the environment (external and internal, human and non-human) for its resolution, the domains of intelligence are simultaneously activated for a dynamic interplay between them which results in the access of our spirituality which is “the deep centre of the self” (Zohar & Marshal, 2000, p. 239) and “the domain of pure potential” (De Quincey, 2005, p. 240).

The socio-/social- dimension of the theories and its constituent disciplines mentioned in the preceding paragraphs are irrefutable in that the function of the prefix (socio-/social-) is similar to that which has been indicated when Constructivism was explored above. But interestingly enough, while this is valid also for Cognitivism, there is a unique feature as purported by the Social Cognitive Theory (SCT) (Bandura, 1986; 2008).

This feature draws the relationship between learning and behaviour. In that sense, socio-cognition is grouped under the behaviourist learning theories. However, it is because I view cognition not with a kind of learning through imitation of behaviour nor a stimulus-response kind of behaviour. I view it as an understanding of why a certain behaviour is necessary and has a particular result and thus the reason for its adoption. Therefore, learning by observation and reasoning why and how a certain behaviour achieves its result is the key to adopt that behaviour sooner rather than later. Like a picture, behaviour tells a thousand words about a person and the teacher's behaviour is an open book to students in which they should see (through modelling) not only what, but how they should learn how to learn. With scaffolding as the teacher behaviour, Vygotsky's Zone of Proximal Development (ZPD) as a pedagogical intervention needs our attention.

2.5 Vygotsky's Zone of Proximal Development

According to Vygotsky's ZPD, learning takes place in the space between what a learner has already mastered (Zone of Actual Development) and what a learner is capable of mastering (Zone of Proximal Development). The Zone of Proximal Development is activated when students are confronted with an authentic/unique/novel challenge, which is located within their own specific social-historical context, while they are assisted by more capable peers (Vygotsky, 1978). It is this theory that learning is socio-historic in nature that provides us with a vantage point from which to conduct studies of the interpersonal aspects of learning, as can be seen in the following quote from Luhrs and McAnally-Salas (2016, p. 30):

> "Social Constructivism [and by design social cognition] draws on the ideas of Constructivism and becomes a model that states that knowledge is not only acquired from the relation of the subject with his environment, but the social environment is incorporated as a factor to this equation" [own insertion].

A visual metaphor depicting a traditional understanding of the Zone of Proximal Development is shown in the figure below:

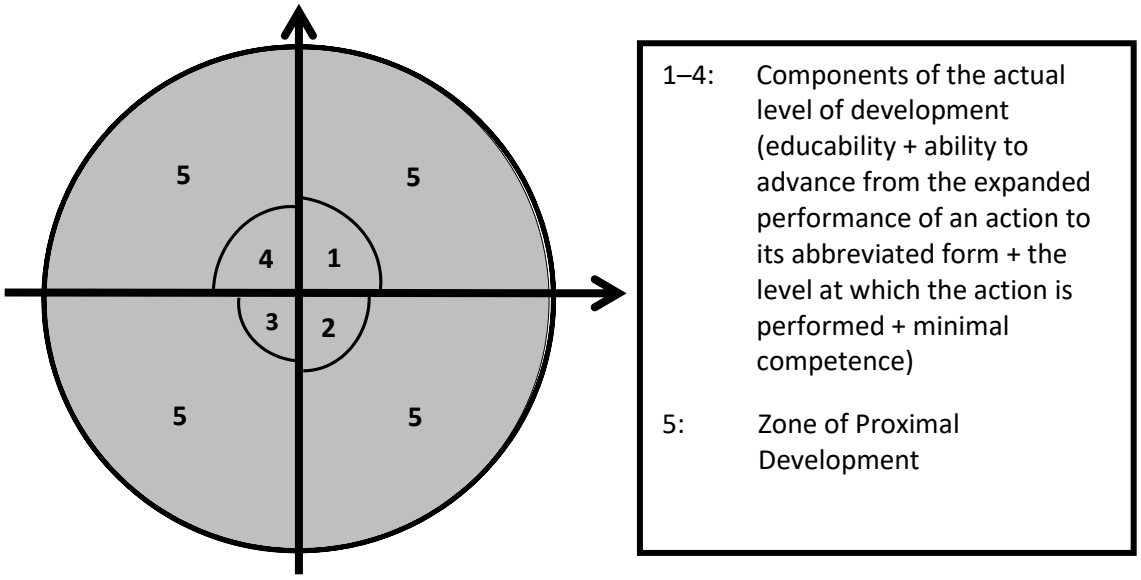


Figure 2.1: A hypothetical structural model of the Zone of Proximal Development adapted from the work of Obukhova and Korepanova (2009, p. 35)

Although many interpretation of Vygotsky's theories exist (one of the most notable being the work done by Daniels, Cole and Wertsch (2007)), during my master's degree (Joubert & Slabbert, 2017) I formulated my own adaptation of this traditional representation of Vygotsky's ZPD, which I named the Domain of Self-Transcendence (DOST). It is important at this juncture to note that it is only a visual tool that I created to help understand Vygotsky's ZPD. Specifically, my adaptation explains Vygotsky's learning theory from the perspective of a teacher. Vygotsky's ZPD does, however, remain the theoretical framework of this study. It was during the research phase of my master's study that I concluded that the

actions of a teacher are ultimately the component in the learning process that has the greatest agency to determine the amount of learning accessed by students during the learning process. To indicate this, I added an additional area called the Dynamic Domain of Self-Transcendence to the visual illustration of Vygotsky's development theory. By visualising the effect of a pedagogical intervention within the development process, I was once again reminded of the responsibility placed on the shoulders of a teacher. It is vital that within education we must first fully understand how learning takes place before we can accurately measure the quality of learning in our classrooms and thereby gauge the effectiveness of our pedagogical interventions. My adaptation of the traditional visual metaphor explaining Vygotsky's Zone of Proximal Development theory is shown below:

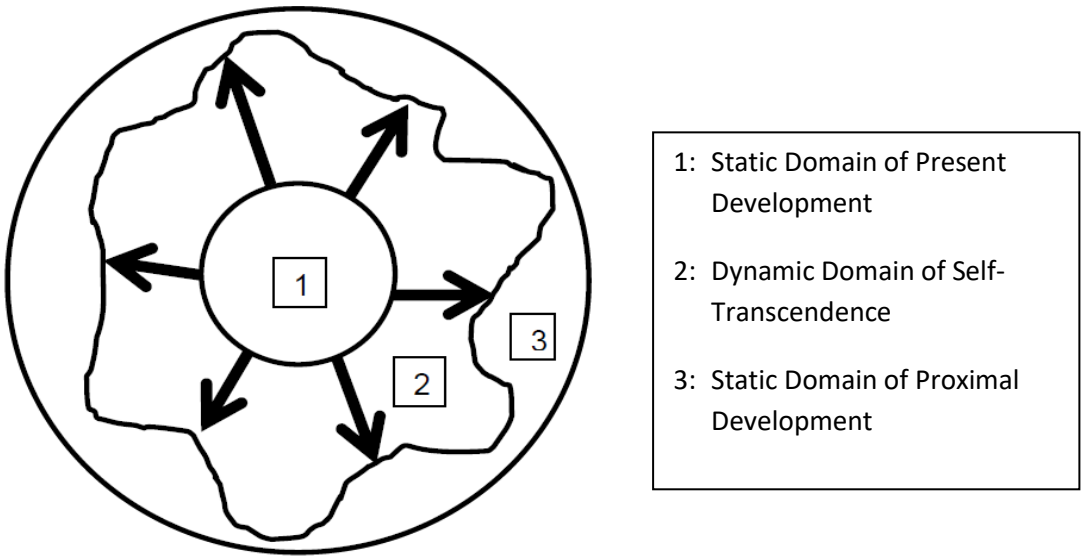


Figure 2.2: The Domain of Self-Transcendence

My visual representation of this theory is called the Domain of Self-Transcendence (DOST), which is the domain between that which has been mastered and that which can possibly be mastered, namely: the Dynamic Domain of Self-Transcendence (self-transcendence referring to a learner's ability to transcend inherent mental and emotional challenges). Aside from the addition of a third domain, I also renamed the 'Zone of Actual Development' to 'The Static Domain of Present Development' and the 'Zone of Proximal Development' to 'The

Static Domain of Proximal Development'. My motivation for making these changes is three-fold:

- To indicate that when a learner enters a classroom, that learner has a static history of development: Residing in the past, the Static Domain of Present Development is fixed and will vary for every individual learner based on a range of factors such as their biological mental development, the experiences they have been exposed to previously, etc. The extent of this domain will be unknown to the teacher.
- To indicate that each learner has a limited range of growth / learning that can take place in any lesson: The Static Domain of Proximal Development is fixed, as it is based on fixed factors including the developmental age of the learner, the time available in the lesson, etc. Although there are broad signposts for the level of development to be expected of students according to their age group (Piaget, 1977), the exact extent of this domain will be unknown to the teacher.
- To indicate that the quality of learning that can take place in a lesson is dynamic: It can change depending on a range of factors within the lesson, such as the learner's motivation to engage with the task, the educational environment in which the lesson takes place and the actions of the teacher. I believe that of all these factors, a *pedagogical intervention* done by a teacher has the greatest influence when it comes to increasing the quality of learning.

Learning quality and all its variants, like the quality of education, is a contentious issue primarily because, like the quality of most human endeavours, it is difficult to quantify. However, when we consider the quantified results of the many international tests like the Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS) and South Africa's

national tests like the Annual National Assessments (ANA), the South African School and Administration Management System (SA-SAMS) and the National Senior Certificate (NSC), the international World Economic Forum Global Competitiveness Report and the more locally Southern and Eastern Africa Consortium for Monitoring Education Quality Report are able to rank the quality of our education. However, an understanding of the three domains of the DOST leads us to conclude that to determine the actual quality of learning, the area of the Dynamic Domain of Self-Transcendence provides a 'measurement'. To put it differently: the amount and level of mental and emotional challenges that a learner transcends during a lesson indicates a measurement of the quality level of the learning.

Interestingly, the digitised realm of learning does have similarities to Vygotsky's view of learning, as can be seen in the following statement:

> "Constructivism is the most common pedagogical approach for online learning. The central constructivist idea is that the teacher does not transmit or impose meaning. Learners create meaning from learning activities chosen by the teacher. Meaning is personal and it depends on what is previously known, the way that knowledge is used and the motives and intentions of the learner" (Luhrs & McAnally-Salas, 2016, p. 30).

The following quote has an even more specific focus on the field of CSCL:

> "Computer-supported collaborative learning (CSCL) denotes a pedagogical approach characterised by the sharing and construction of knowledge among participants using technology as their primary means of communication or as a common resource" (Cen, Ruta, Powell, Hirsch & Ng, 2016, p. 188).

Noting that there are visible links between digitised learning and Vygotsky's learning theory, we need to remind ourselves at this point that Vygotsky's theory of learning only applies to scenarios where students are immersed in authentic

learning. It should also be highlighted that 'constructed knowledge' needs to adhere to rigorous standards set within an educational context, requiring that the knowledge has a high level of accuracy, relevance, cohesion, etc. With this understanding of how learning takes place, it is now possible to search the literature of online learning for evidence of supporting real-life authentic learning.

2.6 The many forms of online learning design

With the many different forms that online learning can take, it will be of benefit to this study to briefly outline the most salient forms of what is essentially distance education supported via technology. Investigating the literature, we see that the shift towards technology driven online learning can be credited to technology's ability to:

- eliminate the need for physical proximity, as stated by Burgess (2015), for whom online education made it possible to continue teaching her university course load despite the fact that she had moved out of state;
- mirror the workplace, as can be seen in the writings of Andert and Alexakis (2015, p. 146), who states that "organizations use technology and social media as the cost-effective, even the preferred, rapid communication and teaming modality", requiring students to "possess fluency in the selection and use of computer mediated communication and virtual teaming applications"; and
- allow for innovating teaching, as described by Armellini (2016, p. 17), who states that technology will "continue to widen the range of approaches to learning and teaching" and that any technological innovation that improves results will necessarily in time become "mainstream practice" (p. 24).

Florian (2015, p. 120) summarises a contemporary need for an online educational solution as follows:

> "The global delivery of education is in flux. Institutions are searching for viable options to cope with the supply of, and demand for, skills

> required by a global workforce. Students need options to maximize their ability to gain the skills necessary to compete for future jobs in the global economy. Educators also need tools that will increase student engagement in the learning process and ensure that students are obtaining the skills that will be in demand in the global economy."

But how do we define online learning? According to Crews (2015, p. 89): "The definition of online learning has developed based on a variety of definitions of distance learning." Before the advent of the Digital Revolution, distance education consisted of students communicating with teachers via written letters. This was known as correspondence programs. As technology advanced, computers became the predominant medium for communication in distance learning, which led to a rapid increase in its use. This is illustrated by the fact that between "1991 and 2004, enrolments in online distance education have grown from virtually nothing to more than 2.35 million students" (Adams, 2007, p. 1). In addition, rapid development in the world of Information Technology (IT) translated into a rapid evolution of distance education based on IT platforms.

One of the most common forms of online education is the use of specifically designed, integrated, digital learning platforms that offer students and teachers a means to communicate. An example of such a platform is Moodle (Florian, 2015; Petrovic-Dzerdz & Trépanier, 2018), which allows, amongst many other things, teachers to create online activities for students to complete. These systems are usually very robust, catering for a wide range of administrative and pedagogical needs that an academic institution might have. Additional technologies (which may or may not be included in online learning platforms) can be divided into two camps, namely: synchronous and asynchronous.

Synchronous online technologies refer to digital tools that allow people to converse in real-time, like when two people are having a face-to-face conversation. The modes of conversing can be either text-based or can be done using audio or video. Synchronous modes of communication are valuable, as it allows decisions to be made quickly (Donelan & Kear, 2018, p. 39) and it simulates real-life group dynamics which allows for the development of inter-

personal skills – especially when a group is faced with an open-ended problem which requires a significant amount of interaction among students (Croft, Dalton & Grant, 2010; Lenar, Artur, Ullubi & Nailya, 2014; Kebritchi, Lipschuetz, Santiague & Fojtik, 2018). Asynchronous online technologies are those tools where people do not communicate in real-time. Wiki's and emailing fall into this category (Donelan & Kear, 2018) as (similar to the post) a message is sent, only to be answered whenever convenient by the receiving party. The advantage of using asynchronous tools lies in the fact that two parties can communicate without having to schedule a time to meet in the online environment. This is especially helpful where people who live in different time zones have to communicate. Aside from the categories of asynchronous and synchronous, another popular term found in online education literature is Open Education.

Open Education is a movement that started with the creation of Open Education Resources, which can be accessed online, free of charge. Although the study by Pakevicius, Veletsianos and Kimmons and Royce (2018) shows that people usually interpret the term 'Open Education' as referring to 'Open Education Resources', this form of online education also has an accompanying pedagogical model addressing freely accessible modes of learning, using Open Education Resources. An example of this is massive open online courses (MOOCs), which "came about as a means for enacting networked and open education" (Paskevicius, et al., 2018, p. 118). Although research has shown that pure online learning environments "provide great opportunities for potentially high quality learner-to-learner collaborative learning situations" (Costley & Lange, 2018, p. 69), many institutions that have physical lecturing facilities rather employ a blended learning model.

In blended learning, compulsory contact sessions between students and teachers are built into the online learning program, allowing for face-to-face interactions which, according to Motta (2016), focuses on "the social construction of knowledge" while "self-paced online learning … improves individual retention" (p. 138). The last form of online learning to be discussed is also the latest development in this realm; the use of virtual reality.

A consensus on Constructivism, as being the natural way in which human beings learn, has done much to prompt the use of virtual reality (VR) within an educational setting. This is clearly evident in the following insightful words of Huang and Liaw (2018, p. 91):

> "Within a constructivist paradigm, the virtual reality technology focuses on the learner's actively interactive learning processes and attempts to reduce the gap between the learner's knowledge and a real-life experience. Recently, virtual reality technologies have been developed for a wide range of applications in education …"

As this is a very new field of online education, the verdict is still out on whether virtual reality can mimic reality to such an extent that it engenders an intrinsically authentic emotional and mental response in students and not merely a temporary adrenaline hype before actual reality sets back in. In view of this, it is understandable that there is a call in the literature for researchers in the field of virtual reality to "establish appropriate and effective learning techniques and practices to motivate meaningful learning" (Huang & Liaw, 2018, p. 91). Personally, I am sceptical whether technological advancement will ever be able to mimic real-life to the extent that students experience a challenge authentically since, by definition, the reality provided by VR is virtual / indirect / implied / implicit and not authentic.

Within these broad areas of online learning, a field named "Learning Design" (Dalziel, Conole, Willis, Walker, Bennet, Dobozy, Cameron & Badilescu-Buga, 2016) has come to the fore as a discipline focusing on learning design in an online environment. Researchers and educators within this field "are earnestly attempting to convey great teaching ideas among educators in order that students may learn more effectively" (Dalziel, et al., 2016, p. 28) by continually adding to a Learning Design Conceptual Map. This integrated presentation of learning theories already includes the work of:

- Masterman and Manton (2011),
- Gedik, Kiraz and Ozden (2013),

- Kats (2013),
- Pahamov (2014),
- Mueller, Tippens and Stewart (2014) and
- Teras and Herrington (2014).

Viewed through the lens of my understanding of Vygotsky's requirements for authentic learning I am, however, concerned that the nature of the challenge (the real-life challenge), is not universally stated as a requirement for learning in these theories. It is also worrying that the field of Learning Design does not specifically reference the requirement of 'struggle' or whatever corresponding authentic experience to be present within learning. This is contrary to my understanding of the learning process as postulated by Vygotsky and so I did not find a form of online learning which mirrors authentic learning as I understand it.

I did, however, find calls to researchers to investigate the highest quality of online learning as can be seen when Ching and Hsu (2015) state that a massive growth in the number of "online courses offered in higher education in the United States" has brought about an urgent need within the education community to "ensure quality educational experiences for these unprecedented numbers of online learners" (p. 31). As facilitation is (according to Vygotsky's tenets) key to authentic learning, understanding the role of the teacher within this online realm is paramount. Interestingly, the digital nature of this field opens new pathways for educational researchers to study the process of learning.

Researchers previously struggled to gain access to the data representing interactions between students, as is explained by Cen, et al. (2016, p. 188):

> "While there is a wide body of qualitative evidence reporting the benefits of collaborative learning, the thorough quantitative analysis is clearly lagging behind in the literature. This is perhaps due to difficulties with formal knowledge representation and the lack of data capturing the complete process of collaborative learning in sufficient detail."

Searching through the massive amount of online learning approaches in the literature, and finding it wanting in terms of my understanding of authentic learning, was very frustrating. Thus it was with great excitement that I came upon a learning theory championed by Manu Kapur named “Productive Failure” (2007, p. 1). I will now proceed to elaborate on Kapur’s “Productive Failure”, which is a specific learning theory brought about via the analysis of data generated by students struggling in an online-chat program with a challenge that is beyond their current ability to resolve.

2.7 A promising example of online learning

Productive Failure can be traced back to ‘Impasse Learning’, which states that learning only takes place when a learner arrives at an insurmountable impasse (Kapur, 2008). Although Productive Failure was not designed as an online learning theory per se, the experiment conducted by Kapur placed this learning theory within the online learning realm. In Kapur’s study he refers to a ‘hidden efficiency’ present in this type of learning. This efficiency benefits the students in the long run by equipping them with the ability to solve much more challenging ill-structured problems. In contrast to this, well-structured problems may encourage short-term recall or elementary application of ‘recipes’, which are learnt by rote. His research shows how students, given an ill-structured problem, must first battle to structure the problem before they can attempt to solve it. Even though failure may ensue in the short term, these students walk away with a much deeper, long-term understanding of the fundamental principles surrounding the problem and even knowledge on what may not be a way to resolve it. According to Kapur (2008) it is key that no pedagogical intervention takes place during the process, as any such form of help given to a learner will, according to Kapur (2008), decrease the quality of learning, which distinguishes this from other forms of online learning like hybrid learning (Allan, 2016).

Kapur and Kinzer (2007) state that an “extensive amount of research in face-to-face settings has empirically examined the advantages of ill-structured over well-structured problem solving” (p. 440). According to Jonassen (2000), ill-structured problems have multiple solutions (or possibly no solutions); have multiple

evaluation criteria; and often require students to make judgements – characteristics shared by real-life challenges. This resonates with my understanding of the highest possible quality of learning outcome as depicted in the following list of identifiers (Joubert & Slabbert, 2017, p. 183):

- "The aim of a pedagogical intervention is the authentic intra-personal transformation of students.
- Challenges that students are confronted with should be authentic real-life challenges (non-standard and holistic), reflecting the nature of real-life.
- The learning process needs to be facilitated within a social environment (human agency) by the teachers, who have to make themselves increasingly redundant in order to promote students' self-transcendence.
- The learning process is learner- and learning-centred."

It is interesting to note that the efficiency Kapur refers to is hidden because current classroom practices (mired in 20th century structures) are geared to exhibit short-term gains. Within a 20th century classroom setting, students facing a well-structured problem will do better in the short term, as these students can immediately identify the salient aspects of the problem and then apply rote-learnt recipes. This fits 20th century paradigm modes of assessment. However, although students who face an ill-structured problem do not experience initial success to the same extent as their well-structured counterparts, by reflecting on their experiences they have a better understanding of the problem-solving process, which ultimately leaves them better equipped to deal with future problems. Thus, we see that Kapur's Productive Failure theory correlates with my own understanding of the highest possible quality of learning outcome to a great extent. But where do we differ? The first crucial difference becomes apparent when comparing Kapur's 'ill-structured problem' with the 'authentic real-life challenge' as suggested in this research.

In his writing, Claxton constantly refers to real-life as a necessary requirement for learning (Claxton, 2007; 2008; 2012). Slabbert, et al. (2009) explain an authentic real-life challenge as a challenge that elicits a high level of intra-personal motivation from students since they can make a connection between the problem and their personal everyday life experiences. As the challenge links with their personal experiences, they recognise the impact of the challenge on their own well-being and so they want to resolve it. Therefore, it is like an ill-structured problem in the sense that it is not a closed challenge with only one answer supplied by the teacher.

An authentic real-life challenge also creates uncertainty in the learner (like an ill-structured problem), which Claxton defines as the very nature of learning, as can be seen in the following quote: “Learning is what you do when you don’t know what you do” (Claxton, 2000, p. 11). Unlike an ill-structured problem, however, an authentic real-life challenge must come from the realm of everyday experiences of the learner. In contrast, ill-structured problems do not have this requirement and are thus at risk of being contrived, conceptual and far removed from the interests of the learner. This can decrease the intrinsic motivation within students to resolve it. ‘Authentic real-life challenges’ thus contain the criteria for high-quality learning sought by Kapur, with the added benefit that they also elicit intrinsic motivation. In a way, they can be viewed as a heightened form of Kapur’s ill-structured problem. In addition to this different view on the type of learning challenge, we also have different views regarding the role of the teacher.

Based on my understanding of the work done by Piaget, when it comes to the danger of ‘helping’ students, I fully agree with Kapur. Students need to struggle and discover knowledge for themselves, and the moment they are given an answer this journey of discovery stops (Piaget, 1977, p. 27). I also agree with Kapur that all the aspects of the learning endeavour (including the hidden proficiencies of working in groups which contributes a social dimension that provides the opportunity for increased learning quality) form part of what can be learnt in any given lesson. Even when using scaffolding, we inject structure into a learning period and in doing so we ensure that our students may never discover

the means to construct the scaffolding support on their own. Kapur's solution to the risk of a pedagogical intervention is to remove it completely. In doing so one is assured that students have the highest possible chance of self-discovery, while struggling with a problem that might be too difficult for them to solve. My concern with removing any form of pedagogical intervention completely, is that it makes the learning quality wholly reliant on the students themselves. While this is the eventual purpose of education, the journey to that point requires a special pedagogical intervention of having the students learning how to accomplish the achievement of pursuing the highest possible quality of learning themselves while they are struggling with solving the problem, instead of leaving the quality of their learning to chance.

It is the process of learning to learn which is known in the realm of cognition as metacognition (Motta, 2016). And in the realm of socio-cognition this particular intervention by the teacher has to portray the behaviour of a resilient and persevering creative problem solver, which the learners would need to adopt making the challenge and role of the teacher obsolete. Aside from the challenge and the role of a teacher, another difference in our understanding of the highest possible quality of learning outcome can be found in the alteration between the individual and the collective phases of learning.

Sceptical of any form of 'assistance' that can 'help' students, in his experiment on Productive Failure (2008), Kapur introduces a group of students to a problem that was too hard for them to solve. In his analysis of the transcriptions of the group dialogues he then found a decrease in the level of participation equity as the discussions progressed. According to Slabbert, et al. (2009), students first need to confront a challenge individually. By struggling individually, they can acquire intrapersonal life skills, making them better meta-learners. After a set amount of time, the students are then placed in a structured group where they can develop their interpersonal life skills. I believe that by first allowing students to work on their own, I will be able to decrease the participation in-equity evident in Kapur's data. Even if the individual phase is only a short space of time to allow students to create their own opinions, it will be enough to increase their participation as

they will have something to share with their peers. Thus, my understanding of achieving the highest quality of learning diverged from Kapur's experiment in the following three ways:

- Instead of an ill-structured problem (Kapur), participants are confronted with an authentic real-life challenge;
- Instead of leaving all the participants to struggle on their own (Kapur), there is a pedagogical intervention in this study; and
- Instead of having participants only work cooperatively (Kapur), participants are first confronted with the authentic real-life challenge individually and then cooperatively.

The table below summarises the differences between the work done by Kapur and my view on the highest quality of learning:

Table 2.1: Comparison between Kapur's experiment and my view on the highest quality of learning

Experiment facet	Kapur's experiment	My view on the highest quality of learning
Initiating learning	Students are confronted with an ill-structured problem.	Students are confronted with a real-life challenge.
Facilitator intervention	No intervention.	Facilitators of learning intervene in the learning process.
Structure of experiment	Students worked cooperatively in an online environment.	Students first work individually and then cooperatively in an online environment.

Implementing these changes bring Kapur's experiment in line with my own understanding of the highest possible quality of learning outcome, while still giving me a basic template for my experiment design in this study. Having identified the experiment conducted by Kapur as a viable framework for this study, the specifics of the most appropriate pedagogical intervention can now be discussed.

2.8 Authentic learning

As an integral part of the human experience, education can be traced back to the "earliest occupational era of hunters, gatherers and later agricultural civilizations" (Slabbert, et al., 2009, p. 35). In terms of the world of work, the initial goal of work was to survive, and the entire community needed to work together in order to overcome the many challenges they faced. This made the act of work, and consequently the orally conveyed education associated with it, deeply meaningful and authentic. With the advent of the industrial age and the invention of factories, the act of work devolved into routine tasks performed by individuals. These men and women were not required to understand their role in terms of the holistic chain of activities that finally led to a product, but were rather expected to be content in focusing only on their own repetitive (and seemingly disjointed) task.

Concurrently, institutionalised schooling presented reality to students as a set of disjointed disciplines or subjects. Doing so effectively distanced students from the content presented to them, as they had no means of making connections between their own lives and these artificially delineated slices of reality. Thus, authenticity departed from formalised education. It was only much later in the 18th century that this duality between the content to be learnt in schools and real-life was addressed by researchers in education. The following table shows how Piaget, Dewey and Whitehead radically reinterpreted the learning process:

Table 2.2: Piaget, Dewey and Whitehead: learning as a process (Slabbert, et al., 2009, p. 45)

CONTRIBUTER	CONTRIBUTION	EXPLANATION
Jean Piaget 1896-1980	Learning is a process of: • Equilibrium • Disequilibrium • Re-equilibration	• The nature of open systems [systems open to query] gives prominence to uncertainty, which depends on challenges, perturbations and disruptions. In his research, Piaget explained that the driving force of development is situated in the non-balance or disequilibrium that disturbs equilibrium in order to create 're-equilibrium' but always at a higher level and in a continuous process of re-equilibrium. • In open systems change, and not stability, is the essence.

John Dewey **1859-1952** "An ounce of experience is better than a ton of theory simply because it is only in experience that any theory has vital and verifiable significance." (Dewey, 1916).	Experimental learning and reflection. A transformative process.	• Emphasis is placed on *experiential learning* and *reflection* to bring about the dialogic and transformative process. • Reflection brings quality to the learning and makes the learning a transformational experience. • Classrooms become communal places where 'had' experiences could openly be analysed and transformed, not in a competitive environment but through mutual cooperation and negotiation between students and teachers.
Alfred North Whitehead **1861-1947**	Being as a continual becoming through a transcendental process of a continual dynamic emergence of the newly created within the rhythm of education.	• A pupil's mind is a growing organism. • The only avenue towards wisdom is by freedom in the presence of knowledge. • Growth and wisdom occur when there is a balance between the creative opportunity freedom can give and the knowledge acquired from discipline. • Romance (play), precision (mastery) and generalisation (abstraction) are a continually integrated process.
From the three different but interrelated processes identified by Piaget, Dewey and Whitehead, we deduce that *process* becomes an essential ingredient in 21st century education.		

As the focus of learning shifted from the end-goal of summative test scores in the 20th century paradigm, to learning being a process in the 21st century paradigm, the significance of this process (which has the goal of the highest possible quality of learning outcome) has been restored. To put it differently: To learn is to establish relationships between the internal and external environment of a human being. It is from these relationships that meaning can be constructed. Authentic learning thus refers to a scenario where the learner connects with the 'content' to be learnt in a manner which spurs on further investigation, allows knowledge gained to be incorporated within the learner's personal, holistic understanding of reality and also compels the student's further investigation which constitutes an improvement on the quality of the learning. As described by Lombardi (2007, p. 2): "authentic learning typically focuses on real-world, complex problems and their solutions."

From the work of Olivier, Herrington and Reeves (2002), Lombardi (2007) and Harrington, Parker and Boase-Jelinek (2014), a ten-point definition of / for

authentic learning can be constructed. This may provide a useful checklist to those working in the field of authentic learning that is valid for any curriculum:

Table 2.3: A ten-point checklist for identifying authentic learning

1. *Real-world relevance*: Authentic activities match the real-life tasks of professionals in practice as closely as possible. Learning rises to the level of authenticity when it asks students to work actively with abstract concepts, facts, and formulae inside a realistic and highly social context. In this regard, Newman, Marks and Gamoran (1995, p. 1) says that our students should "become 'active learners', capable of solving complex problems and constructing meaning that is grounded in real-world experience." That is why Claxton's (1999, p. 11) definition of learning is so striking in its simplicity yet powerful in its meaning: "Learning, in the way I am using the term, is what you do when you don't know what to do" and getting increasingly competent in why, when, where, how and what to do when you don't know what to do.
2. *Ill-defined problem:* Challenges cannot be resolved easily by the application of an existing algorithm. Instead, authentic activities are relatively undefined and open to multiple interpretations, requiring students to identify the tasks and subtasks needed to complete the major task of their own accord.
3. *Sustained investigation:* Problems cannot be solved in a matter of minutes or even hours. Instead, authentic activities comprise complex tasks to be investigated by students over a sustained period, requiring a significant investment of time and intellectual resources.
4. *Multiple sources and perspectives:* Students are not given a list of resources. Authentic activities provide the opportunity for students to examine the task from a variety of theoretical and practical perspectives using a variety of resources, requiring students to distinguish between relevant and irrelevant information in the process.
5. *Collaboration*: Success is not achievable by an individual learner working alone. Authentic activities make collaboration integral to the task, both within the course and in real-life.

6. *Reflection (metacognition)*: Authentic activities enable students to make choices and reflect on their learning, both individually and as a team or community.
7. *Interdisciplinary perspective*: Relevance is not confined to a single domain or subject matter specialisation. Instead, authentic activities have consequences that extend beyond a particular discipline, encouraging students to adopt diverse roles and think in interdisciplinary terms.
8. *Integrated assessment:* Assessment is not merely summative in authentic activities but is integrated seamlessly into the major task in a manner that reflects real-world evaluation processes. It consists of a process of continuous critical reflection on the quality of the learning process as well as all the intermediate products and the final end product outcome.
9. *Polished products*: Conclusions are not merely exercises or sub-steps in preparation for something else. Authentic activities culminate in the creation of a real product, a whole product, a valuable product and a completely functional product in its own right.
10. *Multiple interpretations and outcomes:* Rather than yielding a single correct answer obtained by the application of rules and procedures, authentic activities allow for diverse interpretations and competing solutions.

Although authentic learning is a holistic endeavour, it is of vital importance to recognise the role of the emotional human constituent in the authentic learning process. In fact, the ignition, experience and expression of the emotional constituent of being human during the authentic learning process, is ultimately a key characteristic of the authentic learning experience. This is aptly described by Claxton (1999, p. 15):

> "Learning is often hard and protracted, confusing and frustrating, and it is necessary to stick with it and recover from setbacks. New understandings of the biological basis of emotion show that our feelings are absolutely integral to our learning … learning involves exhilarating spurts, frustrating plateaus and upsetting regressions …

> Even if learning is going smoothly, there is always a possibility of surprise, confusion, frustration, disappointment or apprehension – as well, of course, as fascination, absorption, exhilaration, awe and relief."

When students are thus emotionally engaged, they become intrinsically motivated to resolve the real-life challenge, as this would consequently improve the students' quality of life (Claxton, 2008). It is this key characteristic of authentic learning that postulates the question about its relationship with experiential learning.

2.9 The relationship between authentic learning and experiential learning

It may be as a result of the relationship between emotions and experience that there is an equal relationship between authentic learning and experiential learning (Kolb, 1984). Experiential learning forms a vital foundation for authentic learning. This is reflected when Kolb (1984, p. 41) postulates his learning theory as follows:

> "Learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience. This definition emphasizes several critical aspects of learning as viewed from the experiential perspective. First is the emphasis on the process of adaptation and learning as opposed to content or outcomes. Second is that knowledge is a transformation process, being continuously created and recreated, not an independent entity to be acquired or transmitted. Third, learning transforms experience in both its objective and subjective forms. Finally, to understand learning, we must understand the nature of knowledge, and vice versa."

He also identified the following characteristics of experiential learning:

a. "Learning is best conceived as a process, not in terms of outcomes.
b. Learning is a continuous process grounded in experience.
c. The process of learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world – learning is by its very nature full of tension.
d. Learning involves transactions between the person and the environment.
e. Learning is a holistic process of adaptation to the world.
f. Learning is the process of creating knowledge – the result of the transaction of personal and social knowledge" (Kolb, 1984, p. 79).

Central to his learning theory is the belief that learning takes place essentially in four major stages which he called concrete experience, reflective observation, abstract conceptualisation and active experimentation. The figure below is a schematic representation of Kolb's (1984) Experiential Learning Cycle:

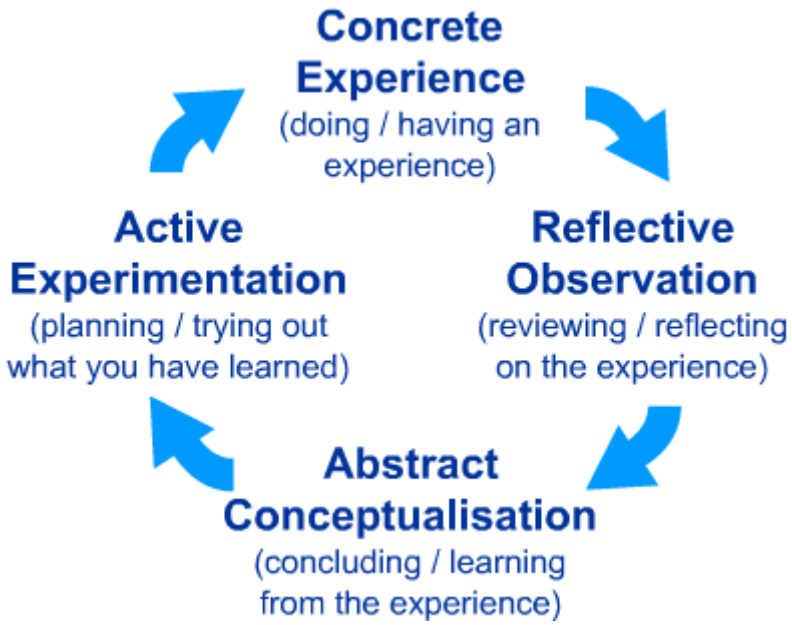


Figure 2.3: Kolb's Experiential Learning Cycle (Kolb, 1984)

What is so significant about Kolb's experiential learning theory, is that having reviewed 71 learning theories/models and analysing the 13 major ones, David

Kolb's (1984) experiential learning theory is still the most influential and most frequently used in studies amongst all of them (Coffield, Moseley, Hall & Ecclestone, 2004). Despite the critique all theories are normally subjected to, it is not difficult to understand why Kolb's experiential learning cycle is so appealing: it is a holistic model of the learning process and development which is consistent with what we know from various fields about how we naturally learn, grow and develop.

However, besides the inseparable relationship of experiential learning with authentic learning and Constructivism, what is most significant about Kolb's experiential learning cycle is the neurophysiological confirmation of the theory by Zull (2002, p. 18) when he indicates that "concrete experiences come through the sensory cortex, reflective observation involves the integrative cortex at the back, creating new abstract concepts occurs in the frontal integrative cortex, and active testing [experimentation] involves the motor brain. In other words, the learning cycle arises naturally from the structure of the brain."

Within the context of experiential learning, the relationship with authentic learning in terms of the experiential learning cycle could be described as follows: The authentic learning cycle starts with the students' immersion in an authentic real-life experience created by a demanding real-life challenge that they need to resolve. This is followed by a continuous critical reflection on the real-life experience that leads to the transformation of the real-life experience into a conceptual construction of dynamic knowledge, which would function as the foundation of an active exploration into the newly constructed real-life challenge. The figure below depicts this cycle.

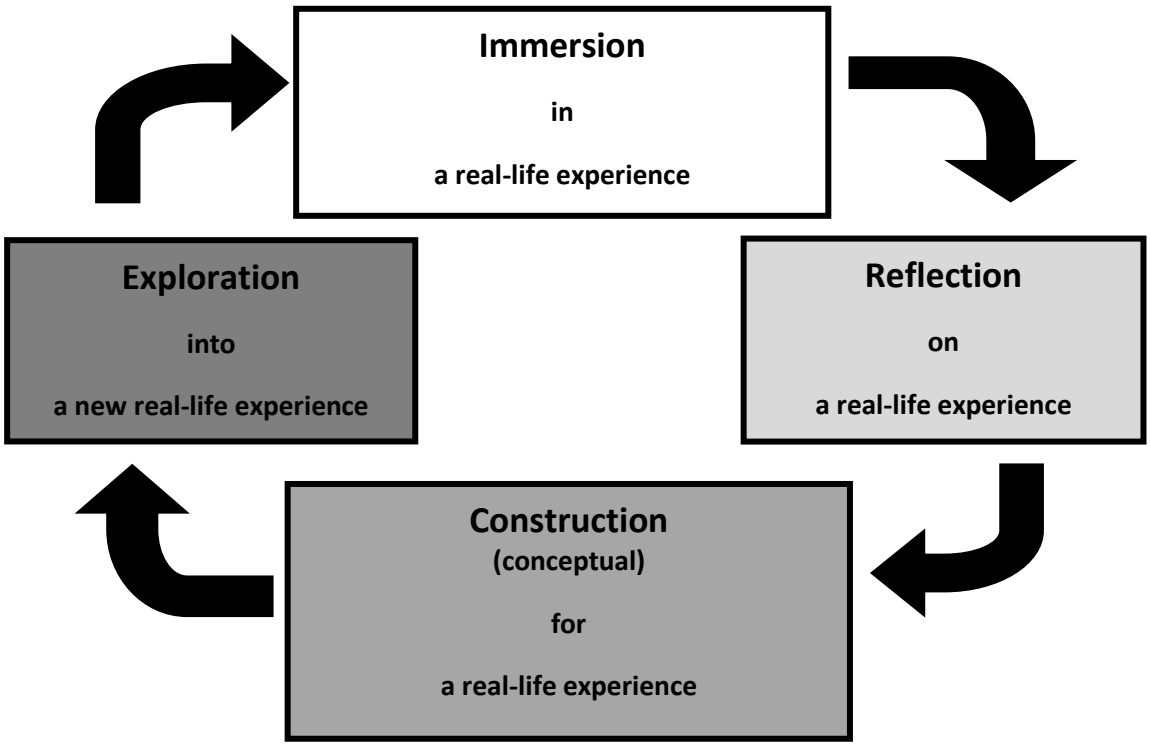


Figure 2.4: The authentic learning Cycle (Slabbert, et al., 2009, p. 73)

The very nature of authentic learning, as depicted in the preceding paragraphs, can pose a challenge in a context where students are not used to struggle. According to a Vygotskian understanding, the act of learning necessitates a struggle. The first challenge faced by teachers, when facilitating authentic learning, is the fact that the students might not be willing to move outside of their comfort zones. The problem is compounded by the service-orientated nature of education in recent times (Slabbert, et al., 2009), where the parent (and by extension the learner) is the client, and the teacher is the service provider. My own teaching experience has made me very aware of the effect of this relationship on teachers, who always try to minimise any form of discomfort or confusion in the classroom, lest they get a visit from a disgruntled parent during a parent evening. In view of this, it is understandable that today's students expect teachers to promptly clear up any uncertainties that they might have. Instead of being a marker for learning, uncertainty has thus become an indicator of teacher incompetence. Aside from their resistance to struggle, technology has also conditioned students to distance themselves from reality.

Being a teacher in the 21st century has necessitated that I acknowledge the fact that I am competing for the attention of my students against all manner of 'screens'. Whether it is a cell phone, a tablet or a laptop – the digital natives whom I teach always want to have some kind of screen on hand. Be it to quickly find an answer on the internet, or to entertain themselves when they find lessons boring – the world of technology is always one click or finger swipe away. At the end of 2017, CNN reported that new research results show that 50% of teenagers feel that they are addicted to their cell phones (LaMotte, 2017). The article states that some of the effects of heavy reliance on cell phones include shying away from face-to-face interactions and having an aversion to any form of conflict. Whether you are sending a message to a friend, looking up information on the internet or playing a computer game, in all these instances the user is distanced from the action taking place on the device. If someone phones you, you have the option of refusing the call. When the website you are visiting is not able to give a satisfactory answer, you can just jump to a different website. If the computer game irritates you, you can exit the game at any time. The implied power behind these choices means that a person can avoid any form of confrontation (Slabbert, et al., 2009, p. 27). This power of technology which allows a user to avoid confrontation does not, however, translate to real-life situations.

On an interpersonal level, having a face-to-face argument with someone who has a contradictory view to your own can be a very challenging ordeal, as you cannot simply shut down or ignore the other party with the click of a button. On an intrapersonal level, real-life also has a way of challenging us through problems that can only be resolved when all our faculties are "fully engaged" (Slabbert, et al., 2009, p. 66). This is the domain of authentic learning. Students who are heavily conditioned by technology will naturally be frustrated by the fact that a real-life challenge implicitly does two things: First, it makes you aware of your limitations in terms of resolving the challenge (necessitating that you move out of your comfort zone) and secondly, it requires you to commit yourself without reservation if you are to have any hope of resolving a challenge that seems to be too difficult. Understanding that schools condition students to resist uncertainty and that technology teaches them that they do not have to deal with confrontation,

brings us to the last challenge to authentic learning to be discussed, namely the cost of learning.

During the industrial revolution, the aim of education was to educate as many students as possible to fulfil the need of the burgeoning factory landscape. A one-size-fits-all approach was used in classes, and students were expected to be passive recipients of knowledge transmitted to them by teachers (Slabbert, et al., 2009, p. 22). Although this model of learning succeeded in producing greater numbers of schooled students than ever before, 21st century times have found the quality of this educational model to be insufficient in terms of the needs of our current context, exemplified by information overload and a rapidly changing workplace (Barnett, 2004, p. 249). As the shift from quantity education to an increasing demand for quality education took place, teachers soon found that the very structure of our schools (inherited from the industrial factory model) poses a challenge towards the highest possible quality of learning outcome.

Maximising profit is a universally accepted concept in today's world of work (Felder, 1990). By minimising the cost of a product / service that you deliver and maximising the compensation for said product / service, you ensure that you get the maximum financial benefit from any endeavour. A similar truth can be found when it comes to facilitating for the highest possible quality of learning outcome. We can describe the act of learning in a school as a business transaction: Facilitators of learning ('service providers') are tasked with facilitating the learning ('services delivered') of students ('clients') within the constraints of their educational context (the 'production cost') in such a way that the students are empowered to meet the challenging demands of the 21st century workplace. Facilitators of learning are thus called to bring about the most 'cost efficient' learning quality possible within their specific context.

This can be a daunting task as 'learner empowerment' refers to the holistic development of the learner, including an increase in all domains of intelligence (physical, mental, emotional and spiritual) (Slabbert, et al., 2009, pp. 76-78), as well as the attainment of fundamental human virtues, which can only be acquired through real-life experiences (p. 92). These virtues refer to the required human

qualities to flourish in a super-complex world with an unknown future and include: honesty, integrity, trustworthiness, faithfulness, responsibility, independence, and effort. Looking at these nouns it becomes apparent that a learner who has acquired these human virtues will be equipped with a strong moral platform, which will serve as a foundation when resolving future real-life challenges (Slabbert, et al., 2009). In order to bring about the most 'cost efficient' learning, one must first be fully cognisant of the 'costs' associated with authentic learning.

2.10 The cost of authentic learning

By acknowledging that only authentic learning will lead to the highest possible quality of learning outcome, we do, however, also need to acknowledge that exposing students to an authentic real-life challenge can lead to negative emotions. Zull (2011, p. 74) explains that students need to be equipped to productively manage these emotions, as can be seen in the following quote:

> "The journey toward mind must include experiences that challenge us. Meeting challenges is an integral part of gaining knowledge and wisdom. Treating emotions as tools rather than as enemies should become a primary goal in education. To use them as tools, we must have control and self-awareness. This awareness of our feelings is central to development of mind."

The possible negative response to the highest possible quality of learning outcome in a consumer-driven society, where students are conditioned to think of themselves as 'clients' entitled to 'service', which corresponds to their personal preferences, leads me to label the use of real-life challenges as being 'risky'. Aside from the consumer-mindset, honestly tackling the fact that we live in what Barnett (2004) refers to as a supercomplex world that is ultimately unknowable, can also be a cause for concern. It is a world shaped by uncertainties where we are constantly bombarded with the awareness that there are multiple interpretations to all aspects of reality. As explained by Barnett (2004, p. 249):

> "The challenges of supercomplexity, in contrast, could never be resolved. They are challenges that arise from the question: what is a

> university? Or: what is a teacher? Or: what is a doctor? The challenges of such questions could never be dissolved, at least not in ways similar to those of complexity. For such questions, in principle, yield a multiplication of answers and further questions. And some of those answers and further questions spring from perspectives, value positions and even ideologies that are mutually incompatible."

Recently, this complexity has been amplified to an even greater extent with the concept of "post-truth" being introduced into the international vocabulary – it was even the word of the year in 2016 (Oxford Languages, 2016). According to the Oxford Dictionary, 'post-truth' is "an adjective defined as relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief." To put it in layman's terms: the facts don't really matter and even if they did – the news (or as US President Donald Trump puts it: "The fake news" [The Washington Post, 2019]) never accurately report the facts and so you have no way of ever knowing what is real and what is not. If the goal of teaching is to equip students for this supercomplex reality, then it is only logical that students will experience a certain amount of cognitive dissonance during such a process. As stated by Barnett (2004, p. 252):

> "… an *ontological risk* … arises out of supercomplexity [referring to our current postmodern reality]. If there are no stable descriptions of the world, then there are no stable descriptions of 'me'. The 'I' is liable to be destabilized."

The traditional school system, where students are conditioned to only solve neatly structured, closed problems in textbooks, further increases the risk of using real-life challenges during lessons as students are not used to being taken out of their comfort zones. This leads Claxton (2008, p. 122) to state that he has "argued again and again that what young people need is the temperament to cope confidently with difficulty and uncertainty: in other words, to be powerful real-life learners." This does, however, highlight a potential threat to quality learning when

making use of real-life challenges in a school system which has to appease multiple stakeholders.

Firstly, one must be cognisant of the expectations of the diverse range of stakeholders in education. These stakeholders can include the Department of Basic Education, universities, the workplace, the school governing board, principals and parents. Ignoring the needs of these 'clients' will cause stakeholders to lose trust in the capabilities of the teacher. In view of this, it becomes crucial that a teacher needs to be skilled in fulfilling external expectations. This must be done while still ensuring the highest possible quality of learning outcome through a holistic, authentic learning process, which compels personal (internal) development of the highest order as its result. This is no mean feat in a South African educational context, as can be seen in our failure to implement OBE as stated by Spady: "[B]y maintaining the very 'non-OBE' Matric and annual examination systems that had always been in place, the government kept everyone locked into traditional / conventional modes of thinking about learning, curriculum, achievement, assessment, and qualifications" (2008, p. 17).

Even though there are laudable exceptions to the status quo described in the quote above, it does still seem that, generally, the educational community is averse to move away from the traditional, standardised objective tests used for assessment (Claxton, 2007, p. 116). This brings to the fore the realisation that the set of expertise required of a teacher is double-barrelled. Not only do they need to be able to facilitate towards the highest quality of learning, but they also need to become an expert in the curriculum of their subjects to fulfil the expectations of stakeholders – even if these expectations are impediments to the highest quality of learning. In addition, the increasingly digitised world also brings along the requirement that facilitators of learning must have a high degree of computer literacy, to make optimal use of technology in the classroom.

Although online education has opened a door to a realm of potentially powerful learning tools, being proficient in the use of these new platforms

> "… is not a simple endeavour. It involves the design of some carefully guided activities that require a teacher to not only master the subject [curriculum required by the government that students have to master], but to also have a high level of digital literacy, and often collaborate with other professionals, such as instructional designers" (Petrovic-Dzerdz & Trépanier, 2018, p. 273).

Coincidently, it should be noted that instructional design has the same drawback as pre-designed scaffolding, in that it is essentially a closed program, structured to such an extent that valuable opportunities for struggle are kept from students. Aside from the requirement of the highest level of expertise and a high level of computer literacy, the highest possible quality of learning outcome also entails a 'cost' of intensive preparation.

In 20th century schools, students were passive recipients of knowledge. Traditionally, preparation by a teacher focussed on answering three questions:

- What information do the students need to acquire?
- How should the required information be transmitted to the students?
- How will it be assessed whether the students have acquired the information?

As is still the case today, the first question is answered by the set curriculum of a subject. The second question was commonly addressed by a teacher standing in front of a classroom, referring the students to either the blackboard or their textbooks. The third question is traditionally answered by means of externally set, objective, written tests commonly referred to as 'summative assessment'. Even with the considerable advancements in technology over the years, many supposedly 21st century classrooms still follow the same 20th century structures of teaching and assessing. Against this backdrop, it becomes apparent that a teacher is tasked with appeasing stakeholders (who may have expectations that align with low levels of learning quality) via facilitating authentic learning (which leads to high levels of learning quality) (Slabbert, et al., 2009). This authenticity

can only be introduced to the learning process by packaging the process within a real-life challenge. Students faced with a real-life challenge will be intrinsically motivated to discover the required curricula (which would allow them to appease the external stakeholders) through the process of an authentic struggle (which is the catalyst for the highest quality of learning).

Considering the intricate and complex nature of this call to facilitators of learning, it becomes evident that designing such a lesson (which could span across multiple lessons as is required for the highest possible quality of learning outcome) (De Corte, 2003) will be a real-life challenge in itself for the teacher. Creative connections will have to be made between reality as experienced by the students in thát specific class, the content required by the curriculum and the limitations of the classroom. The challenge also needs to be presented in such a manner that it evokes urgency within the students (Slabbert, et al., 2009). The authentic nature of the real-life challenge necessitates a tailored design for a specific set of students who have a specific context, suggesting that these lessons will not be a generalised content-based transmission of knowledge as traditional lessons in the 20th century is characterised by.

All this can be distilled to a simple truth: The higher the quality of learning, the more costly (in more than a monetary sense) that learning is. Acknowledging that this cost is compounded by our present 20th century school contexts, it is extremely encouraging to see the emergence of a grass roots educational movement which, by its very nature, is conducive towards experiential learning. The name of this movement is called: The MakerSpace movement.

2.11 The MakerSpace movement

Interest groups who come together to create something new have always been part of human history. Whether it was pottery clubs in ancient Greece around 400 BC, or quilting societies in the 1700s, throughout the ages like-minded men and women have been getting together to share their passions and pool their resources. In 2005 *Make Magazine* was first published featuring articles on do-it-yourself projects, and so the MakerSpace movement was born (Oliver, 2016). It

is a disparate movement including a range of technologies, spaces, membership types, manifesto's, etc., summarised by the following quote from Oliver (2016, p. 160):

> "MakerSpaces take many forms but generally involve a physical space with shared resources to pursue technical projects of personal interest with the support of a maker community. While MakerSpaces to date are more commonly found in non-classroom spaces such as public libraries, and making is more commonly practiced in after-school camps and clubs, making has the ability to enrich the school-day curriculum and bridge formal and informal learning contexts."

In terms of understanding the extent to which the latest technological advancements permeates this movement, the definition put forth by Marsh, et al. (2017) is of assistance:

> "These are spaces that enable participants to create a range of artefacts using specialist tools and resources, such as electronics, laser cutters, 3D printers, in addition to everyday resources, both digital and non-digital."

The manner in which students deliver outputs, through discovering ways in which to utilise the specialist tools mentioned above, supports constructivist and experiential learning theories (Shrock, 2014). To understand the activities that typically take place and how these activities are viewed within a MakerSpace, the Maker Manifesto, as compiled by Hatch (2013, p. 1 ff), can be of assistance:

Table 2.4: The Maker Manifesto

MAKE – Making is fundamental to what it means to be human. We must make, create and express ourselves to feel whole. There is something unique about making physical things. These things are like little pieces of us and seem to embody portions of our souls.

SHARE – Sharing what you have made and what you know about making with others is the method by which a maker's feeling of wholeness is achieved. You cannot make and not share.

GIVE – There are few things more selfless and satisfying than giving away something you have made. You must have access to the right tools for the project on hand. Invest in and develop local access to the tools you need to do the making you want to do.

LEARN – You must learn to make. You must always seek to learn more about your making. You may become a journeyman or master craftsman, but you will still learn, want to learn and push yourself to learn new techniques, materials and processes. Building a lifelong learning path ensures a rich and rewarding making life and, importantly, enables one to share.

TOOL UP – You must have access to the right tools for the project to hand. Invest in and develop local access to the tools you need to do the making you want to do. Tools for making have never been cheaper, easier to use or more powerful.

PLAY – Be playful with what you are making, and you will be surprised, excited and proud of what you discover.

PARTICIPATE – Join the Maker Movement and reach out to those around you who are discovering the joy of making. Hold seminars, parties, events, maker days, fairs, expos, classes and dinners with and for other makers in your community.

SUPPORT – This is a movement, and it requires emotional, intellectual, financial, political and institutional support. The best hope for improving the world is us, and we are responsible for making a better future.

CHANGE – Embrace the change that will naturally occur as you go on the maker journey. Since making is fundamental to what it means to be human, you will become a more complete version of you as you make.

Looking at this manifesto the high quality of learning embedded in this movement is evident. Adapted from the work of Marsh, et al. (2017), the table below identifies principles of the MakerSpace movement that correlate with high quality learning as articulated within the educational literature:

Table 2.5: Correlation between MakerSpace principles and educational literature

MakerSpace principle	Correlation in educational literature
Child-centredness	Froebel (1899;1874) Betrem and Pascal (2002)
The importance of play	Vygotsky (1938;1967) Lieberman (1977) Vandeburg (1980) Holmes and Geiger (2002) Wood and Attfield (2005)
Social and emotional development	Denham and Brown (2010) Petrich and Bevan (2013)
Empowerment of the child to be an autonomous learner	Froebel (1899;1874) Montessori (1917;1965) Piaget (1936;1953) Vygotsky (1978)

Due to its ability to provide novel problems to solve Saorin, Melian-Diaz, Bonnet, Carrera, Meier and De La Torre-Cantero (2017, p. 189) state that a MakerSpace environment is ideal for situations where learners explore a "large quantity and different solutions to the same problem." They add that a MakerSpace environment is an ideal context for creative thinking:

> "Although a generic denomination for this space does not exist, terminology such as 'Coworking Spaces', 'innovation laboratories', 'Media Labs', 'Fablabs' or 'Hacklabs' have one aspect in common. That is, the fact that they all came to be as authentic laboratories in design and digital fabrication, where students have the opportunity of developing their creative competence through innovation" (p. 189).

Despite its educational potential, this movement has yet to manifest within the formal curriculum of schools, as is indicated by the following research:

> "During our literature review we searched different reference libraries, such as ERIC, Ebsco host teacher reference centre and Proquest, using the terms makerspace, fab lab, hackerspaces and tinkering in a string with the terms education, schools, formal education, primary and early years. We read through 34 abstracts from papers and books, including exemplars of makerspaces in formal education. Upon closer scrutiny, the literature did not provide many examples of actual making projects within formal education but rather in libraries and in relation to after-school activities. The main focus of the literature was on STEM or STEAM projects, but with rather loose connections in terms of the makerspace context. However, there was a strong understanding of the possibilities of enhancing learning through making and the value of a maker culture in support of formal education" (Marsh, et al., 2017, p. 38).

From teacher seminars that I attended at the 8th Annual 21st Century Learning Conference in Hong Kong in 2016, I came to understand that the challenges of conducting MakerSpace as a formal subject included:

- Time: For students to discover ways in which to resolve challenges using technology the learning periods needs to be of suitable length. There also has to be a specified time allotted for students to be able to attend the MakerSpace during school hours.
- Content: Although there is plenty of MakerSpace reading material available, there is no designated subject curriculum for it.
- Space: The expensive nature of the equipment in a MakerSpace brings about a bottleneck in class as there are not enough tools for all the students to be able to work simultaneously. The smaller the budget for such a space, the less equipment can be acquired and the smaller the number of students that can work concurrently.

The authentic nature of the MakerSpace movement, where nothing is learnt if not needed but everything is learnt that is needed, combined with its inherent

inclination towards the use of creativity to create real-life solutions, inspired me to establish a MakerSpace at my own school to be taught as a formal subject. To this end, I started to petition the owners of my school and one year later the necessary funding was allocated for me to set up a MakerSpace that would accommodate a maximum of eight students. I addressed the challenges associated with conducting MakerSpace as a formal subject as follows:

- Time: The MakerSpace was designated as a branch of the Grade 9 subject Technology, which is a subject in the National Curriculum of South Africa aiming to "produce engineers, technicians and artisans needed in modern society and the need to develop a technologically literate population for the modern world" (Department of Basic Edu, 2011, p. 8). It was marketed to students as an optional alternative to the hospitality component of Technology, which made up 50% of the Technology periods per cycle. Students who were interested could thus take MakerSpace instead of Hospitality Studies for a double period (about an hour) every cycle (at my school we make use of 6-day cycles).
- Content: A combination of Technology textbook material (mostly the design process) and popular MakerSpace literature was used to create the needed learning material for this subject, where students are confronted with real-life challenges to be resolved over the course of approximately six months.
- Space: Even with the generous amount of funds made available for this space, the maximum number of students that we could accommodate at a time was eight. Thus we only took the top most promising eight students per Grade 9 class who were interested in doing this subject.

Although this project was triggered by my exposure to a public MakerSpace in Hong Kong (named Makerbay) in 2016, establishing a MakerSpace within a school environment turned out to be a prophetic decision, as in 2019 the

president of South Africa announced that in the future South African schools will need MakerSpaces “to provide hands-on, creative ways to encourage students to design, experiment, build and invent” (Staff Writer, 2019, p. 1). So, from 2017 to 2019 I have been using the MakerSpace at my school to facilitate my understanding of the highest quality of learning by confronting students with real-life challenges. This brings us to the point where it becomes possible to identify a pedagogical intervention of which the sole purpose is the achievement of the highest possible quality of learning.

2.12 Identifying the required pedagogical intervention

2.12.1 An orientation

Too many times have educational change been attempted without establishing exactly why education needs to change, and, if so, how it should change. In terms of the international community, three major changes have taken place in recent history. The first one is the phenomena of climate change (Mineo, 2020). Although the destruction of our external environment may also be attributed to natural disasters, there is no doubt that human beings are a vital cause of its demise (William, du Toit & Malherbe, 2020). Secondly, the world of work and its demands have become increasingly unique (De Villiers, 2005; Neethling & Rutherford, 2005; Lansbury, 2018). Thirdly, the youth of our time is fundamentally different from previous generations in terms of them being digital natives (Jukes, 2005; Kardefelt-Winther, 2017) as opposed to the older digital alien population. We are all witnesses of these changes that are regarded by Drucker (2000) and the students of the 4th Industrial Revolution (Schawb, 2016) as one of the most significant shifts in human history, for which we have been and still are completely unprepared. This has been emphasised by the global attack of a Corona virus which, despite all the advances in the digitisation of our world, have exposed the seriousness of the consequences of these changes described already two decades ago by Dreyden and Vos (1999, p. 21) as follows:

> "The seismic scope of this change forces us to completely rethink everything we've ever understood about learning, education, schooling, business, economics and government."

Ultimately, this pandemic has exposed our most significant vulnerability. Despite our digital supremacy in virtually all domains and on all levels of life, our frail, gullible, ailing human condition is laid bare. "We are more powerful than ever before, but have very little idea what to do with that power" (Harari, 2014, p. 7). That is why Barnett (2007, p. 101) indicates that education under the conditions of the supercomplexity of the 21st century world is, in principle, not an epistemological task of the acquisition of knowledge (which we have indicated is actually only information) and skills, but it is, primarily, the ontological challenge of the transformation of the condition of the human being – nothing less.

Barnett (2007, pp. 40-51) refers to our conditioning as human beings, starting even before we came into this world and continuing thereafter through our education, which has inevitably deprived us of our authenticity. Simply stated, authenticity is the degree to which one is true to one's own inherent personality, spirit or character, despite the continuous onslaught of external forces to conform to a deceptive, inauthentic identity, which deviates from one's true self (Heidegger, 1962). Fortunately, our authentic potential remained intact. But, says Barnett (2007, p. 40), authenticity in education is so important that an "education that does not call, does not insist, on authenticity in the student is no education" and, therefore, "authenticity has to be fought for, won and sustained." Our authenticity is constituted by our human dispositions and qualities that are durable:

> "Through their dispositions and their qualities, students have the capacities to acquire both knowledge and skills. They constitute the student's pedagogical being. It is they that have to be the focus of 'teaching'" (Barnett, 2007, pp. 101-102).

And when we have a closer look at these dispositions and qualities, an undeniable relationship with Aristotle's virtues is exposed from which we could

deduct that the essential intra- and interpersonal human virtues which we have indicated before, constitutes our authentic potential. If these virtues should be the focus of our education, the begging question would be how are they acquired? As potential, they already exist and since they cannot be taught or learnt in the traditional sense, these virtues are ignited and come to fruition “only with experience of life” (Hursthouse, 2011, par 7).

The phrase “only with experience of life” has been expressed in various ways throughout this research and in particular as a mode of learning. Since it is postulated that learning is the ultimate foundation of education, and that the experience of life is the associated mode of learning, we need to determine what the pedagogical process would be to ignite the essential human virtues to fruition that would allow us to take ownership of our authenticity.

2.12.2 Identifying the required mode of intervention for learning quality

Our traditional answer to the question of how learning is achieved in education is through teaching. However, Sternberg warns us about such a naïve assumption in that the “problem is that teachers think that if they ‘teach’, students ‘learn’” (Sternberg, 2008, pp. 143-144). Since teaching cannot guarantee learning, and since learning cannot be taught, the most appropriate and purposefully descriptive verb to effect learning would be to facilitate it. But it is crucial to identify the associated noun for the role, namely a facilitator of learning who is Facilitating Learning. The dichotomous link between these two concepts is important to distinguish it from a facilitator in general. While a facilitator is someone independent and objective with no vested interest in whatever is being facilitated, save that an amicable outcome that satisfies all parties has been reached; a facilitator of learning is intimately vested in the commitment to the sole purpose of ensuring the highest possible quality of learning outcome.

Facilitating Learning (FL) is distinctly different from teaching. Rooth (2000, p. 35) states in this regard that “Facilitating Learning is not teaching, not telling, not lecturing, not preaching and not guiding.” She says that Facilitating Learning creates the learning environment in which students can learn, explore, discover,

construct and develop. Facilitating Learning is also qualitatively different from teaching. Mohanan (2005, p. 1) states that "if teaching activities do not result in learning, there has been no teaching. Likewise, if the learning is lacking in quality, the teaching is unsuccessful to that extent." However, we have seen that education requires a 'learning to be' experience where students are "facilitated to develop their unique potential" (Holdstock, 1987, p. 49). This means that the facilitators of learning are "in the business of making themselves redundant" (Alexander & Potter, 2005, p. 179). Although this is regarded as a new pedagogy, Heidegger (1962, p. 44) has claimed many years ago that "[T]he real teacher, in fact, lets nothing else be learnt than – learning. His conduct, therefore, often produces the impression that we properly learn nothing from him." Facilitating Learning as a new pedagogy is therefore effectively the direct opposite of teaching.

2.12.3 What is all this learning for?

Having identified Facilitating Learning as the mode of the pedagogical intervention that pursues the highest possible quality of learning outcome, we now need something that encapsulates what has been revealed in this research, which is explicit enough to express a mutual focus towards what we could do with the power we have. However, education has to fulfil an ethical imperative that indicates what we should do with that power. Amidst this demand, it seems strange that such an explicit aim of education is still eluding the pages of research and even the halls of our educational institutions. Is there really nothing that unites us to the extent that we want to exhibit what the essence of our profession entails? I have been exposed to an aim of education with which I am completely aligned and which I am proud to articulate when I am confronted to reveal the character of my profession with the question: What is education?

> "Education is creating the most powerful learning environment possible that evoke learners' empowerment to maximise (completely develop and fully utilise) their human potential (essential human virtues) through facilitating (demanding the highest possible quality of) lifelong, authentic learning (by resolving real-life challenges) in

order to create a safe, sustainable and flourishing future for all – a quality imperative" (Slabbert, 2015, p. 132).

2.12.4 The professional practice theory of and for facilitating authentic, lifelong learning

From the preceding paragraphs we are finally capable of putting a name to the proposed pedagogical intervention which maintains the primary purpose of pursuing the highest possible quality of learning as Facilitating Learning. It is important to be a little more explicit regarding the label of this pedagogy.

Identifying this pedagogical intervention is based on my own personal experiences as a student within my PGCE program and as a teacher among my colleagues nationally and internationally, my literature review for my master's degree and for this research. My exposure as student teacher to the intervention prescribed by FL during the PGCE program was systematically experiential. The reason for this is what Korthagen (2001) found, that student teachers or practicing teachers who are confronted with educational reform do not use the expert, abstract, theoretical, knowledge (episteme) they are provided with. For teacher professional development, "phronesis [Aristotle: practical wisdom] perceptual knowledge is most important. As a consequence, the professional learning of teachers starts from concrete experiences and their subjective perceptions of practical situations" [own insertion] (p. 255). This is achieved through "sufficient new experiences to help build alternative gestalts" (Korthagen, 2001, p. 182). Through our own concrete practical experiences of what constitutes the highest possible quality of learning, we had to construct our corresponding practice theory of our pedagogy – because it was derived from our practice. Subsequently, we were able to use our (continually improving) practice theory for the design of new pedagogical practices. In this way the obstinate practice-theory dichotomy gap has been aborted through a professional understanding of the translation between practice and theory and vice versa. For practical purposes the title could be shortened to: The Professional Practice of/for Facilitating Learning. But since Facilitating Learning (FL) is the noun and key concept in this substantial all-encompassing pedagogy, I propose that this be its functional title going forward.

And to prevent any misunderstanding, I find it not only appropriate but actually necessary to adopt the best descriptive noun for my function in this pedagogy as a Facilitator Of Learning (FOL).

The fact that this pedagogy revolves around learning is expressed by three purposes of Facilitating Learning. They are: initiating learning, learning and maintaining learning. The purpose of maintaining learning is critical because only if learning is maintained, may the highest possible leaning quality ensue. These purposes of Facilitating Learning can only be fulfilled if a lesson period of some kind evokes the purposes into action. In fact, this pedagogy revolves practically around a learning task, which is the demanding real-life challenge with which the learners should be confronted. What links the learning purposes with the learning task is the one or more functions of Facilitating Learning associated with each of the purposes. The structure of the pedagogy of Facilitating Learning (FL) is presented in the table below:

Table 2.6: The structure of Facilitating Learning (Slabbert, et al., 2009, CD)

<table>
<tr><th colspan="3">FACILITATING LEARNING IN PRACTICE</th></tr>
<tr><th>What is the major purpose?</th><th>What is the Facilitating Learning function?</th><th>What is the relationship with the learning task?</th></tr>
<tr><td>INITIATING

LEARNING</td><td>Learning Task Design (LTD)</td><td>Learning Task Design (LTD)</td></tr>
<tr><td></td><td>Learning Task Presentation (LTP)</td><td rowspan="4">Learning Task Operation (LTO):

The learning task is put into operation with both the facilitator of learning and the students participating.</td></tr>
<tr><td>LEARNING</td><td>Authentic learning (AL)</td></tr>
<tr><td rowspan="3">MAINTAINING

LEARNING</td><td>Learning Task Execution (LTE):
• Metalearning (ML)
• Cooperative learning (CL)</td></tr>
<tr><td>Learning Task Feedback (LTF)</td></tr>
<tr><td>Learning Task Consolidation (LTC)</td></tr>
</table>

2.12.4.1 A critical perspective on the pedagogical intervention of Facilitating Learning

As we have discovered along the way up to this point, there are a large number of foundational philosophies, theories and disciplines that underpin the theory of

education in general. Collectively, they contribute to a complexity that simply becomes overwhelming. The added multitude of teaching strategies, methods and techniques aggravate this condition and with the exponential advancement of all the different kinds of smart technologies, the field of education is becoming incomprehensible.

As was stated in the rationale of this study, such an environment may indeed stimulate a pluralistic and eclectic approach to education (Mcculloch, 2002, p. 100). It is, therefore, true that a multitude of approaches to education exist. However, it is the moral imperative of professionalism in education that puts an ethical price on its integrity when the choice of components and its interrelatedness becomes a possibility in an eclectic consideration (Campbell, 2003; Gallant, 2019). The question is: Is the outcome of the choice(s) that are possible the best and why?

Although I do not claim any completeness in my research up to this point in time, I have yet to find an education theory that so explicitly recognises that *learning* is pivotal to education and so closely associated to the ethical imperative of the highest possible quality of learning, with every subsequent consideration based on that premise, like I am introducing here. I also could not yet find one that could bring together the disparate educational disciplines and its accompanying research in recent times to the extent necessary to avoid unacceptable educational fragmentation. In the same vein, I still need to find a pedagogical intervention that adheres to the non-negotiable requirement of the holistically integrated interrelatedness of its constituents in harmonic coherence like the one that follows. Finally, I am still looking for an education theory that has been translated so eloquently into an all-encompassing pedagogy, and its consequent practice theory, where everything revolves around learning.

Despite the preceding accolades of this pedagogy of Facilitating Learning, I do also acknowledge that this is only one such practice theory of probably many that I am not even aware of and, as is the case with any theory, critique on this constructivist epistemology is bound to be subject to criticisms like what we have

experienced in preceding paragraphs. One prominent criticism is that although it may be theoretically sound, it does not seem to be practically viable (Leslie & D'Ambrosio, 1995; Richardson, 1997; Brophy, 2006; Tilikainen, et al., 2017; Zabihi & Khodabakhsh, 2019). I must admit that in the process of my exploration of this pedagogical intervention, to present its essential character in its entirety for your perusal as reader, I was confronted with a contradictary dilemma. The unfortunate inevitable limitations of written sequential language communication like a report like this inadvertantly resulted in a theoretical rendition of the rather substantial pedagogy of Facilitating Learning, which could easily be overwhelming in that sense – and may very likely seem to be impractical. Even our experiential mode of exposure had its doubtful moments, but it was indeed the ever increasing excercise in practical wisdom that allowed us to construct a sound practice theory from our experiences.

Closely related to this criticism is the fact that the practice theory as it will be presented later might be perceived to be instructive with no allowance for creativity. This unfortunate misconception is justified unless and until we recognise the context within which this intervention is imbedded as is illustrated in Table 2.3. It consists of specific purposes, each with one or more associated functions – equally specific as everything is directed specifically to pursue the highest possible quality of learning. In that sense it is important to state that, besides the nature of the function, its representation contains guidelines through which the function operates – which may be incorrectly assumed to be prescriptions. And creativity? Facilitating Learning requires creativity from the facilitator of learning to design a demanding real-life challenge – which proved to be a challenge in itself. It requires creativity from the learner to resolve the real-life challenge with the reward that it was the best possible job done well and the satisfaction of personal development of a higher order than in previous rote learning problems.

The other criticism also lodged at this pedagogy, is that it is more suited to the fields of mathematics, science and technology which includes some of my fields of expertise. Although, as one student among many other PGCE students from

all kinds of academic disciplines enrolled for offering education in all school subjects, all of us were witness to the principled basis of this pedagogy with regards to the nature (content) and structure (epistemology) of academic disciplines from which school subjects are derived. One of the best examples that confirm this *generic* nature was witnessing one of our peers who was qualifying as an English language teacher. During her school practice period in an ordinary middle-class multicultural school, she challenged her Grade 9 students to write their own short stories for Grade 1 learners in a multicultural black township school. Her school was partnering with this school which had no library and consequently no books to read. The stories had to comply with strict criteria and faultless English. They had to edit their stories several times before she would accept it. Eventually, the stories were of such high quality that a publisher offered to print 150 books which the Grade 9 authors delivered to the school. During the handover the authors read their published stories to small groups of Grade 1 students – to the delight of readers and listeners alike.

As you might be able to gather from this pedagogical intervention is that it is educationally professional – as it should be. Its implementation should be done with associated cautionary respect because the cost is high but its benefits immeasurable. The exploration of the pedagogical intervention of Facilitating Learning is based primarily on the work of Slabbert, et al. (2009).

2.12.4.2 The first function of Facilitating Learning: Learning Task Design (LTD)

From the preceding paragraph it is obvious that FL, through its purposes of initiating learning, learning, and maintaining learning, requires the execution of functions that compel students to maximise their human potential, represented by essential qualities and dispositions. It has also been indicated that FL is indeed a pedagogy. For a pedagogy that is pursuing the highest possible quality of learning it requires the design of the most powerful learning environment. According to De Corte (2003), the most powerful learning environment is constituted by a learning task. The key question, therefore, is: What is a learning task?

> "Learning tasks are concrete, authentic and meaningful real-life experiences that are provided to learners, [they are] real-life or professional tasks … situated in problem solving in real-life, authentic contexts … [where] meaningful experiences enable the learner to learn the ways of knowing of the expert" (Van Merriënboer & Paas, 2003, p. 9).

The learning task, therefore, is designed for students in order to attain essential qualities to flourish in the 21st century which are the holistic human qualities of "knowing of the expert." Referring to such specific qualities, Barnett (2004, pp. 256-257) describes the nature of the required pedagogy as follows:

> "The achievement of qualities such as these calls for a transformatory curriculum and pedagogy … This is a curriculum that is aimed at the transformation of the human being; nothing less."

Education is therefore not primarily an epistemological task but an ontological challenge where "the student's being and becoming [human qualities and dispositions] is more significant than the student's knowing [knowledge and skills] efforts" (Barnett, 2007, p. 165). The transformatory pedagogy which has been identified is facilitating lifelong, authentic learning. However, most importantly is the requirement that would have students engage in this type of learning. Such a transformatory curriculum is accomplished when students are engaged in an authentic pedagogy requiring them to "become 'active learners', capable of solving complex problems and constructing meaning that is grounded in real-world experience" (Newman, Marks & Gamoran, 1995, p. 1).

This latter quotation provides the key as to what is the prerequisite of and for FL: Resolving real-life challenges embedded within real-world experiences with its uncompromising complexity. What is of crucial importance, though, is that the learning task, as the real-life challenge, is defined in terms of a problem as follows:

> "The problem is encountered first in the learning process and serves as a focus or stimulus for [acquiring and utilising] problem-solving or reasoning skills, as well as for the search for or study of information and knowledge needed to understand the mechanisms for the problem and how it might be resolved. The problem is not offered as an example of the relevance of prior learning or as an exercise for applying information already learnt in a subject based approach. A problem in this context refers to an unsettled, puzzling, unsolved issue that needs to be resolved. It is a situation that is unacceptable and needs to be corrected" (Barrows & Tamblyn, 1980, p. 18) [own insertion].

Further clarification of what a learning task is comes from Claxton (1999, p. 38):

> "A problem exists for which there is currently no ready-made solution. A challenge is posed for which the requisite skills are not yet established. A plan is disrupted by an unanticipated event. In each case the effect of what happens next is uncertain."

As in real-life, the struggle in resolving a challenge never encountered before forces one to do whatever is necessary at the time and the resulting knowledge and skills acquired in the process become utterly meaningful and transferable to subsequent novel and challenging encounters with real-life. Of course, the learning task should encapsulate as much of the particular curriculum of the discipline or subject on the level of the student.

From the above, it becomes apparent that the real-life challenge has to be something (or as close as possible to) that the students are experiencing in their lives right now; or it has to be something that needs immediate action or some form of resolution right now in order to improve the quality of their lives; or preventing an imminent disaster somewhere in the future. In that sense, the challenge has to be a personalised one for every student so that they are compelled to take ownership for resolving the challenge because it is in their own interest and because they will experience an appropriate immediate achievement

of the benefit of resolving the particular (or intermediate) challenge they are confronted with right now.

The most important aspect of the learning task design which constitutes the real-life challenge, is that the students have to produce four very specific and tangible end product outcomes. These are:

a. **The learning product** or the resolved real-life challenge must be an actual product of their learning in at least one of the following forms:
   - a physical object that has been produced
   - a decision that has been made and executed
   - a process that has been generated and executed
   - a service that has been provided

AND

b. **The learning process** or how the real-life challenge was resolved is the process or procedure that has been followed. This will represent the learning process and will include **the skills and competencies** that the learners attained and employed.

AND

c. **The learning content** as a construction of the **content** that students have acquired (in the form of a concept map or any other appropriate way aligning with the level of the students and their learning) and how everything is related regarding the resolution to the challenge. This will represent the learning content acquired, which implies that the learners are actually writing their own "textbooks."

AND

d. **The essential human virtues** attained as it finds expression in an observable change in new and enhanced **behaviour** that expresses a growing value system that transfers to all domains of life.

The students, therefore, effectively produce their own, but much more meaningful and relevant, textbooks. Looking at what needs to be accomplished by such a learning task, we see that its design is indeed in itself a professionally demanding challenge for the facilitator of learning.

2.12.4.3 The second function of Facilitating Learning: learning task presentation (LTP)

The learning task presentation is of critical importance because it is the students' confrontation and first encounter with the real-life challenge that they have to resolve. The learning task presentation may be done in various creative ways as it is experienced in real-life. The purpose of the learning task presentation is to immerse the students into the real-life experience in the shortest possible time and with only the most essential information and context that will confront them head-on with the challenge. This has to be done through utmost clarity conveying the urgency and importance of achieving the resolution for the challenge ASAP, and compelling action immediately (Slabbert, et al., 2009). This should be done without interaction with the students, because whatever might cause an interaction from the students will be most likely in relation to one or the other issue about the fact that the challenge has been conveyed to the students in its ill-structured uncompromising complexity just as it is occurring in real-life. In fact, the learning task presentation should provoke the students' spontaneous motivational initiative to engage with the learning task, but this would be the ignition of authentic learning which is the next function of Facilitating Learning.

2.12.4.4 The third function of Facilitating Learning: authentic learning (AL)

There is little more to say about authentic learning within the context of this research other than what has been explored in the paragraph with that heading earlier. As the third function of Facilitating Learning, it is the authentic real-life challenge that constitutes the cyclical learning process that relates to experiential learning, cognition, neurophysiology, and all the other related aspects that were addressed earlier in this chapter. It is in this cyclical process of authentic learning

that the whole of Facilitating Learning is imbedded when students are experiencing the learning task presentation, as the immersion in the real-life experience. But it then continues especially when students start with learning task execution and all the subsequent functions of Facilitating Learning (Slabbert, et al, 2009).

At this point it seems to be the most appropriate place to provide a definition of learning that is authentically significant. It is Claxton's definition (1999, p. 11) that was provided earlier, but now combined with his later extension of the definition, it becomes authentically significant:

> "Learning is what you do when you don't know what to do and to become increasingly more and more competent at why, when, where, how and what to do when you don't know what to do."

In a more educational, scientific sense, although seemingly restrictive, I prefer the following amended definition of learning:

> "Learning is the authentic construction of meaning by the student that transforms into dynamic meaningful knowledge, which the student is then capable of using to do something creatively new" (Slabbert, et al., 2009, p. 82).

This brings us to the fourth function of Facilitating Learning.

2.12.4.5 The fourth function of Facilitating Learning: Learning task execution (LTE)

The previous paragraph has described authentic learning as the deeply imbedded learning that takes place inside the learner. However, authentic learning cannot happen in a vacuum. It is, in fact, the learning that takes place when the students are executing a learning task. What is also important about learning task execution is that it pertains not only to the execution of the learning task, but also how the learning process is maintained during learning task

execution, which is the second purpose of Facilitating Learning. A learning task is executed through two major learning modes, namely metalearning and co-operative learning.

a. Metalearning

Metalearning is derived from metacognition. Metacognition was introduced by Flavell (1976, p. 88) as that "'Metacognition' refers to one's knowledge about one's own cognitive processes and products and anything related to them." Metacognition is the foundation of self-regulation. Biggs and Telfer (1987) brought metacognition into the realm of education and called it metalearning. Metalearning is also popularly known as learning how to learn. Metalearning can best be described as the higher order learning process of managing one's own learning by taking full responsibility for and complete control over one's own learning (Slabbert, et al., 2009, p. 109) with the purpose of achieving the highest possible quality of learning outcome that results in personal development of the highest order (Alexander & Potter, 2005, p. 66).

What is critical about metalearning, it has to be said at the start, is that it is learning that is done by an individual learner, personally and operating alone. Metalearning is achieved through perhaps very obvious managerial metalearning strategies by each individual student. These strategies relate to a situation where a student is confronted with a demanding real-life challenge:

Table 2.7: Metalearning strategies and some possible questions

Metalearning strategy	Some corresponding questions to answers
Planning for resolving the real-life challenge	What is this all about? What is the problem? What am I required to do? What am I given about the problem? What do I not know about the problem? Where and how will I get it? How will I go about resolving this?
Executing the plan	Am I following the plan?
Monitoring every step of the way	What is the next step? Do I understand what I am doing? Is this the best way of doing it? Have I completed what I needed to do?

	What else do I need to do?
Assessing the product	How could I have done this even better? What is this worth to me?

Watkins (2001, p. 7) confirms a number of the most important characteristics of metalearning namely, that it promotes the versatile learner, that it mediates the quality of learning outcome, and that it ensures high performance and exceptional retention because the learner has tremendous memory capacity when learning is embedded in real-life experiential contexts. Metalearning cultivates an active, effective, independent, high quality, lifelong authentic learner.

Besides the reasons above, it is only through metalearning that students can attain the essential intrapersonal human qualities or virtues like courage, motivation, initiative, responsibility, perseverance, resilience, resourcefulness, and independence as a manifestation of their potential. The learning task feedback (LTF) that should take place continuously during metalearning should be directed at individual students.

Watkins (2001, p. 7) states that metalearning "plays a key role in a learner's self-regulation of learning, building the autonomy on which even collaborative work thrives."

b. Cooperative Learning

Johnson and Johnson (1990) were some of the first authors who introduced cooperative learning while Jacobs, Power and Loh (2002) did so around a decade later by indicating that our inevitable social interconnectedness is best represented through cooperative learning. Slabbert et al (2009, p. 112) defines cooperative learning as follows:

> "Cooperative learning takes place when learners in small groups cooperate to learn with the exclusive purpose to increase the quality of each other's learning in order to maximize their individual and collaborative potential."

Essentially, cooperative learning is created as a way in which achievements could be reached that cannot be done individually. In order to achieve this, it is assumed that more than one learner working in a small group will achieve this. Reality proved this not to be the case unless the groups of students are compiled in a particular way and adhere to a set of stringent requirements – especially when the highest possible quality of learning is to be achieved. They are the following:

Table 2.8: Stringent requirements for cooperative learning (Slabbert, et al., 2009, CD)

1	Groups should be compiled as heterogeneous as possible in all respects.
2	Four members per group is preferred because this number contains the highest number of interaction lines with the least number of members. This may also represent a “base-group” because it allows for many other group compilations and sizes in relation to whatever kind of task or sub-task the students need to execute.
3	Positive interdependence amongst members meaning that each individual member is dependent upon every other member to achieve mutual success with the learning task.
4	Individual accountability meaning that each individual member is accountable for his/her own required contribution, but has to contribute perfectly to the work that everyone else has been doing.
5	Promotive (face-to-face or face-to screen) interaction between all members to promote their learning quality.
6	Assessment of collaboration – not assessment of the result of the learning task completion – should be frequent and regular.

Under these conditions the difference between cooperative learning and collaborative learning is revoked: Each individual student is responsible for their own work separately and they are also in charge of the collaborative work of the team as a whole. Furthermore, groups can all work on the same learning task or different groups can work on different sub-tasks of the main learning task. Whatever the case may be, under these conditions the work of one member of a group should be representative of all other members of the same group. This makes it possible that the assessment work of the facilitator of learning can be reduced by up to 75%.

The most important value of cooperative learning lies in it becoming a community of truth. When learners engage in the community of truth, as in real-life, they share their observations, interpretations and constructions, correcting and complementing each other; torn by conflict in one moment and joined by consensus in the next. It is through the dynamism of conflict that they can publicly test their ideas in a communal effort to stretch one another beyond their perceived potential. Such a community rescues them from ignorance, bias, and self-deception if they are willing to submit their assumptions, their observations, their theories – indeed themselves – to its scrutiny (Palmer, 2007, pp. 101-104).

Cooperative learning cultivates active, effective, interdependent, high quality, lifelong authentic learners. It is through cooperative learning that the students become able to attain the interpersonal human qualities like appropriate communication, empathy, compassion, respect, patience, forgiveness and justice. The learning task feedback that should take place continuously during cooperative learning should be directed to the small groups of students.

What is critical about learning task execution, when students are charged to take full responsibility and complete control over their own individual (metalearning) and their collaborative (cooperative learning) learning, is the opportunity for the facilitator of learning (FOL) to utilise the principle of differentiation. During this process, the FOL can focus attention on the struggling individual or groups of students during their process of learning task execution.

2.12.4.6 The fifth function of Facilitating Learning: learning task feedback (LTF)

Facilitating Learning works through three purposes: initiating learning, learning and maintaining learning. This fifth function of Facilitating Learning, learning task feedback is the epitome of Facilitating Learning because this is the process during which learning with all its consequences is optimised.

Feedback in education is a process during which students make sense of information about their performance during the learning process and use it to enhance the quality of their learning process. Hattie (1999, p. 9), says that “the

most powerful single moderator that enhances achievement is feedback." However, it is not the fact, but the nature and structure of the feedback that determines its purpose, which is, in this case, the highest possible quality of learning. We, therefore, need to be reminded that from the very start of learning task execution, the students are already under their own obligation of having taken full responsibility and complete control over their learning (metalearning) for this very purpose. Although the learning task feedback (by the facilitator of learning) is thus determined primarily by the learning task execution (by the learners), it is not dependent upon it, because the facilitator of learning may – or rather should – intervene at any relevant point in time, with the most appropriate and necessary learning task feedback action. Learning task feedback, consequently, is inducing another, higher level of learning quality enhancement.

Within this context of learning task feedback (LTF), the answer to the question as to what constitutes the most appropriate learning task feedback, might differ, in some instances differ vastly, from what is normally regarded as good feedback (Omer & Abdulharhim, 2017; Henderson, Phillips, Ryan, Boud, Dawson, & Molley, 2018). We need to be reminded that the third purpose of Facilitating Learning is to maintain learning for which the function of learning task feedback is designed in order to have the learners maintain their learning so that, or until, the highest possible quality of learning outcome is achieved. LTF is primarily initiated by a student's learning response to the learning task that is executed.

Table 2.9: The criteria for learning task feedback (LTF)

Criteria	Description
Maintain time-on-learning task	Whatever the LTF action, it has to keep or revert students to maintain time-on-learning task.
Provide primarily appropriate emotional encouragement and support	Since LTF is ultimately directed to learner's attainment of essential human virtues, appropriate emotional encouragement and support under the necessary conditions of resolving a demanding real-life challenge is essential.
Determine the exact reason for a student's learning response	Unless the reason for a student's learning response is clear the reason for a particular response should be determined before the best and appropriate LTF can be executed.
Provide only the minimum LTF ("scaffolding")	Only the minimum LTF necessary to revert students to maintain time-on-learning task should be provided. (A suggested scale is provided later on.)

Prevent discussion or interaction	Discussion or interaction with the FOL should be prevented. The students need to have their own internal discussions or discussions between the members of the groups.
Ask content-void but quality demanding questions or give such statements	Do not answer student questions and thus become a source of information. Avoid asking questions that require only one or a few words as answers or questions that require content answers. Ask questions that require quality demanding actions from students.
It should be purposeful	The purpose of the particular LTF has to be in direct accordance with the student's response, but it also has to direct the student towards what the LTF needs to achieve in general.
It has to be timeous	In general, feedback needs to be done as immediately as possible after a student response through any action during the execution of the learning task. But it must be *perfectly* timed in accordance with the content and nature of the student learning response to the LTE.

What is of utmost importance about the pedagogical intervention of Facilitating Learning is the cost-effective way in which it requires only that intervention that is necessary at any point in time. At the same time, Facilitating Learning does not reject or renounce any other learning theories, strategies, methods or techniques. The only requirement is that whatever is selected to be incorporated should not be an a priori choice, but should be utilised only if and when it is necessary, and then in a way that is most appropriate, to allow for the quickest progression to the highest possible quality of individual and cooperative learning – as suggested in the following paragraphs.

Following are some of the most important actions that a facilitator of learning should execute during FL arranged in the hierarchical order from the minimum LTF that might be necessary to have the students maintain or revert back to time-on-learning task, to the maximum (Slabbert, De Kock & Hattingh, 2009, CD) level of assistance.

a. Providing emotional encouragement and support

If the students are learning well and the quality of their learning is sufficient, the facilitator of learning may give feedback in the form of emotional encouragement and support. This may be non-verbal through gestures or facial expressions or

verbal by saying things like: 'You are really doing well' (encouragement); or 'I know you can do it' (support).

b. Asking clarification

Even if learning is continuing smoothly; or if the facilitator of learning observes that the students are getting off track; or the quality of their learning is not good enough or it is suspected that this is the case, then the FOL has to determine exactly where the students are situated in their learning process. The questions that the facilitator of learning will ask can be something like: 'What are you doing?', which should be followed by 'Why are you doing this?' Through these questions the FOL seeks information to clarify the disposition of the students. This is the only case when the facilitator of learning demands an answer from the students and waits for such an answer until it is provided. But asking for clarification is not meaningful in itself and has to be followed up with a challenge to engage students in the experience of metalearning.

c. Demanding metalearning from students through:

(i) Reverting back learner questions

When students request help of any kind from the FOL non-verbally, through facial expressions or verbally through questions, the FOL has to return the question to the students by asking questions like: "What do you think?", or "What would you do?" The FOL needs to remove him or herself physically from the proximity of the learner immediately after the question was asked in order to have the students experience that the question is lingering within and that an answer can only be forthcoming from within.

(ii) Requesting reflection

Whether the FOL has detected insufficient quality of learning or if the learner has made it known somehow, the purpose of the FOL is to have students reflect on what they did, assess it and improve on it. That is why the same principle of immediate removal from the

proximity of the students after asking the question should also be implemented here. The following may be some of these questions:

- Have you thought of everything?
- Have you considered all possibilities?
- Is this the best way of doing it?
- How many more can you find?
- Do you understand what you are doing?
- Do you understand why you are doing it?
- Is this enough?
- How will you improve this?
- How sure are you?
- How will you make sure?
- How well do you think you did?
- What is the meaning of this for your future?

(iii) Referral to resources

If students cannot solve the problem despite previous actions from the FOL, students should be referred to resources where they might find some information to help them, by asking questions such as: “What do you need?” and “Where will you find what you need?” Importantly, the facilitator of learning should have made provision for such a possibility and should have made sure that the resources are available and accessible in the most realistic and appropriate way.

(iv) Advising auto-education

If students are still at this point seriously lacking in knowledge and/or skills to enable them to solve the problem, the FOL, as a last resort, will have made provision for a whole spectrum of educational methods, tools, techniques, materials and resources for the students to access on their own in order to acquire the necessary knowledge and/or skills through auto-education. Note that, although students are

acquiring knowledge and/or skills, this acquisition is meaningful because they have realised that they are lacking it and that they need it to solve the problem. They also learn how and where to acquire knowledge and skills when they need it. Lastly, students become more independent, because they had to acquire the knowledge and skills through their own efforts.

(v) Providing edutainment

One of the most important criteria for life in general, and obviously for learning, is efficiency. Efficiency is determined by the combination of the time it takes to complete a task, the effort that was exerted to complete the task and the accuracy with which it was completed. If for any reason time and/or accuracy and/or effort becomes paramount for efficient learning, then, and only then, may FL require a special kind of intervention which may result in what is traditionally called 'teaching': Supplying information, demonstrating or illustrating something, showing something to be imitated, telling something to be memorised, explaining something to be 'understood', engaging in a Q and A discussion or the demand to become proficient in a particular skill through drill and practice. This will happen only under very special conditions. These conditions appear when students are busy with learning task execution (LTE) and the challenge they need to resolve demands at a particular time that a particular piece of information or a particular skill is a necessary precondition for being able to continue with solving the problem. The facilitator also knows that acquiring this particular piece of information or skill through the authentic learning process will take up so much time and/or may require so much effort to produce the accuracy required, that the students will be distracted from achieving the actual learning outcome that will compel them to fully utilise their potential in the most efficient way. It means that acquiring this intermediate piece of information or skill is not an aim in itself, but serves only as a means to achieve the intended outcome in

the most efficient way. Only under these very special conditions may the facilitator of learning employ the particular activities that will justify learning methods and strategies aimed at regurgitating and repeating like watching, listening, imitating, memorising, drill, practice, etc. But under these conditions, these FL activities are called edutainment.

Edutainment is a very important part of FL. Edutainment is prompted by the real disposition of the students. It is created by a need from the students – the students govern it – or knowing full well that the students will need the information/data or skill at a particular point in time for a 'higher' purpose. There are very important prerequisites for implementing edutainment: The facilitator of learning will edutain only when there is no other possible way that students will be able to obtain the information/data or acquire the skill they need right now within the reality of the time limit allocated or reserved to solve the problem. Whether edutainment will be implemented or not will be guided by the question whether edutainment will be the most efficient way for students to obtain the necessary information/data and/or acquire the necessary skill. If students are left to obtain the information or acquire the skill in any other way, will time, accuracy and effort unnecessarily be wasted in which much more important learning could have been done? Will this cause the students to become distracted in resolving the actual challenge at hand efficiently? Is the learning process of obtaining the information or acquiring the skill a crucial learning experience or are they rather only a means to get to the best solution of the current challenge more efficiently to require the full utilisation of potential? Whenever a decision has been made to implement edutainment, the format in which it is done is also crucial. As far as possible, it should be done based on the principles of drama as learning (Heathcote, 1991; O'Neill, 1995; Wagner, 1999; Andersen, 2004; Taylor & Warner, 2005). The purpose of the edutainment is always to:

> "Provoke; disturb; create disequilibria; cause uneasiness and discomfort; stir; shake; touch the emotions; bring into sharp focus; rock the boat; unsettle; deceive; mislead; impact; stun; be radical; have students really reflect and think critically and creatively!" (Slabbert, et al., 2009, CD)

There is, however, a circumstance under which learning a skill as quickly as possible (through demonstration, imitation, etc.) is justifiable. This is when job creation to solve an immediate economic need becomes inevitable. But, this short-term learning has to articulate with the potential of long-term development – it means that, although it is an aim in itself in the short term, it can be only a means to eventually fulfil the aim of education in the long term. Important to note again is that learning a skill in this way focuses on the skill itself and not how it relates to conditions, circumstances, and the environment. And since circumstances, conditions, and the environment is in a continuous mode of dynamic change, it also continuously requires new skills, and it simply becomes futile for a learner not to be challenged through FL to fully utilise his/her potential.

Thus we see that within FL, the pedagogical intervention when students are grappling with the real-life challenge is learning task feedback (LTF).

2.12.4.7 The sixth function of Facilitating Learning: Learning Task Consolidation (LTC)

At the end of each learning period (face-to-face interaction with students) learning is also maintained through learning task consolidation. A few minutes before the end of a particular learning period, the facilitator of learning has to request students to consolidate what they have learnt up to that point and to present it to the entire group of students. As was the case in the previous paragraph, this entire paragraph is a summary of the work of Slabbert, De Kock, and Hattingh (2009, p. CD). The following are crucial actions that are executed during learning task consolidation:

a. Ascertaining the rate of the learning progress

The facilitator of learning (FOL) demands from students to share what they have learnt up to that particular point in time with the entire group, and, learning from how far their peers have progressed, the FOL and students can ascertain the rate of learning progress

b. Assessing the quality of learning

Not only does a simple sharing of what students have learnt take place, but rather a critical assessment of what has been learnt by the peers and the facilitator of learning. This determines the quality of the students' learning.

c. Determining the next challenge

Having established the progress and the quality of learning up to that particular point in time provides the opportunity for students to realise what they have achieved during that particular learning period and to envision what still needs to be achieved to fulfil the required outcomes. For the facilitator of learning this is also available, and, in addition it allows the facilitator of learning to determine what the challenge for the next learning period should be and how it should be executed.

This entire process, from learning task design up to learning task consolidation represents a continual process of FL. Although each of the preceding functions of FL has its own array of actions and requirements (not necessarily elaborated on in this summary) it was the discovery of the actions, requirements and options of learning task feedback and consolidation, in addition to and in relation with the actions, requirements and options of learning task design, that made the most significant impact on my perception of why South Africa's education is generally rated to be one of the lowest in international tests and reports.

In fact, what has become clear to me through my years of study – including this one and my years of experiencing this kind of education myself among that which

I could observe and hear about from national and international colleagues – is that FL might be a benchmark for a good education. FL may be visually represented as is shown below:

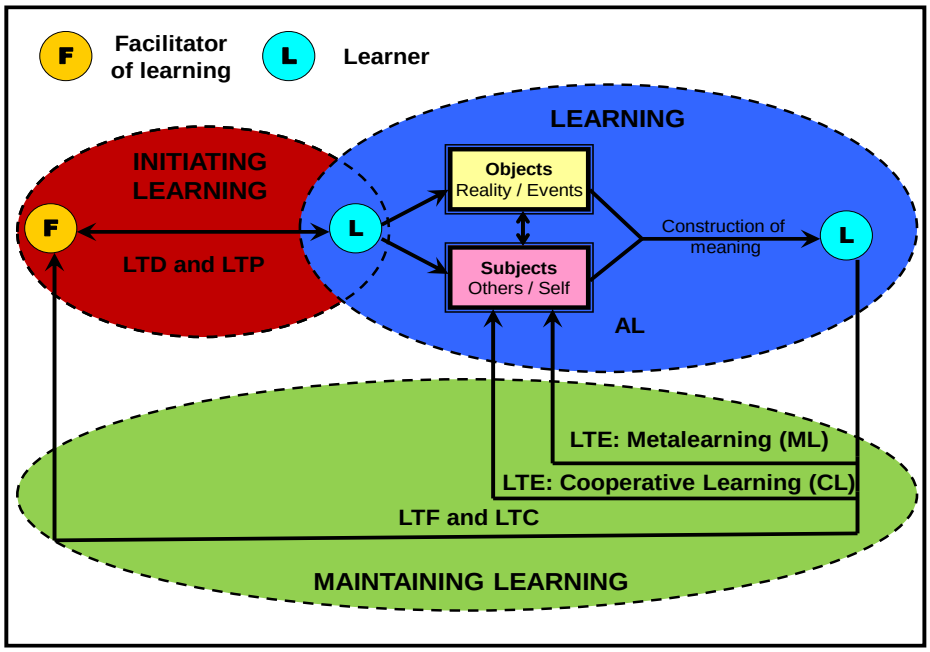


Figure 2.5: The six functions of Facilitating Learning (Slabbert, et al., 2009, CD)

In reflecting on the exploration of FL as it is portrayed in the format of a process it becomes clear that learning is, in fact, a process (in its theoretical conception as well as its practical execution). Thus Facilitating Learning's functional steps (LTD, LTP, AL, LTE, LTP and LTC) would also be a process. However, through my own experiences, right from my introduction to FL, I have discovered that it is a highly flexible process. FL will rarely be executed in a perfect, linear process from beginning to end, and there may be one or more interruptions at any point for many reasons. One of these may be simply that there might not have been enough time to complete the process during one time period and it has to continue in a subsequent one. If this happens though, learning task consolidation (LTC) should be operationalised at the end of the particular learning period for effective continuation at the beginning of the next learning period. This is because of LTC's particular function of effectively bridging the time gap between two consecutive learning periods. There may also be a deviation from progressing in the mainline

process for any appropriate reason. The deviation might be to go back any amount of steps in order to repeat it for learning improvement. The deviation might also be because within any particular step a new real-life challenge emerges that requires a branching off into a new Facilitating Learning event with a later reconnection with the mainline one.

Of importance is that Facilitating Learning is not only a process, but it is also a cyclical process because of its purpose to achieve the highest possible quality of learning outcome which may require a continuous cyclical process. The most essential aspect of the process of Facilitating Learning, as constituted by its functional steps, is the critical importance of the function of each of its functional steps and their relationships, not only to its sequential in-line functions but how each step relates to every other step. The reason for this is that by becoming professionally competent in executing each of its steps in sequential order, the FOL is afforded the possibility of executing FL by virtually starting with any particular step and following any sequence. The creativity in Facilitating Learning lies in designing a learning task with a demanding real-life challenge that would, through its presentation, compel students to ultimately authentically engage in their own, personal and professional development of the highest order according to the aim of education as stated earlier. The figure on the next page indicates the interplay between learning task feedback and authenticity within the context of the LTE function:

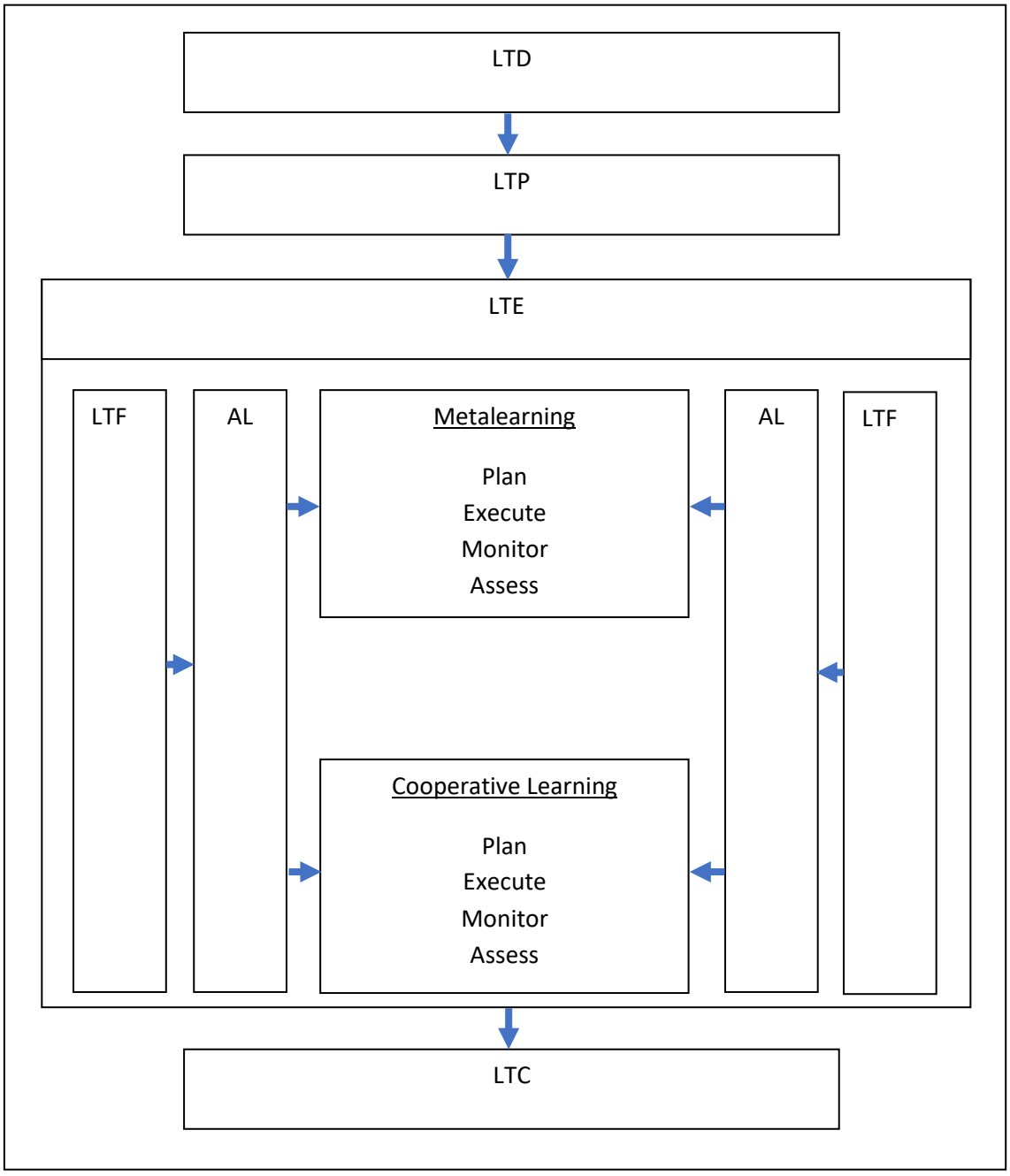


Figure 2.6: The interplay between learning task feedback and authentic learning within the learning task execution function of Facilitating Learning

This is a challenge to our students, and an even bigger challenge to us, the facilitators of learning. It is this challenge which makes education a professional practice of Facilitating Learning – we cannot afford anything less.

2.13 Conclusion

In this literature review, the core aspects of the research were located within the existing literature to clarify the ontological and epistemological lens of the researcher. In doing so, a foundation was laid for the new empirical evidence that this research aims to contribute to the literature. Firstly, the researcher's understanding of a constructivist epistemology was presented, followed by a discussion on authentic learning and its relationship to experiential learning and the subsequent cost of authentic learning. The MakerSpace movement was then identified and discussed as a grassroots movement that lends itself to this form of learning. This was followed by a description of Vygotsky's learning theory (ZPD) as the theoretical framework which explains how students develop within an authentic learning experience. A visual metaphor titled 'The Domain of Self-Transcendence' was presented to depict the effect of Facilitating Learning (FL) on the extent of learning that can take place.

With the backbone of the learning endeavour discussed, I turned to the literature to see the various forms of online learning that correlate with the highest possible quality of learning outcome. After touching on a broad spectrum of online learning forms, an in-depth analysis was conducted on Productive Failure. In Kapur's study (2008) of this learning theory, he made use of an online group discussion which is compatible with the highest possible quality of learning outcome. An analysis of Kapur's 'ill-structured problems' was conducted against the backdrop of the highest possible quality of learning outcome. This culminated in a design decision to make use of an adjusted version of Kapur's experiment, where an 'authentic real-life challenge' replaces an 'ill-structured problem'. An extensive summary of FL followed which laid out the practice theory that would lead to the highest quality of learning. Within the process of FL, the pedagogical intervention introduced into the learning process when learners are faced with the real-life challenge is learning task feedback (LTF). In this study, I thus designed a learning

task where FL takes place and had control groups face the real-life challenge in an online MakerSpace environment without the pedagogical intervention (LTF), while the experimental groups experienced the pedagogical intervention (LTF). With the conclusion of this chapter and in particular the discussion on Facilitating Learning, the first 'dark matter' starts to emerge in the visual metaphor for the study, represented by a faint blue glow, as can be seen below:

Figure 2.7: Galaxy Cluster MCS J0416.1-2403 with 25% indication of dark matter (European Space Agency, 2015)

Although still faint, this promising glow brings us to a detailed outlay of the research design of this study in the next chapter.

CHAPTER 3: RESEARCH DESIGN

3.1 Introduction

Maree (2010, p. 149) states that the purpose of any research design is to "answer a specific kind of research question." The type of data needed to answer the research question thus becomes the primary mover in the process of selecting a research design for a study. In the case of my study, data was required that would answer the following question: What kind of pedagogical intervention is best suited to pursue the highest possible quality of learning outcome from grade 9 learners when resolving authentic real-life challenges on a CSCL online platform in a MakerSpace environment? By conducting a thorough review of the literature, I have determined that Facilitating Learning (FL) provides the highest quality of learning. Accordingly, as the pedagogical intervention put forth by FL, the effect of learning task feedback (LTF) as an pedagogical intervention will be measured. I will start this chapter by discussing all the methodological considerations which were taken into account for this study.

3.2 Design considerations

3.2.1 Research premises: Paradigmatic assumptions and perspectives

The research design for this study was selected based on my personal ontological and epistemological understanding of the world (Cohen, et al., 2001; Maree & Van Der Westhuizen, 2009). Being a pragmatist, I concur with Maree (2010, p. 265), who states that in any study the "research questions are considered to be more important than the methods used to answer them." I endeavoured with the design of this study to let the required data lead me in all my research design decisions, being open for the inclusion of both quantitative and qualitative data collection and analysis techniques if required. A summary of my ontological and epistemological assumptions are indicated in the table below:

Table 3.1: Research premise

RESEARCH PREMISE			CORRESPONDING APPROPRIATE CHOICE FOR THE STUDY
Research premise	Ontological assumptions	Pragmatism	The truth is "what works best" for understanding a particular research problem (Maree, 2010, p. 264)
	Epistemological assumptions	Objective and subjective	Social interaction gives a subjective insight into objective results gained from an experiment

3.2.2 Delineating a mode of inquiry

The mode of inquiry is an overarching design-based research methodology (Hoadley, 2002; Bnnan-Ritland, 2003; Mor, 2010; Anderson & Shattuck, 2012). It includes the substantial literature review conducted in Chapter 2, which laid the foundation for the theoretical and conceptual framework of this study. Ultimately, the goal was to design an experiment where I could measure the effect of a pedagogical intervention (designed particularly for pursuing the highest possible quality of learning) in an online learning platform through the particular mode of Computer-Supported Collaborative Learning (CSCL). In addition, the context of the learning taking place in the experiment was a MakerSpace environment.

In view of the very complex phenomenon of facilitating the learning quality of an online interactive classroom practice where learners are resolving a real-life challenge, a mixed method (quantitative and qualitative) inquiry seemed to best suit this research. Reason being that the use of both these approaches "is built on the premise that it can be more fruitful to consider how the strengths of quantitative and qualitative approaches can be merged" (Lopez-Fernandez & Molina-Azorin, 2011). Within this context I would like to set my entire research with its mutually integrative quantitative-qualitative mode of enquiry on a computer supported platform within a MakerSpace environment from the outset as a 'research assemblage' where it "positions researcher, participants and findings as mutually constituted elements in an enmeshed entanglement of discursive processes, material contexts, animate bodies, social norms and practices" (Martin, 2018: 11).

The complex nature of the main research question to be answered became apparent when I considered that the research needed to effectively measure the effect of an pedagogical intervention on learning quality.

The way in which learning quality is determined thus becomes one of the pillars of this study – a platform from which to inspect the effect of a pedagogical intervention. The mere prospect of validly measuring an abstract concept like learning quality was an extremely daunting goal; the validity of this measure was one of the pivots on which the success of this research hinged. While I did not initially know exactly how the learning quality would be measured, I did suspect that data used to determine the learning quality would have to be quantitative. As the goal of the data collection would be to make evident the influence of a pedagogical intervention, I would also have to collect data regarding the experiences of participants, which from my own experience would require qualitative data. The need for both quantitative and qualitative data pointed to a mixed method approach, described by Creswell as an "approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs" (Creswell, 2014, p. 4). I hoped that in doing so my research would provide me with a "more complete understanding" (Maree, 2010, p. 267) of the complex phenomena being studied.

Mixed method research is described as a "new methodology originating around the late 1980s and early 1990s" (Creswell, 2014, p. 217) and is growing in popularity across several scientific disciplines (Greene, Caracelli & Graham, 1989; Morse, 1991; Dzurec & Abraham, 1993; Morgan, 1998; Rallis & Rossman, 2003; Sandelowski, 2001; Forthofer, 2003; Currall & Towler, 2003; Hunter & Brewer, 2003; Johnson & Onwuegbuzie, 2004). The literature abounds on different types of mixed methods designs. Studying the literature, the first promising design that I came upon was the Explanatory Sequential Mixed Methods Design (Creswell, 2014, p. 224). What interested me about this design was that it consists of two phases: first a quantitative phase, followed by a qualitative phase. In my planned research, the learners would also first take part in an experiment that would generate quantitative data, followed by qualitative

interviews. However, as both the quantitative and qualitative data collection phases are equally important in my study to "understand participant views within the context of an experimental intervention" (Creswell, 2014, p. 231), I concluded that an Embedded Mixed Methods Design would be more appropriate.

The 'embedded' nature of this type of design typically refers to a qualitative measure that gives insight into the experiences of participants in an experiment by including open-ended questions (qualitative data) in a questionnaire. This strongly resonated with my intentions in this research, as data explaining the influence of the pedagogical intervention on learning quality was descriptive in form. My design differed from the Embedded Mixed Methods Design in that the data collection took place in three distinctive, sequential phases instead of the traditional 2 phases. Although this was not necessarily in violation of the definition of Embedded Mixed Method Design, which simply states that it "nests one or more forms of data within a larger design (e.g., a narrative study, an ethnography, an experiment)" (Creswell, 2014, p. 227), the sequential nature of my data collection spurred me to look for another design which more closely resembles my own research goals. This led me to the latest edition of "Designing and conducting mixed methods research" (Creswell & Plano Clark, 2017) where they discuss a "Convergent Mixed Methods Design" (p. 70).

In this design, the equality of the data has to be reflected in the way that it is merged or brought together in the data analysis phase (Creswell & Plano Clark, 2017, p. 71). Building on the concept of the Embedded Mixed Methods Design, the Convergent Mixed Methods Design has more nuanced variants, such as the "questionnaire variant" (p. 74). Still, I did not find a design that specifically refers to sequential phases of data collection where the data of both phases converge to give insight into a specific phenomenon. At this point, I realised that I would have to adjust existing designs in order to produce the research design required by my reseach goals and so I consulted the award-winning article[4] by Leech and Onwuegbuzie titled: "A typology of mixed methods research designs" (2009).

[4] Their paper won the James E. McLean outstanding paper award

In their article, Leech and Onwuegbuzie suggest that all mixed method designs can be classified according to "three dimensions: (a) level of mixing (partially mixed versus fully mixed); (b) time orientation (concurrent versus sequential), and (c) emphasis of approaches (equal status versus dominant status)" (2009, p. 267). Based on these dimensions, my design would be classified as a Multi - Phase Partially Mixed Sequential Equal Status design, which "involves conducting a study with two phases that occur sequentially, with the quantitative and qualitative phases having equal weight" (p. 270). The 'equal weight' condition is conceptual in terms of the contribution to the research results in view of the relatively small sample size which is the complete cohort of learners who are available for this study. This will be clarified when the sampling for the research participants is discussed later on.

While the experiment (Data collection set 1) will generate data allowing me to calculate the learning quality of the groups and in doing so confirm or disprove the experiment hypothesis, focus group interviews (Data collection set 2) would provide data that gives insights into the experiences of participants during the experiment. Finally, as the experimental groups would be the only groups to have any feedback regarding the pedagogical intervention introduced into the experiment, an additional focus group interview (Data collection set 3) will be conducted in order to collect data on the effect of the pedagogical intervention. Table 3.2 provides an overview of the quantitative and qualitative phases of this mixed methods research design:

Table 3.2: A summary of the mode of inquiry

RESEARCH PREMISE			CORRESPONDING APPROPRIATE CHOICE FOR THE STUDY
Mode of inquiry and research design	Multiphase partially mixed sequential equal status design	Data collection set 1: Quantitative experiment	The researcher "tests the theories about reality, looks for cause and effect, and uses quantitative measures to gather data to test the hypotheses (or questions)" (Maree, 2010, p. 257). In this study, data will be collected to determine the level of learning quality between experimental and control participant groups

		Data collection sets 2 and 3: Qualitative interviews	Interviews can usually be found in case studies, where research is a "systematic inquiry into an event … which aims to describe and explain the phenomenon of interest" (Bromley, 1990, p. 302). In my study, learners will be asked to share their experiences of resolving a demanding real-life challenge

With the mode of inquiry discussed, further detail will now be given in terms of the research considerations for this study.

3.3 Research requirements

3.3.1 Selecting the research site

The MakerSpace subject that I had founded at my own school is an integral part of the context wherein the research takes place, and it was the logical choice for the research site of this study. Going forward, I will refer to my school as MakerSpace High. This school caters for the upper spectrum of the middle class in what can be considered a wealthy South African neighbourhood. It has an average class size of 25 while there is, on average, 100 learners per grade. Having identified the MakerSpace subject at MakerSpace High (which allows only Grade 9 learners to partake in the MakerSpace subject during school hours as part of their curriculum) as a suitable vehicle to employ my research, I made use of stratified sampling where the only criteria was that learners were in Grade 9 and taking the MakerSpace subject. With the limited size of the MakerSpace classroom, only between 4 and 8 learners per Grade 9 class were offered this subject. In 2019, the number of Grade 9 learners who chose to enrol for the MakerSpace subject was 24. In order to acquaint the reader with the research site, some photos have been included in this paragraph and can be see on the next page:

Figure 3.1: An elevated view of the facilities at MakerSpace High

Figure 3.2: Outside views of classrooms at MakerSpace High

Figure 3.3: The assembly quad at MakerSpace High

Figure 3.4: The ASTRO hockey field at MakerSpace High

Figure 3.5: An informal settlement is visible in the distance from the school rugby field, which links with the real-life challenge discussed later in this chapter

3.3.2 Compiling the sample

Sample size is a major consideration in doing research and in this research the sample was easy to compile because it consists of the entire cohort of students that could enrol for this MakerSpace subject in a year. However, since it is a relatively small sample, it is important to explicate the value of small sample research within the context of a quantitative research methodology. Since part of this research was inspired by the study of Kapur (2008) it is important to also refer to his sample. According to Kapur (2008, p. 56) his research included "sixty 11th grade learners (46 males, 14 females) 16-17 years old from the science stream of co-educational, English medium school in Ghaziabad, India."

With such a small sample size, I was tempted to make use of a within-subject design experiment as it is more tailored for small sample sizes. However, besides the advantages of a within-subject design, I also had to take cognisance of the drawbacks that this design presents in the "carryover effect", the "fatigue effect" and the "practice effect" (Cuttler, 2017), all of which are critical drawbacks within the context of the integrity of my overall research design. The use of different real-life challenges would not successfully indicate the effect of facilitating learning as I would have no way of ensuring that both challenges are equally difficult for the individual participants (carryover effect). Multiple exposures to the experiment (fatigue effect) would also train the participants towards subsequent exposures (practice effect), which would render the results of the effect of the measurement of the effect of facilitating learning a within-subject design in serious jeopardy.

Thus I decided to rather investigate the literature for other examples of quantitative research designs with small research sizes, starting with an experiment conducted by Tan (2016):

> "[20] pairs of grade eight students [n=80] involved in a school MakerSpace context. Given sixteen little Bits modules housed in a small toolbox, along with some light construction materials, students

were tasked to produce a prototype of a device that could attract teachers' attention during class work sessions" (p. 922).

In the study conducted by Marra, Steege, Tsai and Tang (2016, p. 4) an engineering course was studied with "40 engineering students in their third or fourth year of degree completion", while Tan and So (2016, p. 745) conducted their experiment on "two classes of secondary students (N=40)." Splichal, Oshima and Oshima (2016, p. 832) conducted their research on 48 learners. In view of this, it is apparent that within the literature there are valid examples of small sample sizes. Upon closer inspection it does become evident that in most cases the environment where the research takes place has a great influence on the size of the sample. In this type of research (which tends to be conducted at schools and universities) influences like classroom sizes, the number of learners in a grade and the timing of the research all heavily influence the sample sizes.

In terms of my study, the 24 learners in the MakerSpace class of 2019 were divided into 6 groups of 4 learners each. Each group was compiled to be as heterogeneous as possible (in terms of race, gender, ability and whatever other important diversity measures that may be relevant), also according to cooperative learning composition requirements and the context of this research.

Table 3.3: Sample composition

UNIT	EXPERIMENT IN 2019
Group size:	4
Number of groups participating:	6
Total sample size:	24

Having decided on the sample, the following section will describe the data collection processes followed in this study.

3.3.3 Data collection: Tools, techniques and associated mechanisms

Data collection and its associated tools and techniques are of course key to any research endeavour. In the case of my research where learning quality was the focus, its quantitative measurement, within what is traditionally primarily

qualitative human sciences of education, called for a very deliberate and well thought out series of data collection steps. The first task was to determine what the learning quality measures would be by which the identified pedagogical intervention of my study would be measured in order to confirm or disprove the experiment hypothesis. Even as I took note of complexities attached to having this pedagogical intervention taking place within the context of online learning, through a CSCL modality, in a MakerSpace environment, it still turned out to be a much more challenging event than I originally anticipated. In the next sections the tools, techniques and associated mechanisms are described.

3.3.3.1 Designing learning quality measures

In order to indicate the efficiency of the pedagogical intervention of this research I would first have to establish criteria with which learning quality can be measured. As a teacher with 13 years of teaching experience, one would expect that I was equipped to easily accomplish this task. Ironically, upon reflecting on this endeavour I quickly realised that I could not make use of my experience with assessment over the span of my teaching career.

As a high school teacher, I have experienced first-hand the pressure exerted on the school system to deliver ‘good marks’ on report cards at the end of the year. It is only to be expected that this pressure translates into a classroom environment where assessment is used primarily to train our learners to write the end-of-year examinations, which are usually externally set. With weighting that ranges between 60% and 75% of the year mark, it is understandable that a final examination (with a duration of a couple of hours) becomes the focus of an entire year’s classroom activities. Personally, I also have my learners write practice tests throughout the year, and in doing so I am painfully aware of the fact that assessment in my class does not indicate the amount of learning which has taken place. Instead, my assessments merely test whether a learner can answer a set of closed questions in a manner that they had been trained to do. This manner of assessment is not conducive to the highest quality of learning outcome and is thus not suitable for this study. The following specifics of this study also

contributed to the challenge of finding an existing measure of learning quality in the literature:

1. Learning quality in this study is interpreted according to the Vygotskian principle (as laid out in paragraph 2.5) where struggle is a fundamental part of learning. Despite the inevitability of students' actual struggle in resolving a real-life challenge contained in the research, I could not find other references that indicate the necessity of struggle as explicitly as in the work done by Kapur (2010);
2. The experiment of this study takes place within the context of FL. It can also be seen as an extension of FL into the realm of online learning – I could find no similar study within the existing literature; and
3. The experiment of this study expects participants to resolve a real-life challenge within an online setting – while I did come across multiple studies concerning 'open problems' I could find no examples of online real-life challenges.

When an initial survey of the current literature revealed that the learning quality of an online session is still being measured predominately by the quality of an artefact produced by the session (Cope & Kalantzis, 2016; Wolfe, DiSanto, Poma & Rodriguez, 2018; Amber & Angie, 2018; Qamar, 2019), I turned to a more promising branch of research concerning the learning quality of online groups, namely 'Collaborative Learning'.

Collaborative Learning in an online environment is a growing field with a quickly expanding set of literature and, as stated by Pöysä-Tarhonen, Care, Nafisa, Häkkinen and Ahonen (2016, p. 834), "collaborative problem solving (CPS)" links closely with Vygotsky's learning theories and has become "one of the most promising educational approaches" within a "computer-supported collaborative learning" environment. Although it may not be conducive towards my study to elaborate in depth on my investigation of Collaborative Learning at this point of

my research design, I believe it prudent to highlight some of the more salient findings of my research into this field in a pointwise manner:

- Learning quality is increased when a facilitator of learning promotes “connectedness and engagement” (Crews, et al., 2015, p. 91).
- As stated by Burgess (2015, p. 139), by being “present” within the online environment learners are motivated to complete their studies.
- According to Holmes, et al. (2014, p. 535) learning quality is increased when learners are prompted to reflect on their failures.
- Crews, et al. (2015, p. 90) attribute the increase in learning quality to a multitude of different tasks performed by a facilitator of learning ranging from motivating learners to ensuring learner-centred activities.
- Initiating peer feedback has also been identified as a method that leads to deep change in the belief systems of participating learners (Czajka & McConnell, 2016).
- According to Hardy and White (2016, p. 713) the learning quality is increased when the facilitator of learning understands “the interactional processes by which the group as a whole constructs knowledge, as well as how engagement in these processes relates to individual learning.”
- Alquassab, Strijbos and Ufer (2016, p. 864) believe that learning quality increases if the facilitator of learning understands the “affective aspects of peer feedback statements of a peer feedback message on the learning of the peer feedback sender and recipient” (p. 864).
- Negating the fear of social ridicule is another strategy which can increase the quality of learning (Tsuei, 2011, p. 217; Jung, Yan & Borge, 2016, p. 879) by making it easier for learners to contradict

statements made by other group members (Lee & Song, 2016, p. 41).

- Empowering learners within an online social context is also addressed in the literature on group dynamics in collaboration. Splichal, Oshima and Oshima (2016, p. 831) see collaboration within a group as a shared responsibility for the regulation of learning.
- Kuhn and Goh (2016, p. 771) believe that by supporting the dialogue between learners the learning quality can increase. Marra et al. (2016, p. 14) state that scripting can be used to this effect.
- Training learners to adopt a male discourse style can also help a facilitator of learning to empower learners to come across more confidently in a group, as the work of Sullivan, Kapur, Madden and Shipe (2015) suggests.
- Learning quality is also increased by focusing on intrapersonal skills (White & Frederiksen, 1998; Merchie & Van Keer, 2016; Haigh, 2016; Gilbert, 2016; Gewerc, Rodríguez-Groba & Martínez-Piñeiro, 2016; Reid, Morrison & Bol, 2017).
- By supporting creative thinking, a facilitator of learning can increase the learning quality (Tan, 2016, p. 922).

In light of my understanding of learning quality and after analysing the literature presented above, I identified four learning measures that can be used within this study. Each of these measures will now be listed along with a description of and reason for the measure.

Table 3.4: Learning quality measures used in this study

Measure number	Measure name	Measure description	Motivation for measure
1	Participation in-equity	To what extent did the individual learners not participate equally in the discussion?	This measure is inherited from the study done by Kapur and Kinzer (2007). The less in-equality is present, the higher the quality of learning.

2	Productivity	How productive was the group?	Based on the work of Saorin (2017), the greater the amount of utterances made, the higher the amount of resistance messages which in turn increases the amount of divergent ideas which in turn increases the quality of learning.
3	Adherence	To what extent did the dialogue reflect an optimal dialogue as envisioned by the facilitators?	In this study, the aim of the facilitator of learning will be to guide the discussion of a group towards a pre-set "optimal distribution of discussion types" based on the work of Poole et al. (1995).
4	Challenge	How much struggle was experienced by the group?	According to FL, the challenge is a fundamental cornerstone (and thus indicator) of learning quality (Slabbert, et al., 2009).

I believed that Measures 1 and 2 were good indicators of learner participation in the online interaction, which in turn would point to elements of quality. However, using them on their own would possibly not be comprehensive enough to determine the quality of the learning process during the discussion. The problem lies in the fact that participants who are functioning within their Static Domain of Present Development may be inclined to participate heavily in the discussion, as they feel that the challenge lies within their current capabilities. In order to expose the quality of the discussion, I would, therefore, have to include Measure 3 as it is focused particularly on the quality of the learning process when the group interaction of the learners is from time-to-time interrupted by the intervention of the facilitator of learning. The inclusion of Measure 4 was, likewise, critical because it essentially determines the level of quality the learners are confronted with and the effort that they need to exert to produce that quality.

Having determined the learning quality measures, I could continue to design data collection tools, techniques and associated mechanisms that would provide the necessary data in relation to these measures. However, the context of the data collection in this research was as important as the data collection itself. It is, therefore, important to reveal how the entire Facilitating Learning process (in terms of its six functions: LTD, LTP, LTE AL, LTF and LTC that are not necessarily part of the data), was constructed for the particular learning task that features in

this research, with the particular purpose of collecting data that would reveal the pursuance of the highest possible quality of learning.

For this reason, I have decided to imbed the data collection and its associated tools, techniques and mechanisms within the 'sequential' process of Facilitating Learning constituted by its six functions. The next figure provides a schematic presentation of this process with an indication of the position of the focus of this research, its data collection and its relationship with Kapur's experiment.

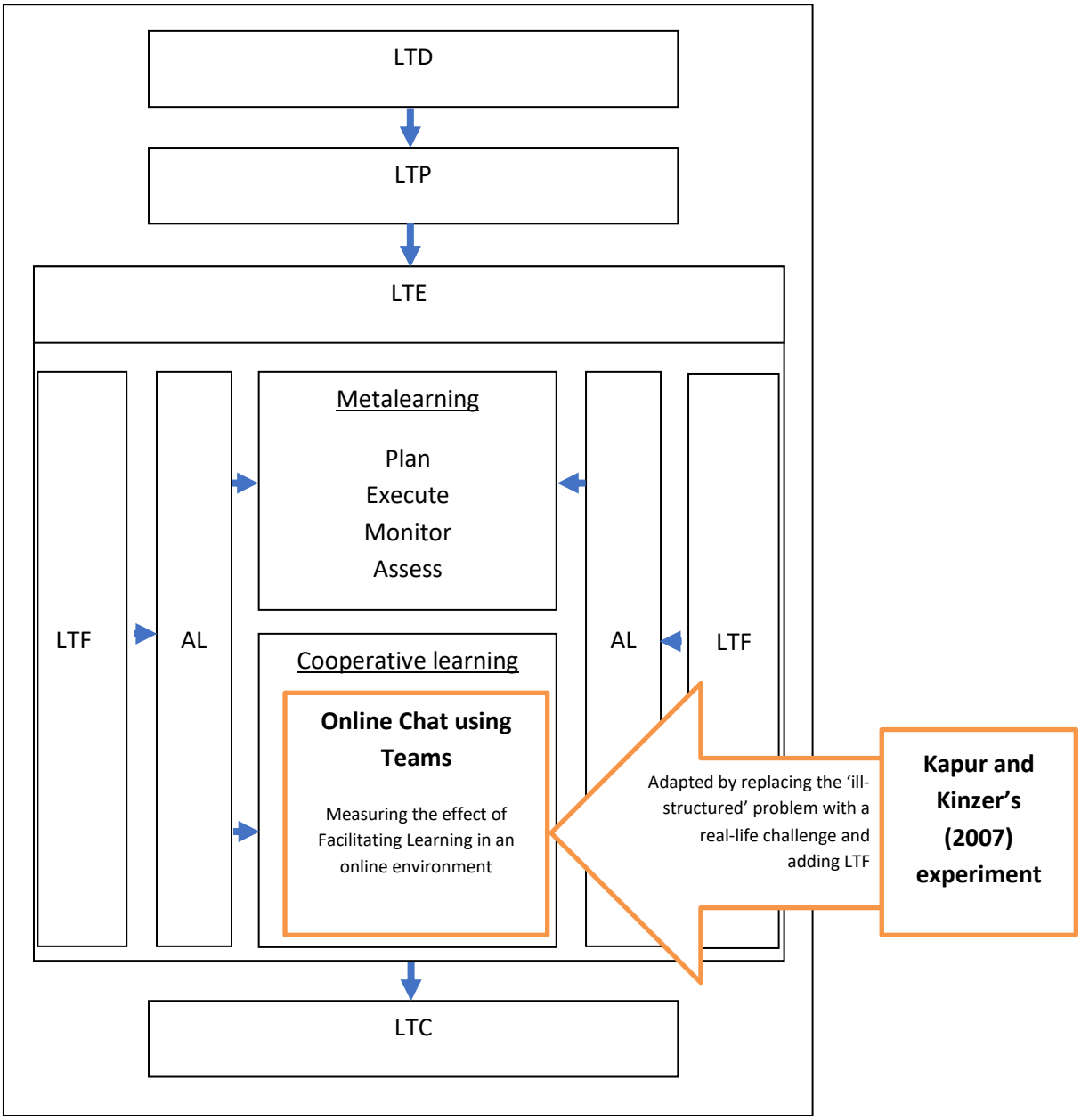


Figure 3.6: The location of the experiment in this research which was influenced by the work of Kapur and Kinzer (2007)

3.3.3.2 The Learning Task Design (LTD)

The first function of Facilitating Learning is learning task design (LTD). As we can deduct from the exploration of Facilitating Learning in Chapter 2, LTD is of critical importance to produce the highest possible quality of learning. In fact, LTD determines the success of Facilitating Learning in its totality.

As could be seen from the exploration of the nature of the learning task in Chapter 2, designing it in the format of a demanding real-life challenge is quite a challenging endeavour. This is a paradox since we are constantly surrounded by real-life challenges that call for a resolution in our lives. The reason for this paradox is probably because our education is not directed towards a disposition of real-life problem solvers – as 21st century education requires. I have experienced this paradox during my introduction to the professional practice of Facilitating Learning as well as becoming a professional facilitator of learning at my school. During my PGCE studies, my fellow students, as well as others that joined the programme later, shared this sense of dis-equilibrium, as was revealed in my Master's degree research mentioned earlier. Although the merging of classroom lessons and real-life challenges is becoming increasingly easier for the facilitator of learning because of one's progressive awareness of the challenges of real-life in its authentic, uncompromising complexity, I still experienced the process of finding the real-life challenge as challenging. Only the result of this process is provided below.

As stated, MakerSpace High is a multicultural school situated in a middle-class community, within viewing distance of the largest township in the province. A township, also known as an informal settlement, refers to land that has been put aside by the government for low-income families to erect structures to live in. The sight of the township in the distance sparked an idea for the real-life challenge after I read the following: According to an Oxfam report released in 2017, South Africa is "one of the most unequal [countries] in the world" (Quintal, 2017) with 1% of South Africans owning 42% of the country's wealth. Within this unequal state, one can find some people who live in mansions inside walled enclaves,

while others live in township shacks. The quality of the structures in these underdeveloped and racially segregated urban areas on the periphery of towns and cities varies according to the availability of materials and the amount of money available. One of the more typical types of houses in the township consists of sheets of corrugated iron, affixed to a basic structure consisting of wooden beams and roofed with the same metal sheets (see the figure below).

Figure 3.7: Typical South African "Shacks" (GroundUp News, 2019)

In colloquial language, this type of dwelling found in informal settlements is referred to as a 'shack'. As a country in its 20th year of democracy, the South African government, under the leadership of the new president Mr Cyril Ramaphosa since 2018, has emphasised that all South Africans have a moral obligation to alleviate the poor living conditions of the majority of people in our country. In his address to the nation in 2018, President Ramaphosa stated that all South Africans "have been given the responsibility to build a new nation, to confront the injustices of the past and the inequities of the present" (Ramaphosa, 2018). In light of this call to help uplift their fellow South Africans, a real-life challenge started to take shape in my mind. As a holistically more privileged community, my school with its teachers and learners has the obligation to use our resources in service of those that are less fortunate.

Since the dwellings of the township inhabitants are fabricated mostly from refuse materials used in an ad hoc manner, they are fraught with deficiencies of all kinds. So, the learners were to be challenged to come up with a solution to one of the deficiencies identified within a shack. This solution needed to be created through

rapid prototyping, which is part of the 4th industrial movement and refers to the ability to quickly create a working prototype of a theoretical technological solution (Liou, 2008). The quicker a prototype can be created, the faster an engineer (or in this case a learner) can test whether the solution works and if not then go back to the drawing board and revise the original resolution. Having found a suitable real-life challenge, I was now charged to properly formulate the real-life challenge to be presented to my learners.

3.3.3.3 Formulating the learning task presentation (LTP)

The aim of LTP is to communicate the real-life challenge in such a manner that learners are intrinsically motivated. It should also be presented with particular clarity that states the quality level of the challenge indicating the importance of resolving it, the urgency with which it should be regarded and to take action ASAP. Following is the LTP which I presented to my MakerSpace learners – the underlined sections in the presentation with the adjectives indicate the quality level of the challenge:

You know that from our school grounds we can see our neighbouring township where some of you live. And from our observations, driving past such townships and your personal accounts who live there, we know that the living conditions are at least challenging. However, as you know by now, we have become very fortunate and privileged in that we could have established our own MakerSpace at our school. Although we have only started, it is already furnished with valuable apparatus and equipment which we can utilise to improve the quality of the living conditions of our neighbouring disadvantaged community as best we possibly can with what we have at our disposal and what we can produce in our MakersSpace. To be as effective as possible we need to visit this community in order to investigate the nature and scope of the deficiencies of the living conditions in general. For this you might also request a short interview with the inhabitants in order to establish their most critical needs. However, since our resources are also severely limited, we may not be able to fix everything – right now. Therefore, we need to identify those deficiencies in and around the

dwellings that need the most urgent and immediate rectification but cannot be accomplished by something that is readily available at a hardware store. It needs to be something that we need to produce in our MakerSpace environment as the best possible, most cost effective and longest sustainable physical object that will do the job. I cannot emphasise enough that we have very little time to prepare for all of this before the bus arrives that will pick us up to go to the township.

From this verbal presentation, compliance with the demanding criteria for LTP is evident. Immediately after LTP, the students needed to move into action. This was achieved by the following announcement:

Here is a Field Trip Document (Appendix AA) *to study thoroughly in order to prepare yourself for what you have to do during our excursion. The trip is officially approved by your parents, the school and the Department of Education. We will depart at 08:00 on the day of your next MakerSpace period and should be back after break.*

With this announcement and upon receipt of the Field Trip Document, the students had to go into action without delay.

3.3.3.4 Learning Task Execution (LTE) and learning task feedback (LTF)

This is the point in time that learning task execution commences with the learners becoming actively involved in the learning task. As indicated in Figure 3.6, the relationship between LTE and LTF is that while the learners are executing the learning task, the facilitator of learning will provide the necessary and appropriate feedback as the identified pedagogical intervention defined by my research. Since LTE consists of two distinctive phases, in this research the decision was made that metalearning will precede cooperative learning, as follows:

a. Metalearning

In view of the vital importance of the attainment of essential intra-personal virtues through metalearning, the learning task execution starts with learners being immersed in a real-life experience individually and alone - preparing themselves

for the trip, to undertake the trip and to be ready to identify the challenge that they need to resolve.

On the assigned date and time, we departed per bus to the township site. There was no LTF for learners during the period of their preparation. Taking the learners to visit the shacks was a deeper emersion into the real-life experience which was likely to ignite at least some emotional response towards a more spontaneous motivational engagement with resolving the challenge. On returning to school each student had a competed Field Trip Document (Appendix AA). This document (filled in by the learners during their investigation) was a complete record of their investigation into the selected shack and its surroundings. This was important data for them because it served as the starting point from which an eventual resolution to the challenge posed to them needed to be created. I collected these documents for safekeeping.

The following MakerSpace period the learners came to one of the IT-labs at MakerSpace High. I handed out their Field Trip Documents to them and presented them with the following real-life challenge:

Today's challenge is linked to the field trip we did. As far as I could see and hear it was an interesting experience for you since most of you might never have been a visitor to our neighbouring township before. Your experience will be very important for what we will be doing today in order to resolve a challenge you are now going to be confronted with. That's why I handed out your Field Trip Document. While you have the MakerSpace resources available you are capable to render a valuable service to your fellow humans in the township by identifying the most pressing deficiency that needs to be rectified by something that is not available in hardware stores. The resolution should be the best possible, most cost-effective and longest sustainable physical object that you are able to produce in our MakerSpace. To start this process, I want each one of you individually and without interference from anyone else, to take some time and carefully reflect on all the experiences you had at the township. Think of the most

important things, what you enjoyed and what not and why and finally write down how you feel about your achievement in filling out your Field Trip Document by the end of the field trip. You have 10 minutes.

b. Cooperative Learning

As has already been indicated, cooperative learning is as important as metalearning because it elicits the attainment of essential interpersonal virtues. This learning task is designed to have students engage in metalearning to individually identify an associated required real-life challenge and its best possible resolution, before they join a group with which they need to share this in order to make valuable and relevant contributions to their group and the quality of their online cooperative learning can be determined.

3.3.3.4.1 DATA COLLECTION SET 1

Reason: To determine the quality of learners' online cooperative learning
Nature: Quantitative
Tool/technique: A between-subject design experiment in an online, anonymous chat group within the Microsoft Teams platform

This data set represents the learning process of the CSCL online discussion between the group members as well as the pedagogical intervention of the facilitator of learning to pursue the highest possible quality of the learners' learning. Since my research design in this regard is influenced by Kapur and Kinzer's (2007) experiment to a large extent, by default much of the data collection tools, techniques and associated mechanisms was determined by his work. For this purpose the table below provides an overview of the differences and similarities between Kapur's experiment and my study. The similarities and differences are explicated as an introduction to the data collection of this set.

Table 3.5: Comparison between Kapur et al. (2007)'s experiment design and the experiment design in this study

Element of research design	Design of experiment in the study of Kapur and Kinzer (2007)	Design of experiment in this study
Age of participants	17	15
Sample size	60	24
Group size and number	20 triads	6 groups of 4 as this is the optimal size of groups for effective cooperative learning.
Experiment type	Randomised experimental design with a pre-test and post-test.	Randomised between-subjects design.
Context	Solving an ill-structured problem where the application of concepts and formulas of Newtonian kinematics need to be applied in an authentic 'car accident' scenario.	Resolving a real-life challenge of rectifying deficiencies in dwellings of a disadvantaged community – no existing knowledge is available.
Experiment group composition	• 10 homogenous, anonymous groups were given an ill-structured problem (IS), without any pedagogical intervention. • 10 homogenous, anonymous groups were given a well-structured problem (WS), without any pedagogical intervention.	• 2 homogenous, anonymous experimental groups are given a real-life challenge with the pedagogical intervention provided by Facilitating Learning. • 4 homogenous, anonymous control groups were given a real-life challenge without any form of pedagogical intervention.
Experiment process	Group members communicated with one another through online synchronised text-only chat.	• In the control groups, only members communicated with one another through an online synchronised text-only chat. • In the educational groups, a facilitator of learning also communicated on the group in the format of the pedagogical intervention provided by Facilitating Learning.
Online synchronous collaborative environment	Participants made use of a Java-based, text-only chat application running on the internet.	Participants made use of the chat function in Microsoft Teams, which is software that runs on the internet.
Internal validity of experiment regarding anonymity	• A seating arrangement ensured that participants of a given group were not proximally located so that the only means of communication between group members was synchronous, text-only chat. • To ensure that participants were not cognizant of their group members' identities; the chat environment was	• A seating arrangement ensured that participants of a given group were not proximally located so that the only means of communication between group members was synchronous, text-only chat. • To ensure that participants were not cognizant of their group members' identities, each participant was identifiable by a

	configured so that each participant was identifiable only by an alpha-numeric code.	randomly chosen name of one of the other participants in the experiment. Before the experiment, learners were informed that they had already been signed into the Teams platform, using a random name of another participant. We checked that all learners were signed into Teams with someone else's name.
Interventions and structuring of group discussions	• No help regarding the problem-solving task was given to any participant or group during the study. • Furthermore, no external member roles or division of labor were suggested to any of the groups. • The procedures described above were identical for both WS and IS groups. All groups were given a sufficient amount of time; they were able to complete the tasks and the time stamp in the chat environment indicated that all groups made full use of the allotted time of 2 hours. • There were no requests for extra time from any of the groups.	• LTF statements were posted into experimental groups chats where deemed necessary. • Aside from the LTF statements present in the experimental groups, the procedures described above were identical for both experimental and control groups. • All groups were given a sufficient amount of time; they were able to complete the tasks and the time stamp in the chat environment indicated that all groups made full use of the allotted time of 80 minutes. • There were no requests for extra time from any of the groups.
Data required	Data which will determine whether IS problems deliver the highest level of learning in synchronous, computer supported, collaborative learning.	To determine whether experimental groups deliver a higher quality of learning through FL than the control groups, by ranking all 6 groups according to their learning quality.
Format of raw data	The raw data unit within each problem-solving discussion was an utterance. In online text chat, an utterance includes everything a participant types before hitting the ''Enter'' button on the keyboard. Hence, each problem-solving discussion is a sequence of utterances.	The raw data unit within each problem-solving discussion was an utterance. In online text chat, an utterance includes everything a participant types before hitting the ''Enter'' button on the keyboard. Hence, each problem-solving discussion is a sequence of utterances.
Data collection	Online interactions of groups were automatically captured.	• Online interactions of groups were automatically captured. • Participants were required to fill in an online questionnaire. • Focus group interviews were conducted. • Reflective group interviews were conducted.

In terms of the comparison in Table 3.5, I need to highlight the following explanations for the differences between my experiment and that of Kapur and Kinzer (2007):

- Where Kapur focused on Mathematics, my study takes place in the context of a MakerSpace subject which was crucial for the learning task execution. It provided the context for the real-life challenge where a prototype of the artefact that would be needed to resolve the deficiency identified in the township shack would be created. However, the focus of this research did not include the completion of the learning task to its conclusion which is the final end product outcome. The focus of this research was on the learning process and the pedagogical intervention through which it should be facilitated to produce the highest possible learning quality outcome. This is, amongst others, the CSCL online synchronous, collaborative discussion of students (Kapur) with the addition of the synchronous pedagogical intervention by the facilitator of learning (my study). The quality measurement within this discussion context would provide evidence to indicate whether the actions of the FOL had in fact increased the quality of the learning. In terms of creating a prototype which would resolve the challenge, the experiment of this study represents the phase where learners had to collaborate 'theoretically' in order to design the best possible prototype to resolve the challenge posed to them – before they started to physically produce the prototype in the MakerSpace workshop.
- Regarding the quantitative data collection: There was no pre-test or post-test. Confronting students cold and unexpected with the challenge was the way that I deemed necessary to eliminate learners' expectations that may be construed by a pretest. And since the quantitative data informed the measurement of the learning quality which was obtained during the experiment, the contribution of a posttest would be questionable in this context. In the same way and for similar reasons, qualitative data in the case of this experiment could only be conducted after the experiment

because observation (which is normally utilised for this type of data collection) during the event was not possible as the communication of participants was text only. For all practical purposes then, the 'pre-test' in this study was replaced with an individual metalearning exercise as indicated before, while the 'post-test' was replaced with an online questionnaire containing corresponding questions of a quantitative nature. Further explication follows later.

The most challenging aspect of this experiment revolved around the synchronised CSCL online group discussion through text which was the source of the data during the LTE phase. Where Kapur and Kinzer (2007) used groups consisting of 3 members, I preferred 4 members per group according to the cooperative learning group requirements and its associated potentially higher quality interactions between members. The challenge increased when LTF from the facilitator of learning was added to the online chat between learners. In a sense LTF is the epitome of FL. The challenge that it brought was the added complexity of the inclusion of the online, textual, synchronised pedagogical intervention of the facilitator of learning in-between the discussion of the group members. This needed to be done in such a manner that the data produced by the experiment in this study could:

- be indicative of the impact of valid LTF which complies with the requirements laid out by the literature on FL, and
- validly indicate the impact of LTF on online groups by allowing us to compare the impact between groups, suggesting that the LTF needed to be similar/comparable between the experimental groups in order to be able to compare their effect.

I was frustrated by the fact that I could not find any literature that resonated with FL in its practical execution. Based on experience, I found that some of the biggest obstacles when conducting LTF in an online environment are:

- keeping abreast of group discussions: In a physical class it is viable for one facilitator of learning to move around the classroom space and be aware of the conversations of various groups of learners to such an extent that LTF can be conducted successfully. In an online environment like the chat groups of Microsoft Teams, learners are placed in their own isolated chat groups. This requires that facilitators of learning move in an out of these groups in such a way that they are effectively at all times cut off from the majority of the learners, making it difficult to keep abreast of the groups' progress to the same extent as in a physical classroom.
- communicating to learners that they will not be 'helped': In a physical classroom it is possible to leave the proximity of a group after making an LTF statement, thereby communicating to the learners that they have to now grapple with what has been said. This physical proximal removal is difficult to emulate in a virtual environment where you still want to be part of a group chat in order to monitor their progress.

Finally, after researching the utilities and functionality of Microsoft Teams I identified the following ways in which these obstacles could be overcome:

- Firstly I realised that the learners would have to type out their conversation in their chat, even though Microsoft Teams allows them the option to make use of audio and visual communication. When learners type and post messages to a group on this platform there is an option where you can be notified that a message has been sent to the group. In practice, this means that all the dialogue of the groups that you are a part of will continuously pop up at the bottom of your screen as the messages are posted, allowing you as a facilitator of learning to follow multiple conversations simultaneously. The fact that learners would have to type also slows down the conversation to the extent that it would be possible for you to keep track of all the comments. An example of this functionality can be seen in Appendix AB3, which is a recording of my computer screen during the experiment.

- Secondly, I realised that my own typing speed would slow down my ability to make LTF statements in a timely fashion. Thus, I concluded that I needed a bank of LTF statements, tailored for the real-life challenge in this experiment, which I could quickly copy and paste into a group as needed. I also suspected that the fact that these statements would be copied verbatim multiple times could engender a sense that the statements are automated. This feeling of automation would be enhanced when a group asked for clarity concerning such a statement, only to be given a repetition of the same statement. Ultimately the goal was to make statements (which are open to interpretation), which would force a group to reflect whether that statement is relevant and how to best respond to it. By having a fixed bank of statements, it also became possible to compare the effect of these statements made in different experimental groups.

So I concluded that it would be best to use a set of pre-set LTF statements. The next logical question was: What would these statements be? Ironically, amidst all the different avenues into the literature on learner facilitation, it was the work of Kapur (who is anti-facilitation) that held the key to the formulation of these statements. According to Kapur (2008), the coding of the data generated in his experiment worked as follows:

> Quantitative Content Analysis (QCA) (Chi, 1997) was used to segment and code interactions. The unit of analysis was semantically defined as the function(s) that an intentional utterance served in the problem-solving process. Thus, every utterance was segmented into one or more interaction unit(s), and coded into categories adapted from the Functional Category System (FCS) – an interaction coding scheme developed by Poole and Holmes (1995). Accordingly, each interaction unit was coded into one of seven categories:

1. PA: Problem analysis (e.g., “I think the man was driving too fast”),
2. PC: Problem critique (e.g., “how can you be sure that the man was driving fast”),
3. OO: Orientation (e.g., “let’s take turns giving our opinions”),
4. CD: Criteria development (e.g., “we need to find the initial speed of the car”),
5. SD: Solution development (e.g., “use the 2nd equation of motion”),
6. SE: Solution evaluation (e.g., “yes, but how do we get acceleration”), or
7. NT: Non-task (e.g., “let’s take a break!”).

Studying the steps above, I came to realise that the seven categories (or FCS steps) identified by Poole and Holmes (1995) actually represent the different types of learning task feedback statements needed in the experiment. For example: step 2 (Problem Critique), encourages a group to create more resistance (Lee & Song, 2016) and thereby seek alternative, divergent solutions (Saorin, et al., 2017). By assessing whether a group’s dialogue is reflecting these 7 categories in real-time, a facilitator of learning should be able to assess the quality of the discussion. These categories then became 7 steps to follow when resolving an open-ended, real-life challenge. But which feedback statements could be posted on a group that will steer them closer to these steps (heightening the quality of learning), without expressly telling them that they have to follow some steps, ‘helping’ them and decreasing the quality of learning?

According to Slabbert, et al. (2009), facilitation which ‘guides’ learners ‘without helping them’, in reality takes the form of a facilitator of learning who, depending on the action of the group or individual, will make the most appropriate LTF statement and then walk away. By increasing the physical distance between the parties and without the proximation to continue the interactive relationship, the learners are compelled to find a resolution of the intermittent challenge by

themselves. In light of this the LTF statements needed to encourage reflection on the categories identified by Poole and Holmes (1995), without explicitly telling the learners what that next step is. I wanted them to discover these steps for themselves. After much deliberation between myself, my supervisor and my fellow teacher who would be part of the experiment, the LTF statements were formulated accordingly and can be seen in the table below:

Table 3.6: Learning task feedback statements based on FCS-steps

FUNCTIONAL CATEGORY SYSTEM (FCS) STEP	STATEMENT COPIED INTO CONVERSATION TO PROMOTE REFLECTION ON EACH SPECIFIC FCS STEP
Step 1: Problem analysis	An expert can see what the real problem is.
Step 2: Problem critique	An expert questions everything.
Step 3: Orientation	An expert needs the input of everyone.
Step 4: Criteria development	An expert knows how to create criteria to rate the quality of a solution.
Step 5: Solution development	An expert can quickly design a solution.
Step 6: Solution evaluation	An expert questions everything.

Thus I concluded that the steps of Poole and Holmes (1995) would serve as a suitable blueprint with which to design learning task feedback statements. The table below indicates a comparison between generic LTF statements as described in the FL process (discussed in paragraph 2.12) and the LTF statements adjusted to suit the needs within this study.

Table 3.7: Adjustments made to the generic LTF in this study

Role of LTF as presented within the FL process	Have any adjustments been made to this role?	Discussion
Providing emotional encouragement and support	Yes	LTF in this study aimed to increase the adherence to the distribution of utterance types.
Asking clarification	Yes	Only LTF statements would be posted in this study. These statements would, however, require that participants gain consensus (clarity) on the LTF.

Demanding metalearning from learners through: • Reverting back learner questions • Requesting reflection • Referral to resource • Advising auto-education • Providing edutainment	Yes	Whereas FL provides a sequence of actions in hierarchical order which should be appropriately respected in a subsequent hierarchical execution, the LTF in this study would consist of only one action. This action would be the posting of an FTL statement with the purpose of guiding the discussion towards the optimal distribution of discussion types, without explicitly telling the participants what to do. In doing so, the LTF in this study would still refer any question which may be asked back to the participants which, in turn requires reflection. There would not, however, be any form of 'referral to source', 'advising auto-education' or 'providing edutainment'. By not engaging any request for clarity regarding a posted LTF statement, a group would have no other alternative than to reflect on it themselves in an attempt to evaluate their own progress.

Having determined the format of the online chat, as well as the learning task feedback statements to employ in the experimental chat groups, the design of the data collection could commence. Each member in each group and the groups itself was allocated an anonymous electronic identity. The chat of two of the six groups was interrupted from time to time by the pedagogical intervention by the two facilitators of learning – one FOL for each of the two experimental chat groups, while the four control chat groups did not receive any intervention. The reason for only two experimental groups is that we had established that to achieve as many as possible pedagogical interventions within the time limit set for the experiment, each FOL should attend to only one group. One of my school's teachers was shadowing me as a facilitator of

learning for quite some time as part of his continuing professional development and after some intensive additional training, he was ready to function effectively as a facilitator of learning for the second experimental group and as co-researcher.

This phase of quantitative data collection was launched with the following announcement to the learners:

From now on you will be working in anonymous groups on the terminals in front of you. You will not know or be able to find out who the other three members of your group are because every individual member needs to be completely safe to freely contribute to the group's endeavour to resolve the challenge. The first thing that I want you to do, is to one-by-one share your reflections on the field trip. After everyone had shared, with your team members as a group you then need to decide which technological invention you will be able to create in the MakerSpace workshop, which will improve the quality of living in a shack. After you have decided on the invention, you as a group need to contemplate the steps to follow in order to create a prototype of this invention, the materials needed and also the tools that would be required. Then you have to critically assess the suggested resolution to eventually improve on its quality.

You will see that your computers are set up on the Microsoft Teams platform and that each of you is already loaded in a specific chat group. You can now start to chat with your group members as we have trained to do in the past weeks. Please note that we expect you to resolve this challenge without us teachers helping you. We (referring to me and my colleague whom they know) do, however, have access to everyone's chat and we may, from time to time chat with you if and when we find it necessary. I am looking forward to your best resolutions to this real-life challenge. Enjoy this interactive session.

3.3.3.5 Engaging in Learning Task Consolidation (LTC)

According to FL, the learning task consolidation phase is where the Facilitator of Learning needs to determine whether the intended outcomes for a learning task have been achieved. In terms of this study, I used this phase for the collection of the next data set.

3.3.3.5.1 DATA COLLECTION SET 2

Reason: Reflection on learners' online discussion and intervention experience

Nature: Quantitative + Qualitative

Tool/technique:

a. **An online questionnaire where learners were asked to rate the level of difficulty of the challenge. Additional supportive data was also collected in the form of Lickert scale questions.**
b. **Audio-recorded focus group interviews with all groups that will be transcribed.**

As the amount of struggle experienced by the individual is one of the most basic principles of learning according to my understanding of Vygotsky, I knew that I had to measure this quality in some way. By asking learners to rate the challenge on a scale from 1-10 immediately after their chat group interaction, I hoped to get as truthfull an indication of their subjective experience on the level of challenge as possible. The collection was introduced as follows:

> *Thank you guys, will you please end off your group chat now. You will see that I have posted a link in your group chat that takes you to an online questionnaire where I ask for feedback on your experience today. Click on the link and please complete the questionnaire. You have 10 minutes.*

After 10 minutes I checked that all the learners had completed the questionnaire. Then I revealed the numbers and identities of the groups and made arrangements with the groups to conduct interviews with them. This type

of interview can be represented by means of a continuum model (Punch, 2009, p. 148) according to the extent that it is structured, as can be seen in the figure below:

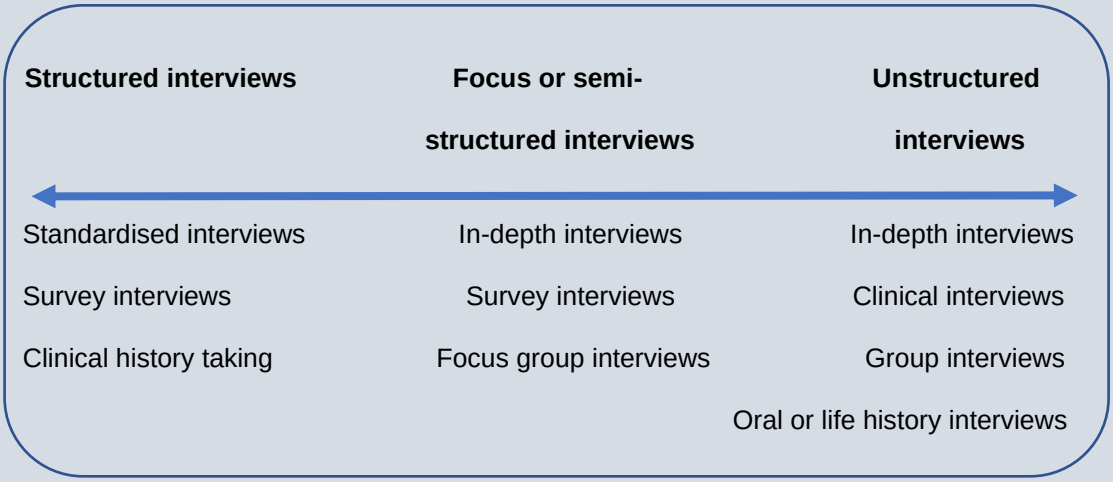


Figure 3.8: Types of data collection interviews

Audio-recorded focus group interviews were selected as data collection tool and transcribed as technique. Reason being that the essence of the experiment revolves around the interaction (discussion) of the individual members of the CSCL (cooperative learning groups) when resolving a real-life challenge towards their individual and subsequent mutual highest possible quality of learning. In addition, it would contribute data that shed deeper insights into the experiences of participants which led to the quantitative data set. With the explication of the quantitative data through the qualitative data, the credibility of the quantitative results will be increased which will in turn increase the credibility of determining the learning quality of the groups which may also be ranked according to learning quality. Special attention to ensure participation equity was taken during the interview, which was introduced as follows:

Hi guys, just now, I am going to ask you to tell me about your experience while you had your online discussion as a group to resolve the real-life challenge presented to you. There are no right or wrong answers and you are not being assessed on the answers you give in this interview. You may respond to my questions in whichever language (Afrikaans or English) you prefer. And please

pitch in whenever you want to say something even if I had not asked you for a response. So if there is nothing that you want to ask me before we start, let's go.

The focus group inteview schedule was as follows:

The main question (to each individual member first): Tell me about your experience while you had your online discussion as a group to resolve the real-life challenge.

Possible susidiary questions:

1. What were your first thoughts/feelings when you saw what the challenge was?
2. How did these thoughts/feelings change when you thought about the challenge a bit?
3. How did these thoughts/feelings change when you discussed the challenge as a group?

Only the two experimental chat groups experienced the pedagogical intervention from the FOL's. Since this is an additional complexity to the online chat process and also pivotal to answering the main research question of this study, an additional data set regarding the experiences of these two experimental chat groups was critical. The particular focus of this dataset was the effect of learning task feedback statements on the chat group's discussion.

3.3.3.5.2 DATA COLLECTION SET 3

Reason: **To collect data on the intervention experience of participants in the experimental chat groups**

Nature: **Qualitative**

Tool/technique: **An ammended focus group interview where the transcribed discussion of the experimental chat groups was read by participants**

Although this data set is critical for this research its collection was quite challenging. For the two experimental groups, their electronically collected online discussions in their chat groups were copied from the Microsoft Teams platform and printed out in hard copy format. Five copies of each of these data sets were made, one for each member of the group and one for the facilitator of learning. These two groups were then separately invited to a carefully structured interview. The idea was that the members of the group would read their own dialogue (utterrances) aloud as to recreate their online discussion verbally as close as possible. However, after each intervention (utterance) from the FOL (read by the FOL) the dialogue was paused to have each participant in the group reflect on how exactly that learning task feedback statement of the FOL had influenced each one of them. This reading of the discussion dialogue, the intervention of the FOL and the response of the participants on the influence of that intervention was also audio recorded and subsequently transcribed.

A table summarising the data collection for this study is shown below:

Table 3.8: A summary of the data collection in this study

Data collection set number	Reason for collection set	Nature	Tools/Techniques
Data collection set 1	To determine the quality of learners' online cooperative learning.	Quantitative	An online, anonymous chat within the Microsoft Teams platform.
Data collection set 2	Reflection on learners' online duscussion and intervention experience.	Quantitative + Qualitative	a. Supportive data from individuals through an online Lickert scale questionnaire. b. Audio-recorded focus group interviews with all

			groups that was be transcribed.
Data collection set 3	To collect data on the intervention experience of participants in the experimental chat groups.	Qualitative	An ammended focus group interview where the transcribed discussion of the experimental chat groups was read by participants.

3.4 Data analysis

3.4.1 Quantitative data analysis

As was the case in the study of Kapur (2008, p. 55), the transcribed dialogue of groups will be analysed using “one or more coding/rating schemes, which when applied to the interaction data result in a cumulative frequency or relative frequency distribution of interactions across the categories of the coding/rating scheme (e.g., depth of explanations, functional content of interactions, misconceptions, quality, correctness, etc.).”

As stated, the first function of the collected data (provided by Data collection set 1 and Data collection set 2) was to measure the quality of learning in the groups. Four learning quality measures were designed to this effect. For every learning quality measure, the coded data of a chat group discussion needed to be analysed before it could be measured. Each learning quality measure, along with the necessary statistical analysis conducted on the coded data to be measured will now be discussed.

3.4.1.1 Measure 1: Participation in-equity

As this measure was inherited from the work of Kapur and Kritzer (2007), the same method of statistical analysis was conducted on the data. The following process was followed to determine the participation in-equity rating:

1. The total amount of utterances was counted and listed for every participant in this discussion.
2. The standard deviation was calculated for the group using these totals.

3.4.1.2 Measure 2: Productivity

To determine the productivity rating, based on the work of Saorin, et al. (2017), the following process was followed:

1. The total amount of seconds available in the experiment was calculated as follows:
   80 minutes x 60 seconds = 4800 seconds
2. The total amount of utterances made by individual participants were added together to produce the total amount of utterances made by the group.
3. The total amount of seconds was divided by the total amount of utterances, which produced the average amount of elapsed seconds between utterances. The smaller this number, the quicker utterances were made on average and the more utterances there were during the discussion.

3.4.1.3 Measure 3: Adherence

According to the work of Poole and Holmes (1995), the greater the extent that the discussion reflects the steps of FCS, the more optimal the dialogue would be. However, as these steps take place over the course of an online discussion, an 'optimal' distribution of these steps across a 80 minute timeline had to be created, to be used as the standard against which the group discussions can be measured. The 'optimal' distribution of steps (utterance types) as envisioned by the facilitators of learning within this experiment, is shown below:

Table 3.9: Optimal distribution of utterance types

PHASE	TIME	TYPE 1	TYPE 2	TYPE 3	Time
1	8:25	OO			5
	8:30	OO			5
	8:35	OO			5
2	8:40	PA	PC	OO	5
	8:45	PA	PC	OO	5
3	8:50	CD	OO		5
	8:55	CD	OO		5
4	9:00	SD	SE	OO	5

	9:05	SD	SE	OO	5
	9:10	SD	SE	OO	5
	9:15	SD	SE	OO	5
	9:20	SD	SE	OO	5
	9:25	SD	SE	OO	5
	9:30	SD	SE	OO	5
	9:35	SD	SE	OO	5
	9:40	SD	SE	OO	5

The entire discussion was divided into four phases, each phase with its own unique combination of utterance types. The first phase was 15 minutes long and consisted only of type OO-utterances. The rationale being that when participants join a discussion group, they must first orientate themselves in terms of the group and how the discussion will take place in order to resolve the challenge posed to the group. Typical OO-activities included gaining clarity, establishing rules for the discussion and planning the discussion. The second phase of the discussion was 10 minutes long and ideally had to be utilised to identify the main problem (PA), critique the main problems suggested by group members (PC) and manage group interactions (OO). The third phase was also 10 minutes long and had to be used to generate criteria (CD), which can be used to assess the suggested solutions to come, as well as to manage group interactions (OO). It was only after 35 minutes that solution development utterances (SD) and solution evaluation utterances (SE) should have occurred. Along with orientation utterances, the rest of the discussion (45 minutes) had to be devoted to suggesting solutions and evaluating them using the criteria created in phase 3.

3.4.1.4 Measure 4: Challenge

Vygotsky's understanding of challenge or struggle in learning is one of the cornerstones of FL (discussed in paragraph 2.10). In order to rate the amount of challenge perceived by a group, the following procedure was followed:

- Directly after the group discussion participants were required to answer an online questionnaire. The question in the questionnaire

asked participants to rate the level of difficulty of the experiment on a scale from 1 (easiest) to 10 (most difficult).

3.4.1.5 Overall learning quality measure

In order to get the overall learning quality measure of a group, these results (variables) obtained first needed to be normalised. I investigated three popular normalisation methods in measurement theory namely: standardisation, rescaling variables and using an ordinal scale. My investigation led me to the following conclusions for each one of these theories:

- Standardisation: The learning quality results would be comparable if each result were to be converted to a standardised value (also referred to as a z-score). However, these z-scores will in themselves only be an indication of the position of each learning quality in relation to the mean of all the standardised values. In this study, this would decrease the readability of the groups' performance according to learning quality measures as these z-scores would have to be first interpreted to understand their true meaning.
- Rescaling variables: By rescaling the learning quality measures to be on the same scale, one could conduct a comparison and still have an output that is suitably descriptive of the performance of the groups in terms of the learning quality measures. However, the formula used to rescale variables is problematic in terms of Measure 1: Participation in-equity, where the smallest observed value is required (see the figure below):

$$Y = \left(\frac{X - X_{min}}{X_{range}}\right)n$$

Figure 3.9: The formula with which to convert variables to have the same lower and upper limits

This formula is problematic in terms of this study where a smaller standard deviation of a group is an indication of a higher quality of learning. Thus, the inversed nature of Measure 1 will not produce a correct scale when computed with the formula above.

- Using an ordinal scale: This allowed me to ignore any arbitrary numerical differences (due to the fact that the variables have different measurement properties) and instead show the underlying differences of the same measure in different groups. In effect, an ordinal scale will rank all 6 groups according to each of the learning measures, whereby the reader will be able to follow the performance of a group's measurement in terms of the other groups. Finally, the average ranked position of each measure relative to the other groups will be calculated for each group, producing a score indicating the performance of the group in all four measures. A low score would suggest that the group ranked high across all the learning measures. This process, where a group's ranking according to the four learning measures ultimately produces a global learning quality measure, will be presented in a step-wise manner during the presentation of the quantitative data analysis in the next chapter.

3.4.2 Qualitative data analysis

Data gathered by the focus group interviews were analysed using thematic analysis which is described by Braun and Clarke (2006, p. 79) as "a method for identifying, analysing and reporting patterns (themes) within data." For the data collected from each of the control and experimental groups (six groups in total), the following qualitative analysis was to be conducted:

- A thematic analysis of the transcribed focus group interview data.

For the data collected from the experimental groups (2 groups in total) in the second set of focus group interviews, the following analysis was to be conducted:

- A thematic analysis of the transcribed amended focus group interview data.

A summary of the data analysis to be used in this study is presented in the next paragraph.

3.4.3 Data analysis summary

The following table indicates the data analysis for this study, as well as the source and motivation for the analysis.

Table 3.10: Analysis strategies of collected data

Data source	Data Collection	Procedure to be used to collect the data	Reason for using the data collection procedure	Data analysis procedure
EXISTING RESEARCH AND CURRICULA	Literature review	An extensive literature study consisting of books, academic journals and curricula.	All research needs to be grounded within an existing theoretical framework in the literature.	A review of current literature
EXPERIMENT	Data collection set 1	Between-Subjects Design experiment consisting of 6 groups: • 2 experimental groups that received LTF. • 4 control groups that did not receive LTF.	An analysis of the quantitative data collected would indicate: • the participation equity per group; • the amount of time spent productively resolving the real-life challenge per group; • the extent to which the dialogue mirrors the ideal sequence of the FCS-steps as determined beforehand by the FOL.	Quantitative content analysis
	Data collection set 2	a. Online questionnaire	An analysis of the quantitative data collected in the questionnaire would indicate: • the individual perceived level of difficulty of the real-life challenge.	Statistical analysis
		b. Focus group interviews	An analysis of the qualitative data collected in the focus group interview would indicate: • how participants had experienced the experiment.	Thematic analysis
	Data collection set 3	An amended focus group interview where participants read out their utterances.	An analysis of the qualitative data collected would indicate: • how each LTF statement influenced the participants; • how the participants experienced the LTF in general.	Thematic analysis

3.5 Quality assurance: Data verification

3.5.1 Validity

Whether my research will be trusted by my peers will depend heavily on the extent that it is deemed to be valid. As stated by Maree (2010, p. 151):

> "For the results of an experiment to be trustworthy, the experiment should have a high degree of both internal and external validity."

Creswell (2014, p. 225) also states that "with all mixed methods studies, the researcher needs to establish the validity of the scores from the quantitative measures and to discuss the validity of the qualitative findings." An immediate threat to the validity of my quantitative phase is the small sample size. However, as with the case of the similarly small study of Donelan and Kear (2018, p. 51), my sample "may therefore not be representative of the cohort as a whole", but in terms of the total number of learners enrolled for this subject, it is a whole cohort sample. In addition, I hope that by providing rich, in-depth qualitative data I will reach a point of data saturation, thereby allowing me to truthfully answer my research question. It should also be noted that the aim of my quantitative data analysis is to primarily rank the participants within this research according to the identified learning quality measures. The qualitative data used to understand these rankings can be extrapolated to other similar contexts. To summarise: although the small sample size will not be accepted towards statistical generalisability, its contribution may be valuable for indicative interpretive possibilities together with the qualitative data. As was the case with Kapur's (2008) research, I validated my authentic real-life challenge by consulting with two teachers who were familiar with the Technology curriculum. I also first piloted the authentic real-life challenge, adjusting the experiment based on my findings.

To increase the validity of the experiment, participant 'blinding' was also present. 'Blinding' refers to a "control procedure that reduces bias by ensuring that data collectors and/or research participants do not have information that distorts perceptions or influences behaviour" (Suter, 2019, p. 188). In the case of this research, all the discussion groups will see that a facilitator of learning is part of

their discussion group. At the start of the experiment, it will be stated that the facilitator of learning will make contributions to groups if needed, but they are not allowed to initiate communication with the facilitator of learning. Thus, all groups were under the impression that the facilitator of learning may at any time comment in their group, without realising that there are in fact only two experimental groups receiving facilitation. Conversely, the facilitated groups assumed that all the other groups were receiving an equal amount of facilitation and thus the participants were effectively 'blind' to the existence of control and experimental groups in this study.

Another concern in terms of the experiment is the required skill of the facilitator of learning to know how to facilitate. As my colleague (who facilitated the second experimental group) had only cursory knowledge of FL or LTF, we decided to conduct multiple training sessions where we looked through transcribed dialogues of learners attempting to resolve a real-life challenge. We then discussed the utterances of the learners and identified which LTF statements would have been appropriate at different stages of the dialogue. In this manner we effectively role played LTF until we were comfortable that my colleague had attained the necessary sensitivity. Analysis of and reflection on the efficiency of the LTF pilot phase also helped us to adequately prepare for our roles in the experiment.

Maree identifies several other general threats to the internal and external validity of a study (Maree, 2010, p. 151). These threats are listed and discussed in the table below:

Table 3.11: Threats to the quantitative results of the study

Threat	Discussion	Pre-emptive measure
Selection	The specific participants can influence the results.	I will adequately describe the research site and population.
Pre-testing	The pre-test itself may influence the results.	I replaced pre-testing with a metalearning activity.
Instrumentation	Changes in the instruments used can lead to varying results.	All instrumentation (including the act of LTF by facilitators of learning) will be piloted and analysed. The same instrumentation will be used in all instances of the experiment.
Selection bias	If the experimental and control groups are not similar, it becomes difficult to compare the results of a post-test.	Ensure that groups are as homogenous as possible.
Mortality	With time there may be a loss of participants.	I will make sure to indicate any attrition that took place in the study and account for this in my data analysis.
Insufficient realism	This refers to a study where the sample does not reflect the general population. It is countered by having a large enough sample in relation to the general population participating in the study.	As this is an exploratory mixed method research, the aim is not to produce data that can be generalised to the wider population. Instead, an in-depth analysis of a specific case study might shed light on a phenomenon. Findings may be applied to similar contexts.
Demand effect	The participants may anticipate what the researcher expects of them and alter their behaviour accordingly.	I will not explicitly state how learning quality will be measured.

Even with the presence of blinding and a high level of similarity present in this research, the absence of a pre- and post-test as well as the small sample size challenged the validity of this study. Thus my research data was limited in terms of the extent of the statistical inferences to be drawn from the data and generalisation to a wider populace. The data generated by this research was, however, enough to credibly and truthfully answer sub-research questions that may be applicable to cases of similar contexts. Whereas validity generally refers to quantitative research, in terms of qualitative research one must ascribe to trustworthiness and credibility.

3.5.2 Trustworthiness and credibility

I hoped to achieve a sufficient level of trustworthiness and credibility by giving a clear and honest account of the study and experiment. It was also important to clearly communicate the methods that were used in order to "establish the credibility" (Cutcliffe, 1999, p. 379) of my data. I endeavoured to achieve internal validity by using the following strategies classified by Merriam (1998):

- Ensuring crystallisation by using several sources and methods to compare findings to one another;
- Doing member checks where my understanding of data is verified with the respondents of the study – especially in the case of the reflective interviews conducted with the two experimental groups;
- Using peer examination, where I solicited my colleagues' opinions on this study. This was especially important when coding the experiment data. As suggested by Creswell (2014) where multiple people will code the data, cross-checking needs to take place to ensure an "agreement at least 80% of the time" (2014, p. 203);
- Clearing research bias through explaining my own ontological and epistemological views at the start of the research, as well as my research background and rationale for this study.

In addition to the strategies, I also paid heed to the criteria suggested by Siegle (2014), as listed below:

Table 3.12: Guidelines to ensure the trustworthiness of qualitative data

CRITERIA		SUB-COMPONENTS	PRESENCE IN THIS STUDY
Trustworthiness and data verification	Credibility (what is the truth value)	Crystallisation (different points of view on the same phenomenon)	Quantitative measures were explained by thematic analysis of quantitative data obtained from questionnaires, semi-structured interview transcripts and transcripts of reflections done by experimental groups.
		Referential adequacy (to what extent are the raw materials available that document these findings?)	• Proposal document for defence available on appendix memory stick. • Drafts moderated by promoter available on appendix memory stick. • All referenced journals available on appendix memory stick. • Voice recordings of interviews available on appendix memory stick. • Questionnaire results available on appendix memory stick. • Transcribed interviews available on appendix memory stick. • Transcribed reflections done by experimental groups available on appendix memory stick. • Thematic analysis on transcribed data available on appendix memory stick. • Quantitative data analysis available on appendix memory stick.
		Member checks (go to the source of the information and check the data and the interpretation)	• Written notes were read back to interviewees to confirm an accurate interpretation of what was said. • During the reflection of the experimental groups participants were asked to clarify certain utterances.
		Avoiding coding bias (ensure that the qualitative data is coded accurately)	• Two researchers coded transcriptions of interviews separately and then compared their findings, discussing instances where their interpretation of a specific utterance differed. This process was then repeated with the next interview up until the point where their percentage of agreement was 80%.

	Transferability (applicability)	The findings of the research could be transferable to similar contexts.	• Other facilitators of learning may be able to use these participants' experiences as a starting point for the design of their own transformative learning programme.
	Researcher bias	By stating my assumptions, research rationale, research focus and problem statement beforehand, I hoped to address and overcome research bias.	• See Chapter 1.

I also had to ensure that the reader was always aware of how data under discussion was generated. With the completed design of my research and having discussed the criteria against which validity and truthfulness was measured, the ethical considerations of this study follows.

3.6 Ethical considerations

For my study to be conducted safely, I subscribed to the following principles:

- *voluntary participation* in research – implying that the participants may withdraw from the research at any time;
- *informed consent* – meaning that research participants must at all times be fully informed about the research process and purposes, and must give consent to their participation in the research;
- *safety in participation* – put differently, that the human respondents should not be placed at risk or harm of any kind, e.g., measures put in place to ensure the safety of learners being driven to a township.
- *privacy* – meaning that the *confidentiality* and *anonymity* of human respondents should be protected at all times;
- *trust* – which implies that human respondents will not be subjected to any acts of deception or betrayal in the research process or its published outcomes (Joubert, 2015).

I also provided all ethical documents for the research, including:

- a letter to the Department of Education with information regarding the research project;

- a letter to the principal of the school with a description of the research project;
- a letter given to the parents/guardians of the respondents of the study;
- a letter of assent given to learners, and finally
- the ethical approval application.

3.7 Possible contributions of the study

With the increase in popularity of online learning, it is more imperative than ever that the educational community critically evaluate the quality of online learning as compared to face-to-face learning. This study will hopefully succeed in translating my understanding of the highest quality of learning into the digital realm. By using the digitised nature of typed out conversations, I also hoped to add empirical data to the literature presenting an example of how we can attempt to measure learning quality in a way that is in line with a constructivist educational paradigm. Finally, I trusted that this study would illuminate the impact of LTF within an online environment which could spur on further research regarding the role of facilitators of learning conducting FL in an online environment.

3.8 The role of the researcher

A mixed method research design infers that as a researcher I had to be able to shift roles as required by a particular phase of the research. In the quantitative phase, I was required to maintain a neutral, objective stance regarding the data to be statistically analysed. During the qualitative phases, it was expected that I would subjectively 'swim in my data' and the phenomena to be studied in order to reach a point of data saturation (McMillan & Schumacher, 2010).

McMillan and Schumacher state that the researcher as fieldworker must choose a research role, which will be appropriate for the purpose of the study. Roles may vary in terms of the way in which a field worker's presence will affect the social system or the subject or respondents being studied (McMillan & Schumacher, 2010).

The actions that I foresaw myself taking in this study included:

- the creation of a literature study;
- setting up the experiment;
- conducting the experiment;
- preparing and conducting interviews;
- analysing collected data;
- drawing findings from the analysed data; and
- finally presenting the study in the form of a well laid out report.

In terms of the role of conducting the experiment, I had to decide how many experimental groups there would be and when the facilitator of learning would introduce an pedagogical intervention in the online group interaction. As previously described, since the facilitator of learning needs to have an expert understanding of the curriculum of a learning task (for accurate FL to be able to take place), it was not feasible to train more than one additional facilitator of learning to participate in the experiment. In the end, the experimental groups were facilitated by myself and another MakerSpace teacher. Being able to facilitate a maximum of two groups (one per facilitator), the rest of the groups were designated as control groups.

3.9 Delimiters of the study

The term “delimiter” (Maree, 2007, pp. 38-39) refers to a perceived boundary that I was aware of before conducting my research. I based the proposed boundaries of this research on the work of Patton, Swanson and Holton (Maree & Van Der Westhuizen, 2009, pp. 38-39), which is indicated in the table below:

Table 3.13: Delimiters of this research

DELIMITERS OF THIS RESEARCH	
Potentially limiting issue	**Delimiter**
Naturalistic enquiry	The experiment will only be conducted on one Grade 9 MakerSpace class.
Holistic perspective	As the participants in this research know me as their MakerSpace teacher, the threat of the 'Hawthorne effect' will be present which could have some influence on the social dynamics present in the experiment.
Reliable coding	As a subjective interpretation is required to code dialogue, two researchers will separately code the transcriptions and then compare their findings continually until their coded dialogue corresponds to the extent where it can be considered to be valid.
Dynamic systems	As the experiment is a once-off event, there will be no shift in the sample investigated.
Unique case orientation and context sensitivity	There may be environmental influences that affect the behaviour of participants during the experiment that I am not presently aware of.
Empathetic neutrality	As the experiment is presented to participants in the form of an exam session, participants will not be made uncomfortable by the fact that they are being observed.

By listing the delimiters for this research above, I aimed to increase the validity of this study and the trustworthiness of myself as researcher by acknowledging these shortcomings.

3.10 Conclusion

In this chapter the research design for this study was discussed. As this research required both quantitative and qualitative data to answer the main research question, a mixed method approach was selected. Studying the literature on mixed method designs, a Multiphase Partially Mixed Sequential Equal Status Design was identified and discussed, including the sample, data collection and data analysis tools. Threats to the usability of results produced by this research were also referred to in discussions on validity, credibility and trustworthiness. Having presented the research design by which the data was collected and analysed towards answering the main research question, additional 'dark matter' was illuminated in the visual metaphor representing this study as shown in Figure 3.10:

Figure 3.10: Galaxy Cluster MCS J0416.1-2403 with an indication of 50% dark matter (European Space Agency, 2015)

In the next chapter, the data produced by this research design is discussed.

CHAPTER 4: EMPIRICAL RESEARCH

4.1 Introduction

The aim of any research endeavour is to generate information that will answer a research question. This information must be distilled from data collected or generated in the field, which makes collected data the *raison d'être* of research. For this study, quantitative and qualitative data was collected and analysed within the framework of a Multiphase Partially Mixed Sequential Equal Status Method research design. However, the presentation of the data gathered in this experiment and its associated analysis in this chapter differs from the structure used in the previous chapter for a particular reason which is described in the next paragraph.

4.2 Data presentation

In the research design chapter, the data collection and the associated data analysis were presented in sequential order within the experiment as a whole. This was done to emphasise the relationship between the research design and the chronological sequence of the intervention (the professional practice of FL) as a means to provide clarity for the structure of the research design. However, in terms of this chapter, which contains the essence of the empirical research, the data and the associated analysis thereof was not necessarily presented according to the sequence indicated in the research design, but rather according to its purpose as described in this chapter. Also, the data itself is not contained in this chapter but in several appendixes with the necessary in-text citations , while some excerpts and/or representative sections of data was incorporated as orientation for reference in this chapter.

4.2.1 Quantitative data presentation

As indicated in the preceding chapters, this research was prompted by the work of Kapur, et al. (2007). He determined that learners' participation while resolving challenging problems in small chat groups on an online CSCL platform (like Microsoft Teams) was a measure of how well the groups are capable of such achievement. With similarity in purpose (the quality of the learning process) and

unit (small chat groups) to Kapur, et al. (2007), the first data that had to be collected was the raw data of the online interaction of the chat groups. The figure below is a screenshot of a computer screen depicting an excerpt of the online chat of a group:

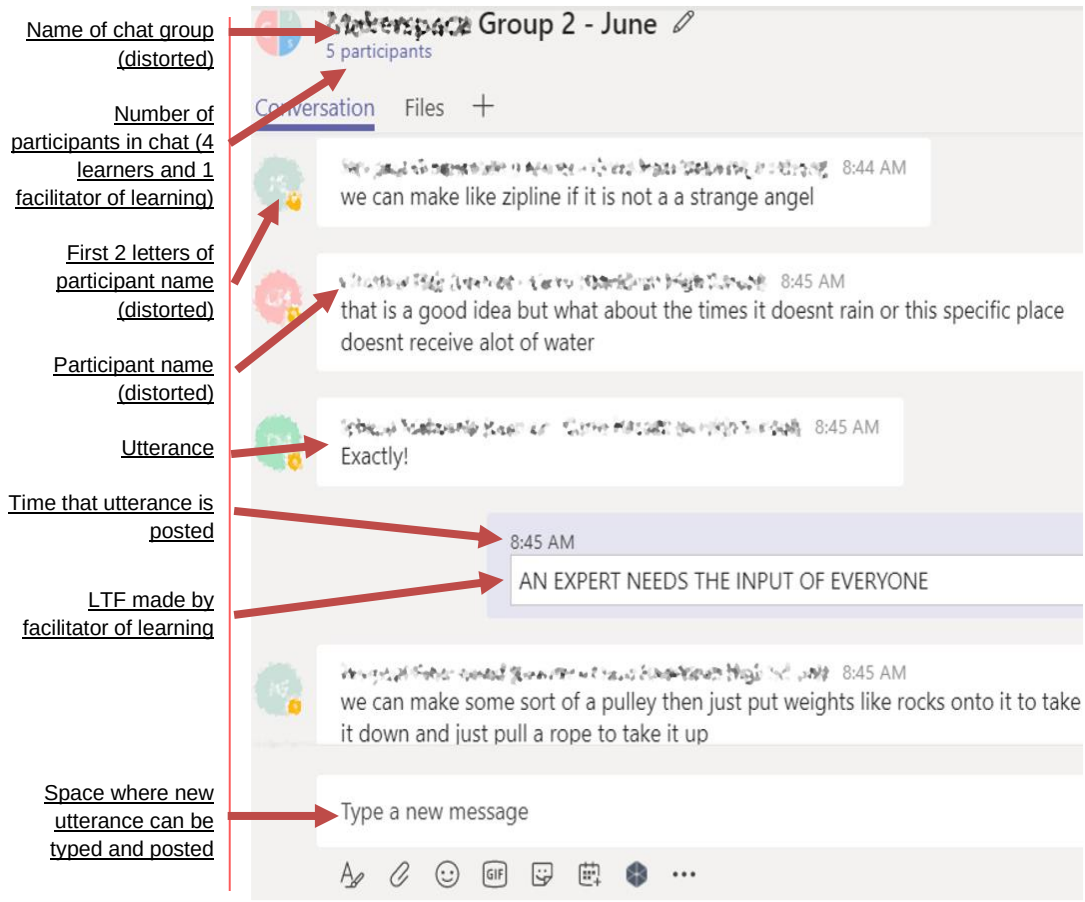


Figure 4.1: A screenshot of a computer screen during the experiment (private information has been distorted)

In Kapur's (2008) study quantitative data of a chat (which he had referred to as an 'interaction'), revealed that the learners' ***participation-inequity*** (indicated by the standard deviation between the individual contributions in the group) provided a measure of their communal problem-solving capability. Participation-inequity was, therefore, not only an attractive learning measure to use in my research, but also afforded corroboration between Kapur (2008) and my results in this regard. By capturing the utterances of the chat in a Microsoft Excel spreadsheet, I was able to ascertain the amount of utterances made per participant and consequently

determine the standard deviation. The data used to derive the participation-inequity measurement also allowed me to identify the three other quantitative measures with which I would measure the quality of learning in a chat.

The second quantitative measure was **productivity**, which was determined simply by counting the total number of utterances in a group over the time period of the chat (which was 80 minutes for all the groups) and finding the average time that elapsed between two consecutive utterances. The smaller this amount of seconds, the more productive the group was.

The third quantitative measure was **adherence** (to an assumed ideal utterance type schema). As indicated in the previous chapter, the classification of the functions of the problem-solving process, indicted by the work of Poole and Holmes (1995), was used to code the utterances. Every utterance was thus segmented into one or more units and coded with the problem-solving categories of Poole and Holmes (1995) as *a-priori* codes (PA: Problem Analysis; PC: Problem Critique; OO: Orientation; CD: Criteria Development; SD: Solution Development; SE: Solution Evaluation; NT: Non-Task). An excerpt of this coding process is shown in Figure 4.2:

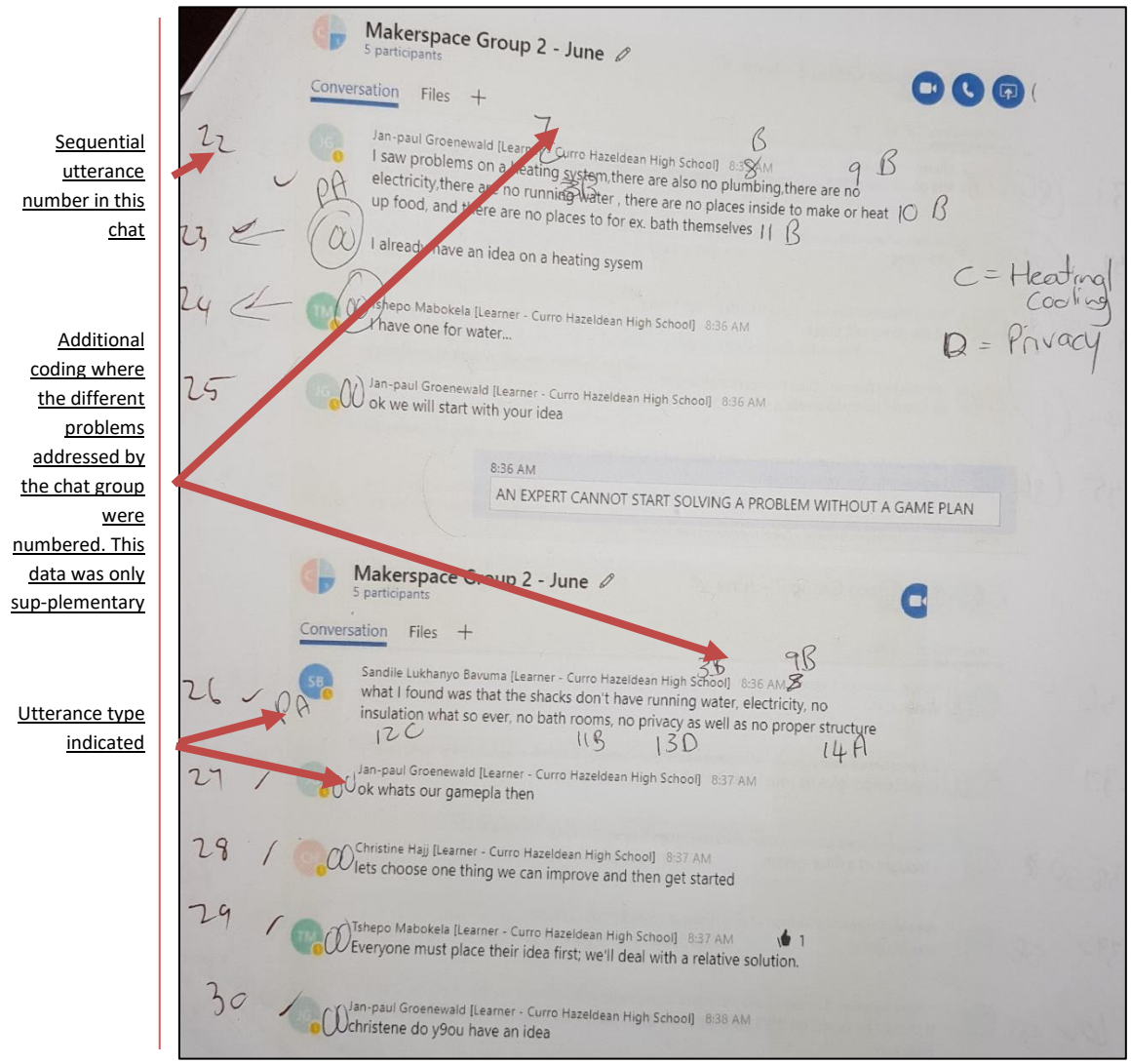


Figure 4.2: An example of a coded chat

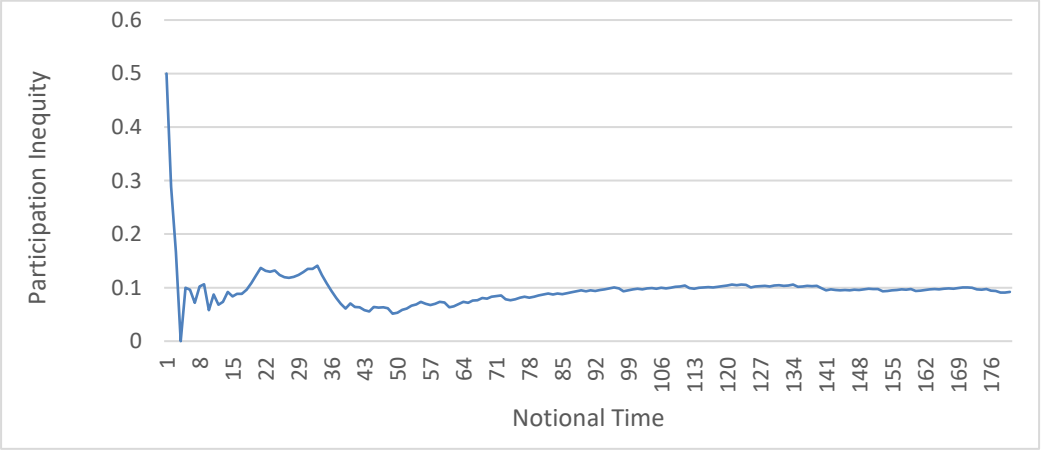
Since the chats were coded with pre-set codes this remained to be considered as quantitative data. However, beyond this coding consideration, this data is subjected to the same credibility and trustworthiness standards as any qualitative data. Coding the transcribed data in this study was challenging, as it required the researcher to interpret utterances based on the priori-coding scheme. However, Appendix A1 contains evidence of the efforts made to ensure a high degree of credibility and trustworthiness. As was the case with Kapur's (2007) study, in this study there were two researchers who independently coded the chat group interactions.

Initially, when the two researchers compared their coding, the comparison of the two sets of coding produced an alpha value of .70 (Appendix ZZ), which is an acceptable level of inter-reliability in Education Science (Keith, 2018). After discussing the disparities, the second chat was once again coded independently and discussed. A comparison of the second sets of coding produced an alpha value of .82 (Appendix ZZ), indicating a high level of correlation between the two coded transcripts. In order to increase the trustworthiness of the coded data presented in this chapter, examples of coding challenges can be found in Appendix A1_DetailedQuanDatasets. An example of the process that was followed can also be seen in Appendix AJ.

The fourth very important measure was **challenge**. More particularly the learners' perceived difficulty of the real-life challenge they had to resolve. In an online questionnaire where the participants had to reflect on their experiences of the experiment, the question asked them to indicate their perceived difficulty of the problem on a 10 point Likert Scale.

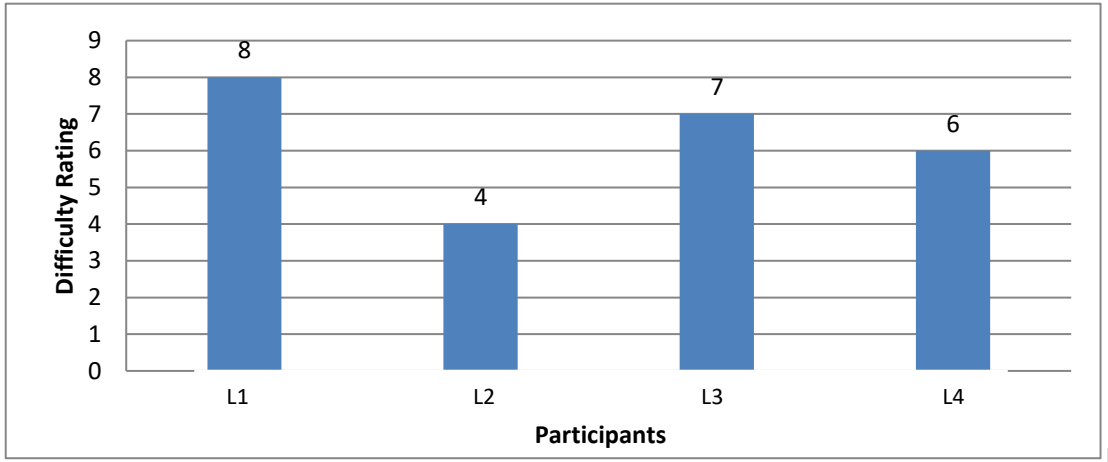
What is of critical importance, though, is that all the quantitative measures I used in this research ,as indicated above, eventually translates to the qualitative identity of the learning process, more or less in the same way that the quantitative SOLO (Structure of Observed Learning Outcome) Taxonomy of Biggs and Telfer (1993, pp. 177-181) translates into learning quality. Within that context the purpose was to eventually rank the groups into a quality ranking from highest to lowest. In addition, exploring correlations between the data captured in the Microsoft Excel sheet (using Excel formulas) produced an entire range of **additional quantitative data sets**. Although these additional data sets were not part of my formal research design, I have compiled them for exploratory purposes. These findings will, however, only be referenced if and when their contribution becomes appropriate and/or necessary. These additional data sets can be found in Appendix A1. The table below is a compilation of all the quantitative data sets indicated in the preceding paragraphs with the data from Control Group 2 used as a random illustrative example.

Table 4.1: Example of quantitative data sets that will be presented for each of the six groups in the experiment

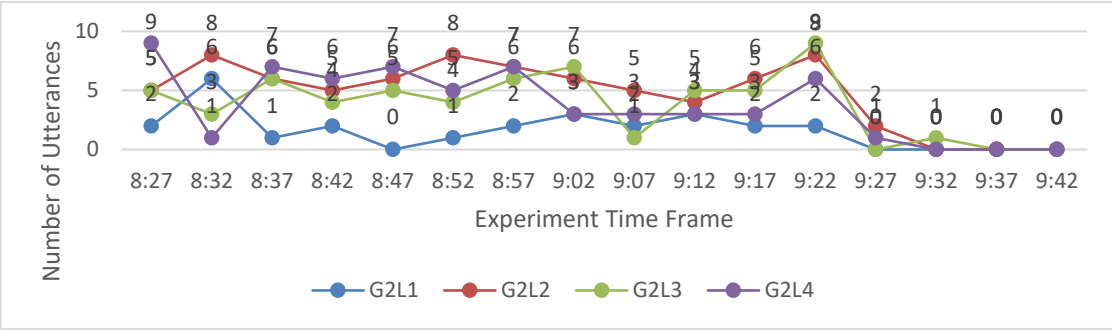
<table>
<tr><th>Data set no.</th><th>Title</th><th>Description</th><th>Data set</th></tr>
<tr><td colspan="4">Learning measures</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Measure 1:
Participation-inequity</td><td>Total amount of utterances per participant during chat.</td><td>KEY: L=Learner
<table><tr><td>PARTICIPANT</td><td>L1</td><td>L2</td><td>L3</td><td>L4</td></tr><tr><td>UTTERANCES</td><td>26</td><td>76</td><td>61</td><td>61</td></tr></table></td></tr>
<tr><td>Standard deviation of utterances between individuals during chat.</td><td>The standard deviation ranges between 0.5 (highest level of deviation for a group of 4 participants) and 0 (equal amount of utterances made by all participants).
The notational time indicates the accumulated utterances made by the group over time.
The standard deviation for the chat is indicated for every 6th utterance.
 
</td></tr>
</table>

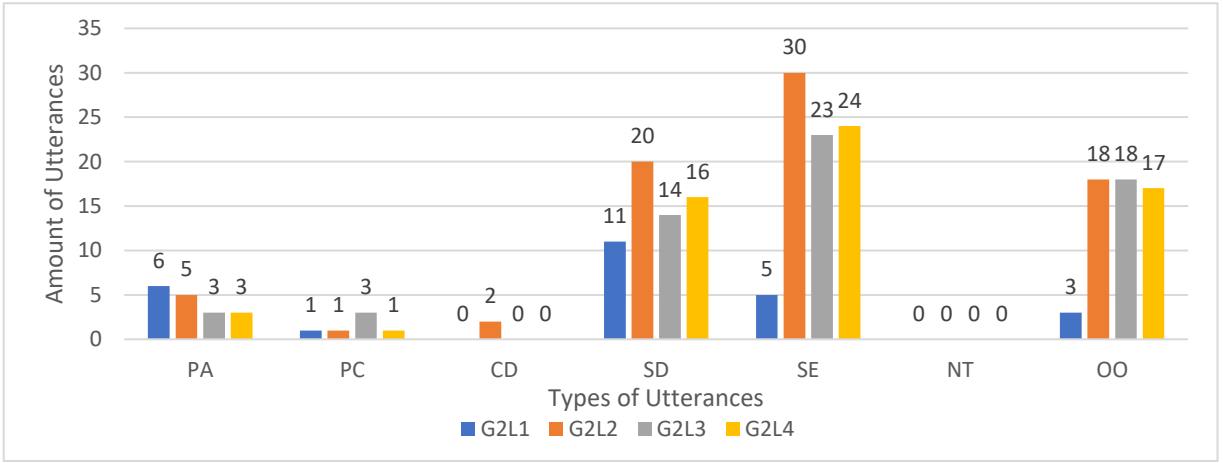
<table>
<tr>
<td>2</td>
<td>Measure 2:
Productivity</td>
<td>Group's productivity during chat.</td>
<td>
<table>
<tr><th colspan="3">Group productivity</th></tr>
<tr><th>Number of utterances made in chat</th><th>Number of available seconds in chat</th><th>Average amount of seconds between chats = unit of productivity</th></tr>
<tr><td>224</td><td>4800</td><td>21.42</td></tr>
</table>
</td>
</tr>
<tr>
<td>3</td>
<td>Measure 3:
Adherence</td>
<td>Measure of adherence to an ideal utterance schema.

The first column indicates four phases in which the chat is chronologically divided. For each phase different utterance types are expected (indicated in green). The amount of utterances present in the green cells indicate utterances that correlate with the ideal utterance schema.</td>
<td>
KEY: PA: Problem analysis; PC: Problem critique; CD: Criteria development; SD: Solution development; SE: Solution evaluation; NT: Non-task; OO: Orientation
<table>
<tr><th>Phase</th><th>Time</th><th>PA</th><th>PC</th><th>CD</th><th>SD</th><th>SE</th><th>NT</th><th>OO</th></tr>
<tr><td rowspan="3">Phase 1</td><td>8:27</td><td>3</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>18</td></tr>
<tr><td>8:32</td><td>14</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>8:37</td><td>0</td><td>6</td><td>0</td><td>5</td><td>1</td><td>0</td><td>8</td></tr>
<tr><td rowspan="2">Phase 2</td><td>8:42</td><td>0</td><td>0</td><td>0</td><td>6</td><td>10</td><td>0</td><td>1</td></tr>
<tr><td>8:47</td><td>0</td><td>0</td><td>1</td><td>5</td><td>11</td><td>0</td><td>1</td></tr>
<tr><td rowspan="3">Phase 3</td><td>8:52</td><td>0</td><td>0</td><td>1</td><td>1</td><td>15</td><td>0</td><td>1</td></tr>
<tr><td>8:57</td><td>0</td><td>0</td><td>0</td><td>8</td><td>11</td><td>0</td><td>3</td></tr>
<tr><td>9:02</td><td>0</td><td>0</td><td>0</td><td>4</td><td>11</td><td>0</td><td>4</td></tr>
<tr><td rowspan="9">Phase 4</td><td>9:07</td><td>0</td><td>0</td><td>0</td><td>7</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>9:12</td><td>0</td><td>0</td><td>0</td><td>6</td><td>9</td><td>0</td><td>0</td></tr>
<tr><td>9:17</td><td>0</td><td>0</td><td>0</td><td>6</td><td>4</td><td>0</td><td>6</td></tr>
<tr><td>9:22</td><td>0</td><td>0</td><td>0</td><td>10</td><td>8</td><td>0</td><td>7</td></tr>
<tr><td>9:27</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>2</td></tr>
<tr><td>9:32</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>9:37</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>9:42</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr><td>4</td><td>Measure 4:
Challenge</td><td>Difficulty rating indicated per participant.</td><td>Participants were asked to rate the level of difficulty on a scale between 0 and 10
KEY: L=Learner
 

r</td></tr>
<tr><td colspan="4">Additional Quantitative Data Sets</td></tr>
<tr><td>5</td><td>Amount of utterance types</td><td>Table indicating the total amount of utterance types in a chat.</td><td>KEY: PA: Problem analysis; PC: Problem critique; CD: Criteria development; SD: Solution development; SE: Solution evaluation; NT: Non-task; OO: Orientation
<table>
<tr><th>Utt. Type</th><th>Total Amount</th></tr>
<tr><td>PA</td><td>17</td></tr>
<tr><td>PC</td><td>6</td></tr>
<tr><td>CD</td><td>2</td></tr>
<tr><td>SD</td><td>61</td></tr>
<tr><td>SE</td><td>82</td></tr>
<tr><td>NT</td><td>0</td></tr>
<tr><td>OO</td><td>56</td></tr>
</table></td></tr>
</table>

<table>
<tr>
<td>6</td>
<td>Number of utterances per participant over course of chat (table)</td>
<td>Table indicating the number of utterances per participant per 5-minute interval over the course of the chat.</td>
<td>KEY: L=Learner
<table>
<tr><th>Time</th><th>L1</th><th>L2</th><th>L3</th><th>L4</th></tr>
<tr><td>8:27</td><td>2</td><td>5</td><td>5</td><td>9</td></tr>
<tr><td>8:32</td><td>6</td><td>8</td><td>3</td><td>1</td></tr>
<tr><td>8:37</td><td>1</td><td>6</td><td>6</td><td>7</td></tr>
<tr><td>8:42</td><td>2</td><td>5</td><td>4</td><td>6</td></tr>
<tr><td>8:47</td><td>0</td><td>6</td><td>5</td><td>7</td></tr>
<tr><td>8:52</td><td>1</td><td>8</td><td>4</td><td>5</td></tr>
<tr><td>8:57</td><td>2</td><td>7</td><td>6</td><td>7</td></tr>
<tr><td>9:02</td><td>3</td><td>6</td><td>7</td><td>3</td></tr>
<tr><td>9:07</td><td>2</td><td>5</td><td>1</td><td>3</td></tr>
<tr><td>9:12</td><td>3</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td>9:17</td><td>2</td><td>6</td><td>5</td><td>3</td></tr>
<tr><td>9:22</td><td>2</td><td>8</td><td>9</td><td>6</td></tr>
<tr><td>9:27</td><td>0</td><td>2</td><td>0</td><td>1</td></tr>
<tr><td>9:32</td><td>0</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>9:37</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>9:42</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table></td>
</tr>
<tr>
<td>7</td>
<td>Number of utterances per participant over course of chat (graph)</td>
<td>Graph indicating the number of utterances per participant per 5-minute interval over the course of the chat.</td>
<td>KEY: GL=Code used to uniquely identify participants

</td>
</tr>
</table>

<table>
<tr>
<td>8</td>
<td>Number of utterance types made per participant during chat (table)</td>
<td>Table indicating the number of utterance types made by each participant during the chat.</td>
<td>KEY: L=Learner; PA: Problem analysis; PC: Problem critique; CD: Criteria development; SD: Solution development; SE: Solution evaluation; NT: Non-task; OO: Orientation
<table>
<tr><th>Utt. Type</th><th>L1</th><th>L2</th><th>L3</th><th>L4</th></tr>
<tr><td>PA</td><td>6</td><td>5</td><td>3</td><td>3</td></tr>
<tr><td>PC</td><td>1</td><td>1</td><td>3</td><td>1</td></tr>
<tr><td>CD</td><td>0</td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>SD</td><td>11</td><td>20</td><td>14</td><td>16</td></tr>
<tr><td>SE</td><td>5</td><td>30</td><td>23</td><td>24</td></tr>
<tr><td>NT</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>OO</td><td>3</td><td>18</td><td>18</td><td>17</td></tr>
</table>
</td>
</tr>
<tr>
<td>9</td>
<td>Number of utterance types made per participant during chat (graph)</td>
<td>Graph indicating the number of utterance types made by each participant during the chat.</td>
<td>KEY: GL=Code used to uniquely identify participants; PA: Problem analysis; PC: Problem critique; CD: Criteria development; SD: Solution development; SE: Solution evaluation; NT: Non-task; OO: Orientation


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<table>
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<td>10</td>
<td>Number of utterance types made per 5-minute interval (table)</td>
<td>Table indicating the number of utterance types made per 5-minute interval (table).</td>
<td>KEY: PA: Problem analysis; PC: Problem critique; CD: Criteria development; SD: Solution development; SE: Solution evaluation; NT: Non-task; OO: Orientation
<table>
<tr><th>Time</th><th>PA</th><th>PC</th><th>CD</th><th>SD</th><th>SE</th><th>NT</th><th>OO</th></tr>
<tr><td>8:27</td><td>3</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>18</td></tr>
<tr><td>8:32</td><td>14</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>8:37</td><td>0</td><td>6</td><td>0</td><td>5</td><td>1</td><td>0</td><td>8</td></tr>
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<tr><td>8:57</td><td>0</td><td>0</td><td>0</td><td>8</td><td>11</td><td>0</td><td>3</td></tr>
<tr><td>9:02</td><td>0</td><td>0</td><td>0</td><td>4</td><td>11</td><td>0</td><td>4</td></tr>
<tr><td>9:07</td><td>0</td><td>0</td><td>0</td><td>7</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>9:12</td><td>0</td><td>0</td><td>0</td><td>6</td><td>9</td><td>0</td><td>0</td></tr>
<tr><td>9:17</td><td>0</td><td>0</td><td>0</td><td>6</td><td>4</td><td>0</td><td>6</td></tr>
<tr><td>9:22</td><td>0</td><td>0</td><td>0</td><td>10</td><td>8</td><td>0</td><td>7</td></tr>
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<tr><td>9:32</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
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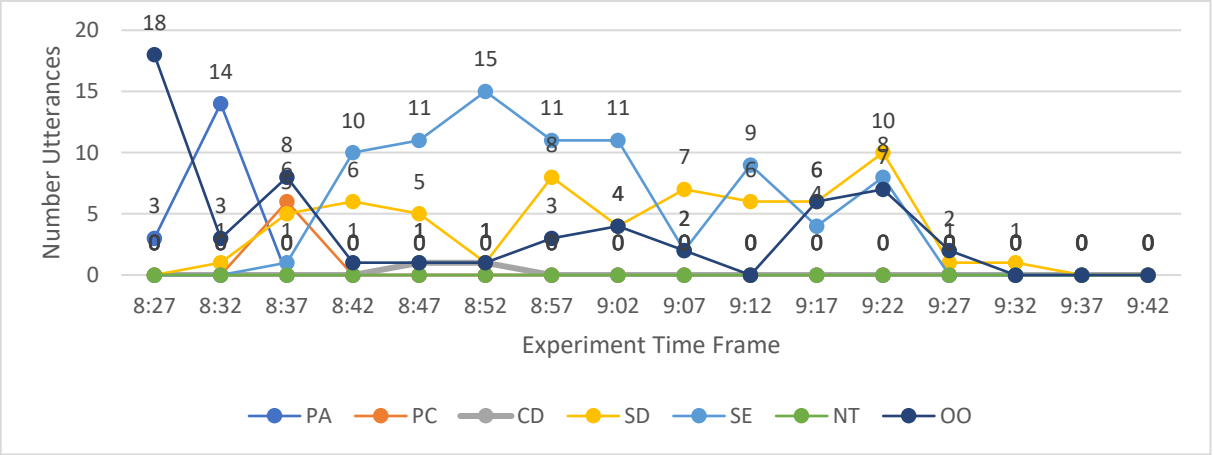
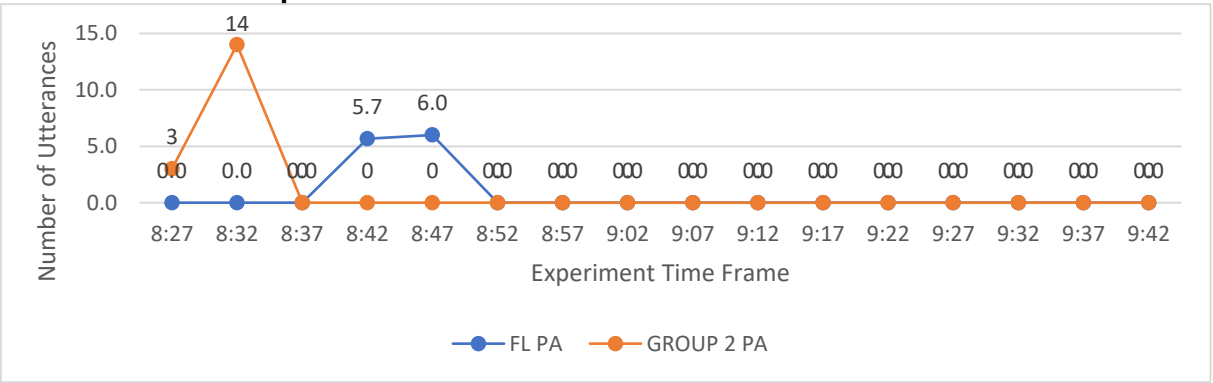
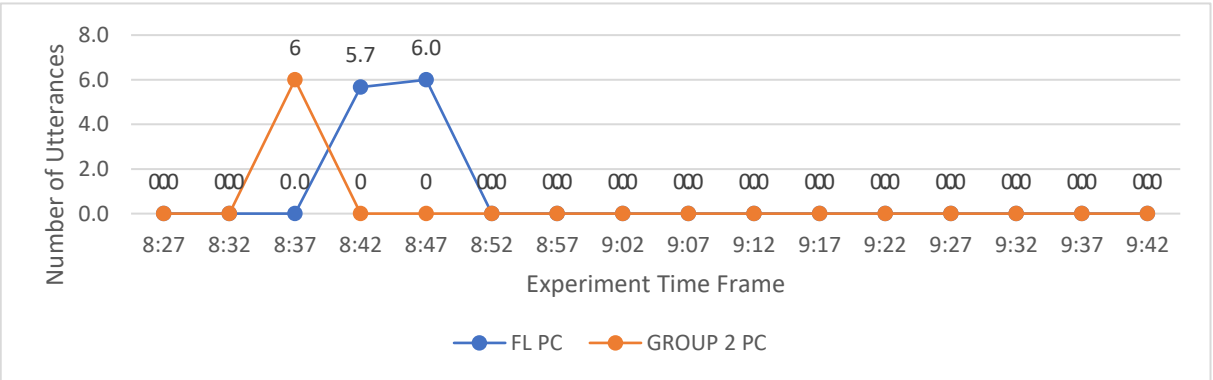
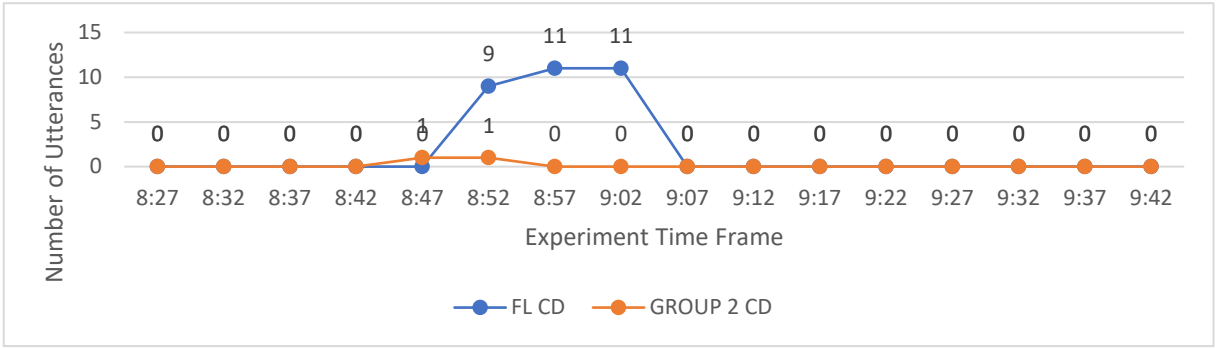
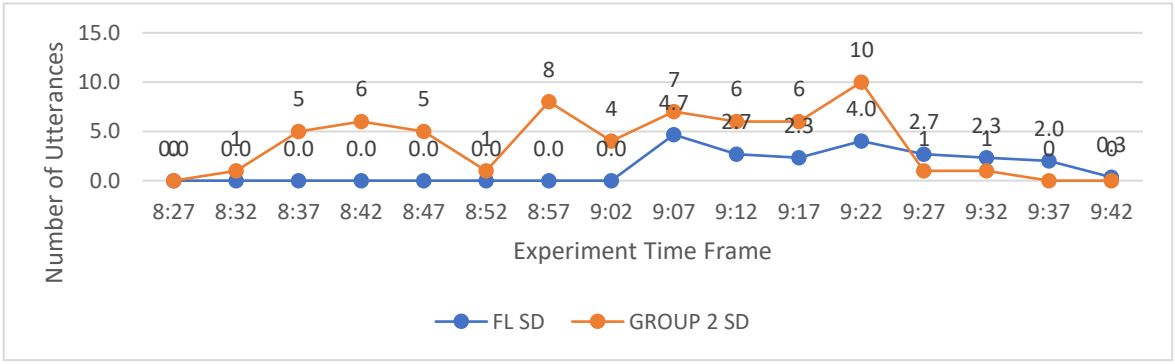
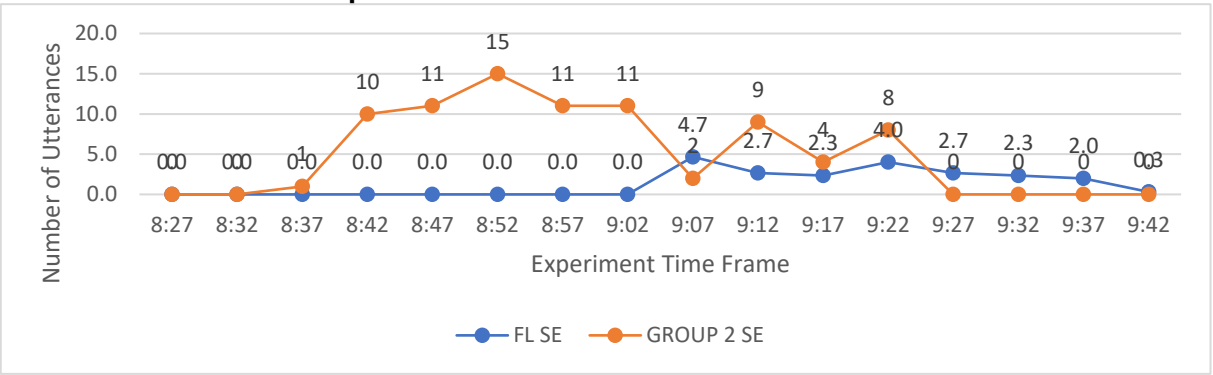
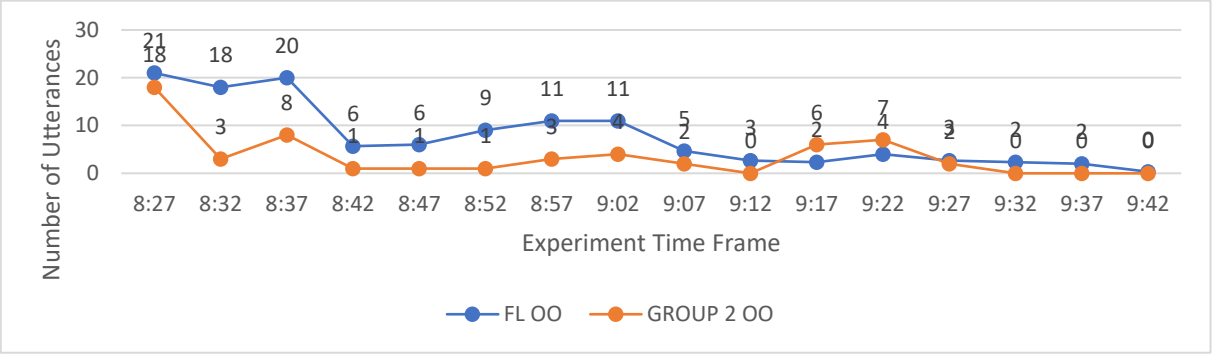
</table>
</td>
</tr>
<tr>
<td>11</td>
<td>Number of utterance types made per 5-minute interval (graph)</td>
<td>Graph indicating the number of utterance types made per 5-minute interval.</td>
<td>KEY: PA: Problem analysis; PC: Problem critique; CD: Criteria development; SD: Solution development; SE: Solution evaluation; NT: Non-task; OO: Orientation


</td>
</tr>
</table>

12	**Adherence: PA**	Graph indicating the measure of adherence for utterance type PA.	**KEY: FL PA: Facilitators Problem Analysis – the ideal PA graph expected by the Facilitator Of Learning** **GROUP 2 PA: Group 2 Problem Analysis – the actual PA graph as indicated in the data collected from Group 2's chat** 
13	**Adherence: PC**	Graph indicating the measure of adherence for utterance type PC	**KEY: FL PC: Facilitators Problem Critique – the ideal PC graph expected by the Facilitator Of Learning** **GROUP 2 PC: Group 2 Problem Critique – the actual PC graph as indicated in the data collected from Group 2's chat** 

14	**Adherence: CD**	Graph indicating the measure of adherence for utterance type CD.	**KEY: FL CD: Facilitators Criteria Development – the ideal CD graph expected by the Facilitator Of Learning** **GROUP 2 CD: Group 2 Criteria Development – the actual CD graph as indicated in the data collected from Group 2's chat** 
15	**Adherence: SD**	Graph indicating the measure of adherence for utterance type SD.	**KEY: FL SD: Facilitators Solution Development – the ideal SD graph expected by the Facilitator Of Learning** **GROUP 2 SD: Group 2 Solution Development – the actual SD graph as indicated in the data collected from Group 2's chat** 

16	**Adherence: SE**	Graph indicating the measure of adherence for utterance type SE.	**KEY: FL SE: Facilitators Solution Evaluation – the ideal SE graph expected by the Facilitator Of Learning** **GROUP 2 SE: Group 2 Solution Evaluation – the actual SE graph as indicated in the data collected from Group 2's chat** 
17	**Adherence: OO**	Graph indicating the measure of adherence for utterance type OO.	**KEY: FL OO: Facilitators Orientation – the ideal OO graph expected by the Facilitator Of Learning** **GROUP 2 OO: Group 2 Solution Evaluation – the actual OO graph as indicated in the data collected from Group 2's chat** 

Where the quantitative measures are designed to determine the quality of learning in the chat groups, the qualitative data in this research aims to understand these quantitative results.

4.2.2 Qualitative data presentation

Not only did the qualitative data provide corroboration of the quantitative data, but it also provided a clearer and deeper explication of such corroboration into the quality of the learning process on a CSCL online platform within a MakerSpace environment. There are two sets of qualitative data to be presented and analysed. The first is semi-structured focus group interviews on the participants' experiences of the experiment of both the experimental and control groups. The second is specifically amended semi-structured focus group interviews with only the experimental groups, as only they will be able to provide deeper insight into the experience of having the additional intervention of LTF by the FOL, of which the sole purpose is to improve the quality of the learning process.

The steps that I followed in order to accomplish this analysis are listed below:

1. I transcribed the semi-structured interviews of each group (Appendix Y).
2. Per group I read through the transcribed interviews and identified emerging themes. As sentences/phrases were linked to themes, I grouped these sentences and phrases according the themes (Appendix Y).
3. I sorted these sentences/phrases according to themes across all six groups (Appendix Y).
4. I grouped all the themes into broader categories, ending up with six main themes (Appendix Z).
5. Finally, I compiled a combination of the aggregated set of themes of the open questionnaire questions with the semi-structured interview transcriptions across all six groups for each of the six themes.

4.2.3 Overview of the data presentation with its accompanying data analysis

The table below provides an overview of the presentation of the data as explained above with its accompanying analysis as it appeared in this chapter and associated appendixes.

Table 4.2: Presentation of the data and its accompanying analysis

Mode of enquiry	Data collected (from participants in the different small experimental and control groups)	Reason for data collection	Data analysis
Quantitative	Number of participatory utterances of each individual in each group over experiment time	**Measure 1** Participation-inequity	Standard deviation between the number of participatory utterances of individuals in the group
	Total number of participatory utterances over experiment time	**Measure 2** Productivity	Average amount of time between two consecutive participatory utterances
	Correlation between utterance types in chat and ideal utterance type scheme	**Measure 3** Adherence (to the ideal utterance type schema)	Utterances that correlate to the ideal utterance schema are added. This amount is then divided by the total amount of utterances in order to produce an adherence percentage
	Open ended online questionnaire – some answers to be provided on a 10-point Likert Scale	**Measure 4** Difficulty (of challenge to be resolved)	Level of difficulty per participant in each group translated into a bar graph
	Additional quantitative data sets	To be utilised if and when its contribution is appropriate and/or necessary	Microsoft Excel data sheets presented as various tables, ordinary graphs and bar graphs
Qualitative	Semi-structured focus group interviews with all groups	Determine participants' experiences of the experiment	The interviews are transcribed and coded for thematic analysis

	Amended semi-structured focus group interviews with experimental groups only	Determine participants' experiences of LTF of the FOL of the experiment	The interviews are transcribed and coded for thematic analysis

By explaining how the data will be presented in this chapter and showing examples of the data sets to be expected, it was my hope that the reader would now be sufficiently orientated to engage with the data analysis in the remainder of this chapter as it corresponds with the relevant data sets. The data analyses for each of the data sets indicated in Chapter 3 was the topic of the paragraphs that follow, starting with the quantitative and then the qualitative data analyses. The data analyses – quantitative and qualitative – was be provided for each of the six chat groups of the experiment.

4.3 Quantitative data analysis

The quantitative data analysis revolves around the four learning measures (participation in-equity, productivity, adherence and challenge) that were quantitatively established and summarised. The following summary is only an intermediate analysis to be used to eventually rank each of the chat groups according to their measure or level of learning quality.

4.3.1 Experimental Chat Group 1

a. Measure 1: Participation In-Equity

Experimental Chat Group 1 made an average of 56.7 utterances during the group chat. The total amount of utterances per participant for Experimental Chat Group 1 can be seen in the table below:

Table 4.3: Total amount of utterances per participant in Experimental Chat Group 1

PARTICIPANT	L1	L2	L3	L4
UTTERANCES	26	76	61	61

While two participants in Experimental Group 1 made the exact same amount of utterances, one participant made a significantly greater amount of contributions. Participant L1 was significantly quieter than the other participants. The average amount of utterances for Experimental Group 1 is 56, while the standard deviation is 21.21. The figure below shows the standard deviation for Experimental Chat Group 1:

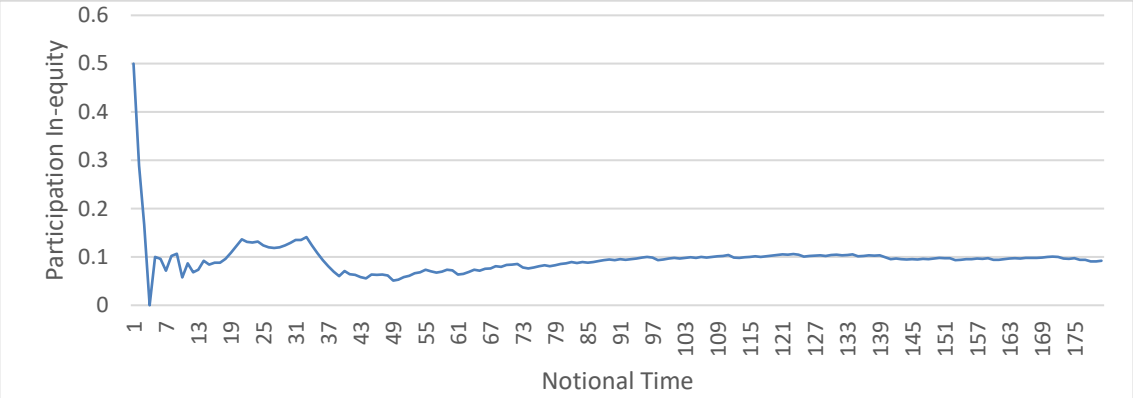


Figure 4.3: The standard deviation of Experimental Chat Group 1

Experimental Chat Group 1's standard deviation indicates that there was an initial phase where the in-equity rose significantly (Notational time 1-33). Thereafter the in-equity falls (Notational time 33-49), only to steadily rise again as time progresses (Notational time 49-177). Looking at the figure below, we see that these fluctuations in the standard deviation roughly follow the inversed movement of the utterances made by participant L1 (blue):

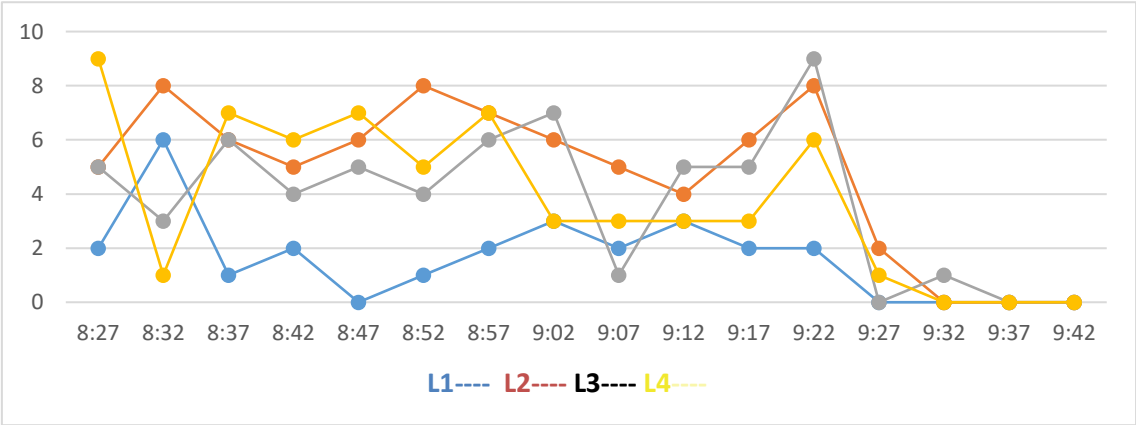


Figure 4.4: Amount of utterances made per participant in 5-minute intervals for Experimental Chat Group 1

When participant L1 refrains from taking part in the chat, the standard deviation rises. As L1 participates, the standard deviation falls. This is testimony to the influence of one member's participation towards the measurable level of in-equality in a group of 4 members.

b. Measure 2: Productivity

The productivity of Experimental Chat Group 1 is indicated in the table below:

Table 4.4: Productivity of Experimental Chat Group 1

Experimental Group 1's productivity		
Number of productive utterances made in chat	**Number of available seconds in chat**	**Productivity measure (Average amount of seconds between utterances)**
224	4800	21.42

This group has no Non-Task utterances. When the utterances of participants are added, the total amount of utterances made in this chat is 224. When 4800 seconds (number of seconds available during the 80 minute chat) is divided by 224, the answer is 21.42 seconds.

c. Measure 3: Adherence

The table below indicates which utterances made by the participants of Experimental Chat Group 1 were in line with the optimal utterances type distribution (indicated by the cells highlighted in green).

Table 4.5: Measure of adherence for Experimental Chat Group 1

Phase	Time	PA	PC	CD	SD	SE	NT	OO
Phase 1	8:27	3	0	0	0	0	0	18
	8:32	14	0	0	1	0	0	3
	8:37	0	6	0	5	1	0	8
Phase 2	8:42	0	0	0	6	10	0	1
	8:47	0	0	1	5	11	0	1
Phase 3	8:52	0	0	1	1	15	0	1
	8:57	0	0	0	8	11	0	3
	9:02	0	0	0	4	11	0	4

Phase 4	9:07	0	0	0	7	2	0	2
	9:12	0	0	0	6	9	0	0
	9:17	0	0	0	6	4	0	6
	9:22	0	0	0	10	8	0	7
	9:27	0	0	0	1	0	0	2
	9:32	0	0	0	1	0	0	0
	9:37	0	0	0	0	0	0	0
	9:42	0	0	0	0	0	0	0

Counting the total amount of utterances that fall within the green cells, indicates the following:

- 29 (18+3+8) utterances in the first phase correspond with the optimal distribution of utterance types;
- 2 (1+1) utterances in the second phase correspond with the optimal distribution of utterance types;
- 9 (1+1+3+4) utterances in the third phase correspond with the optimal distribution of utterance types and
- 71 (7+2+2+6+9+6+4+6+10+8+7+1+2+1) utterances in the fourth phase correspond with the optimal distribution of utterance types.

In total, 111 of the 224 utterances made by Experimental Chat Group 1 was in line with the optimal distribution of utterance types. This translates to an adherence rating of 49,5%.

d. Measure 4: Challenge

The difficulty rating per participant is indicated in the table below for Experimental Chat Group 1. Studying the questionnaire data for Experimental Chat Group 1, we see that their average difficulty level rating of the challenge is 6.25.

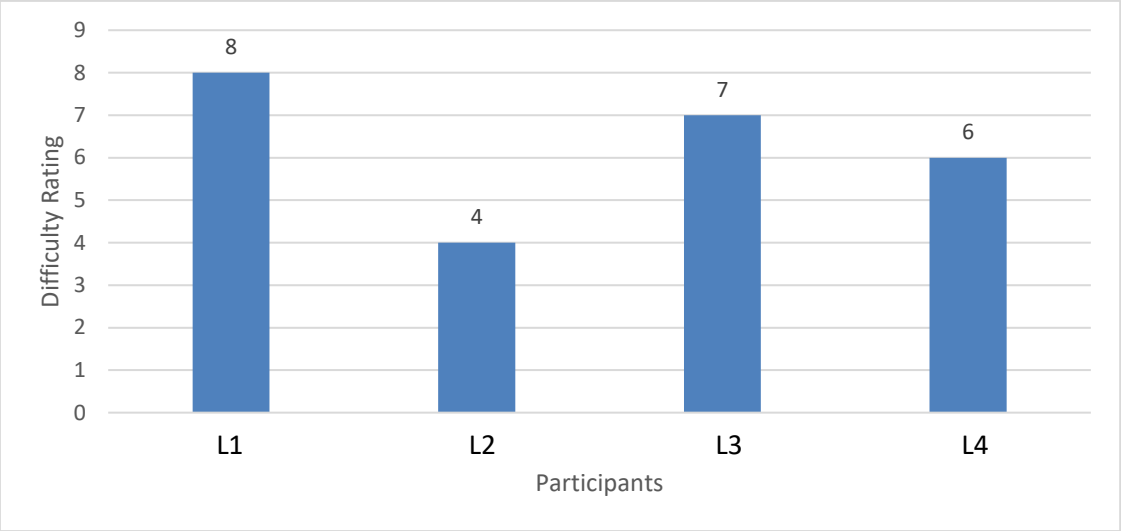


Figure 4.5: Experimental Chat Group 1's difficulty rating per participant

e. Learning quality

A summary of the learning quality findings for Experimental Group 1 can be seen in the table below:

Table 4.6: Measurement of analysed data for Experimental Chat Group 1 indicating learning quality

Measure	Finding
Measure 1: Participation In-equity	• The participation in-equity in the group (indicated by the standard deviation) is 21.21.
Measure 2: Productivity	• There were no Non-Task utterances within the given time-frame of the online chat. • On average they made an utterance every 21.42 seconds.
Measure 3: Adherence	• In total, 111 of the 224 utterances made by Experimental Chat Group 1 was in line with the optimal distribution of utterance types. • This translates to an adherence rating of 49,5%.
Measure 4: Challenge	• The average difficulty rating of the challenge was 6.25 out of a maximum amount of 10.

4.3.2 Experimental Chat Group 2

a. Measure 1: Participation In-Equity

Experimental Chat Group 2 made an average of 97.5 utterances during the group chat. The total amount of utterances per participant can be seen in the table below:

Table 4.7: Total amount of utterances per participant in Experimental Chat Group 2

Participant	L1	L2	L3	L4
Utterances	127	38	151	74

The amount of utterances made by participants in Experimental Chat Group 2 varied greatly (ranging from 38 to 151), which contributed to a high standard deviation of 51.07 for the group. The figure below shows the standard deviation for the group:

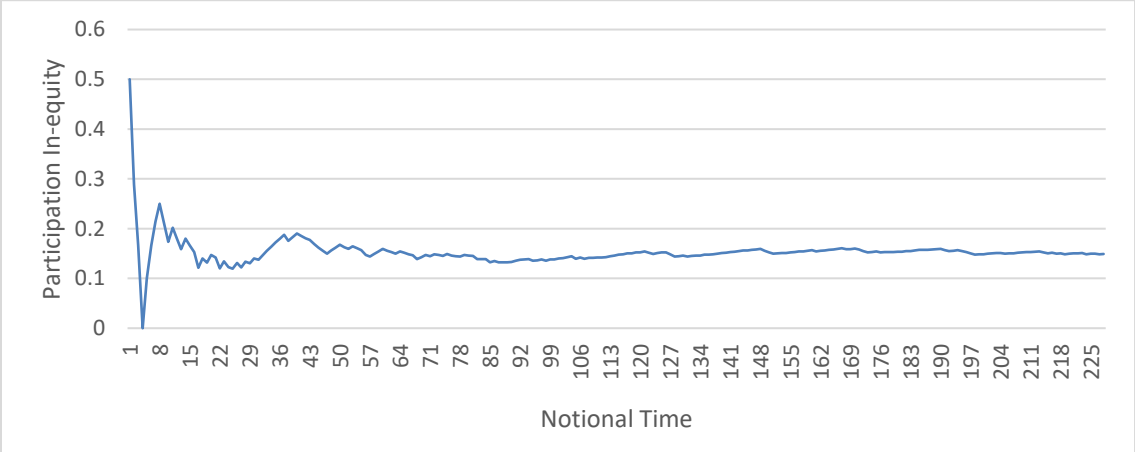


Figure 4.6: The standard deviation of Experimental Chat Group 2

Experimental Chat Group 2's graph indicates a standard deviation line that gradually climbs to 0.2 (Notational time 1-41) before it levels off. It is interesting to note that once the participation in-equity asserts itself in the group, it is quite consistent for the remainder of the chat (Notational time 49-225). This suggests that the comparatively high level of participation in-equity was maintained consistently for the duration of the chat.

b. Measure 2: Productivity

The table below gives us insight into the productivity of Experimental Chat Group 2's chat.

Table 4.8: Productivity of Experimental Chat Group 2

Experimental Chat Group 2's productivity		
Number of productive utterances made in chat	**Number of available seconds in chat**	**Productivity measure (Average amount of seconds between utterances)**
390	4800	12.3

This group has no Non-Task utterances. At the end of the chat, the total number of utterances is 390. In dividing 4800 with 390, the average amount of seconds between the posting of utterances is 12.3 seconds.

c. Measure 3: Adherence

The table below indicates which utterances made by the participants of Experimental Chat Group 2 were in line with the optimal utterances type distribution (indicated by the cells highlighted in green).

Table 4.9: Measure of adherence for Experimental Chat Group 2

Phase	Time	PA	PC	CD	SD	SE	NT	OO
Phase 1	8:27	0	0	0	0	0	0	26
	8:32	19	2	0	1	0	0	7
	8:37	5	1	0	5	5	0	1
Phase 2	8:42	1	0	0	4	10	0	3
	8:47	5	0	0	7	13	0	4
Phase 3	8:52	2	4	0	1	17	0	2
	8:57	1	1	0	4	15	0	4
	9:02	0	1	0	13	19	0	4
Phase 4	9:07	0	0	0	9	12	0	4
	9:12	0	0	0	9	1	0	18
	9:17	0	0	2	15	20	0	4
	9:22	0	0	1	6	5	0	2
	9:27	0	0	1	13	4	0	2
	9:32	0	0	1	9	7	0	1
	9:37	0	0	0	5	8	0	9
	9:42	0	0	0	4	1	0	10

When you count the total amount of utterances that fall within the green cells, you get the following:

- 34 (26+7+1) utterances in the first phase correspond with the optimal distribution of utterance types;
- 13 (1+3+5+4) utterances in the second phase correspond with the optimal distribution of utterance types;
- 10 (2+4+4) utterances in the third phase correspond with the optimal distribution of utterance types and
- 178 (9+12+4+9+1+18+15+20+4+6+5+2+13+4+2+9+7+1+5+8 +9+4+1+10) utterances in the fourth phase correspond with the optimal distribution of utterance types.

In total, 235 of the 390 utterances made by Experimental Chat Group 2 was in line with the optimal distribution of utterance types. This translates to a percentage of 60.2% for the measure of adherence.

d. Measure 4: Challenge

The difficulty rating per participant in Experimental Chat Group 2 is indicated in the table below:

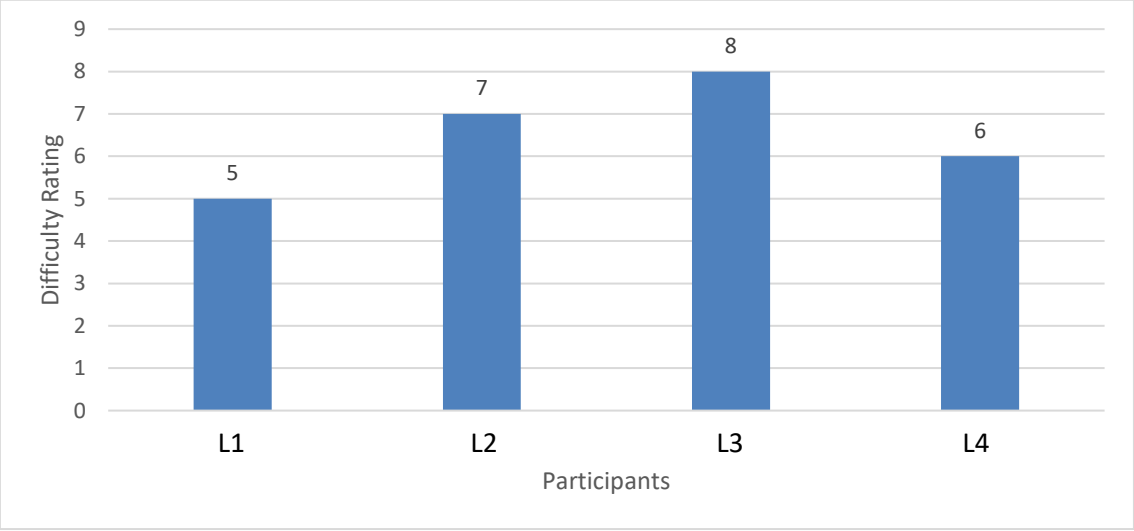


Figure 4.7: Experimental Chat Group 2 difficulty rating per participant

Studying the questionnaire data for Experimental Chat Group 2, we see that their average difficulty level rating of the challenge is 6.5.

e. Learning quality

A summary of the learning quality findings for Experimental Chat Group 2 can be seen in the table below:

Table 4.10: Measurement of analysed data for Experimental Chat Group 2 indicating learning quality

Measure	Finding
Measure 1: Participation In-equity	• The participation in-equity in the group (indicated by the standard deviation) is 51.07.
Measure 2: Productivity	• There were no Non-Task utterances within the given time-frame of the online chat. • On average they made an utterance every 12.3 seconds.
Measure 3: Adherence	• In total, 235 of the 390 utterances were in line with the optimal distribution of utterance types. • This translates to a percentage of 60.2% for the measure of adherence.
Measure 4: Challenge	• The average difficulty rating of the challenge was 6.5 out of a maximum amount of 10.

4.3.3 Control Chat Group 1

a. Measure 1: Participation In-Equity

Control Chat Group 1 made an average of 53.75 utterances during the group chat. The total amount of utterances per participant can be seen in the table below:

Table 4.11: Total amount of utterances per participant in Control Chat Group 1

Participant	L1	L2	L3	L4
Utterances	48	54	66	47

In the case of this chat, it was interesting to note that the standard deviation between L1, L2 and L4 was 3.78, which is relatively low and indicates that there was a relatively equal level of participation between these 3 learners. When you add L3 to the standard deviation formula, however, the standard deviation jumps to 8.73. This indicates that participant L3 contributed a significantly greater amount of utterances to the dialogue, than the other three participants. The figure below shows the average standard deviation for the group:

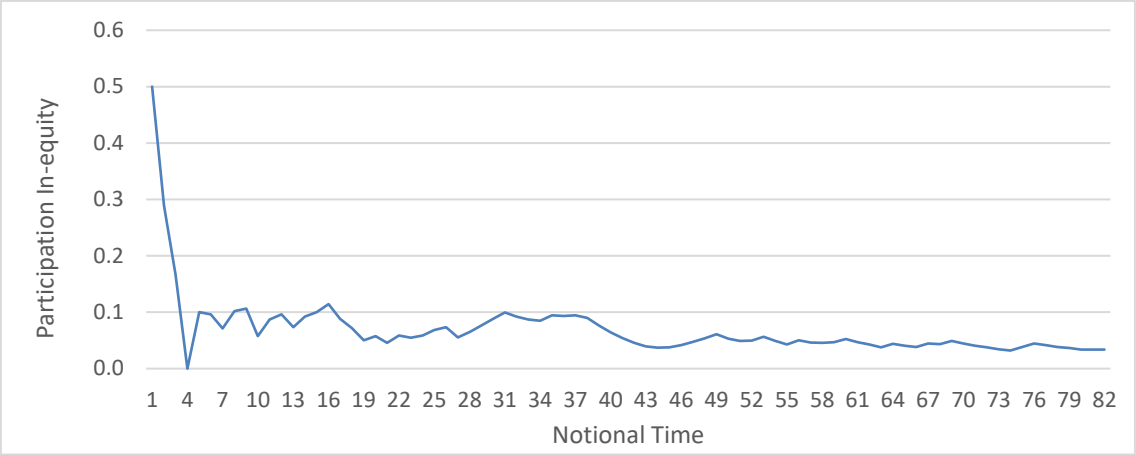


Figure 4.8: The standard deviation of Control Chat Group 1

b. Measure 2: Productivity

The table below shows the productivity of Control Group 1's chat:

Table 4.12: Productivity of Control Chat Group 1

Control Group 1's productivity		
Number of productive utterances made in chat	**Number of available seconds in chat**	**Productivity measure (Average amount of seconds between utterances)**
215	4800	22.32

As this chat has no Non-Task utterances, the 215 utterances of this chat can be used in its entirety to calculate productivity. The average amount of seconds between utterances is then 22.32 seconds.

c. Measure 3: Adherence

The table below indicates which utterances made by the participants of Control Chat Group 1 were in line with the optimal utterances type distribution (indicated by the cells highlighted in green).

Table 4.13: Measure of adherence: Control Chat Group 1

Phase	Time	PA	PC	CD	SD	SE	NT	OO
Phase 1	8:27	0	0	0	0	0	0	27
	8:32	9	1	0	0	0	0	1
	8:37	12	2	3	3	1	0	3

Phase 2	8:42	0	0	5	4	8	0	5
	8:47	0	0	0	5	5	0	3
Phase 3	8:52	0	0	1	8	4	0	5
	8:57	0	0	0	6	6	0	3
	9:02	0	0	2	8	11	0	1
Phase 4	9:07	0	0	0	7	5	0	2
	9:12	0	0	1	2	4	0	1
	9:17	0	0	0	4	2	0	1
	9:22	0	0	0	3	3	0	6
	9:27	0	2	0	4	1	0	1
	9:32	0	0	0	2	4	0	1
	9:37	0	0	0	3	2	0	1
	9:42	0	0	0	1	0	0	0

When you count the total amount of utterances that fall within the green cells, you get the following:

- 31 (27+1+3) utterances in the first phase correspond with the optimal distribution of utterance types;
- 8 (5+3) utterances in the second phase correspond with the optimal distribution of utterance types;
- 12 (1+5+3+2+1) utterances in the third phase correspond with the optimal distribution of utterance types and
- 60 (7+5+2+2+4+1+4+2+1+3+3+6+4+1+1+2+4+1+3+2+1+1) utterances in the fourth phase correspond with the optimal distribution of utterance types.

In total, 111 of the 215 utterances made in Control Chat Group 1 was in line with the optimal distribution of utterance types. This translates to a percentage of 51.6% for the measure of adherence of Control Chat Group 1.

d. Measure 4: Challenge

The difficulty rating per participant is indicated in the table below.

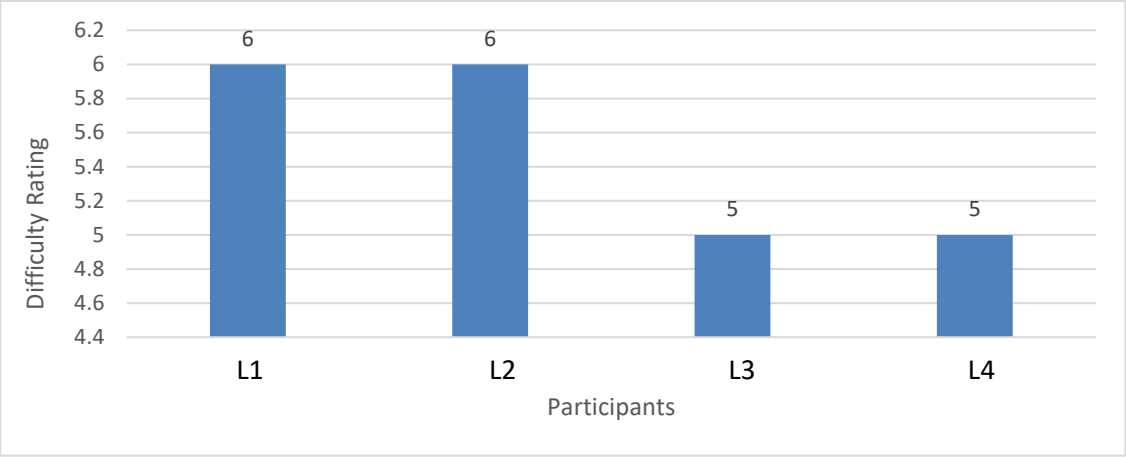


Figure 4.9: Control Chat Group 1's difficulty rating per participant

Studying the questionnaire data for Control Group 1, we see that their average difficulty level rating of the challenge is 5.5.

e. Learning quality

A summary of the learning quality findings for Control Chat Group 1 can be seen in the table below:

Table 4.14: Measurement of analysed data for Control Chat Group 1 indicating learning quality

Measure	Finding
Measure 1: Participation In-equity	• The participation in-equity in the group (indicated by the standard deviation) is 3.78.
Measure 2: Productivity	• There were no Non-Task utterances within the given time-frame of the online chat. • On average they made an utterance every 22.32 seconds.
Measure 3: Adherence	• In total, 111 of the 215 utterances made by Control Group 1 was in line with the optimal distribution of utterance types. • This translates to a percentage of 51.6% for the measure of adherence of Control Group 1.
Measure 4: Challenge	• The group rated the level of difficulty of the challenge to be 5.5 out of a maximum amount of 10.

4.3.4 Control Chat Group 2

a. Measure 1: Participation In-Equity

Control Chat Group 2 made an average of 41.25 utterances during the group chat. The total amount of utterances per participant can be seen in the table below:

Table 4.15: Total amount of utterances per participant in Control Chat Group 2

Participant	L1	L2	L3	L4
Utterances	39	42	18	66

The amount of utterances made by participants in Control Chat Group 2 ranged between 18 and 66, delivering a standard deviation of 19.65 for the group. The figure below shows the average standard deviation for Control Chat Group 2:

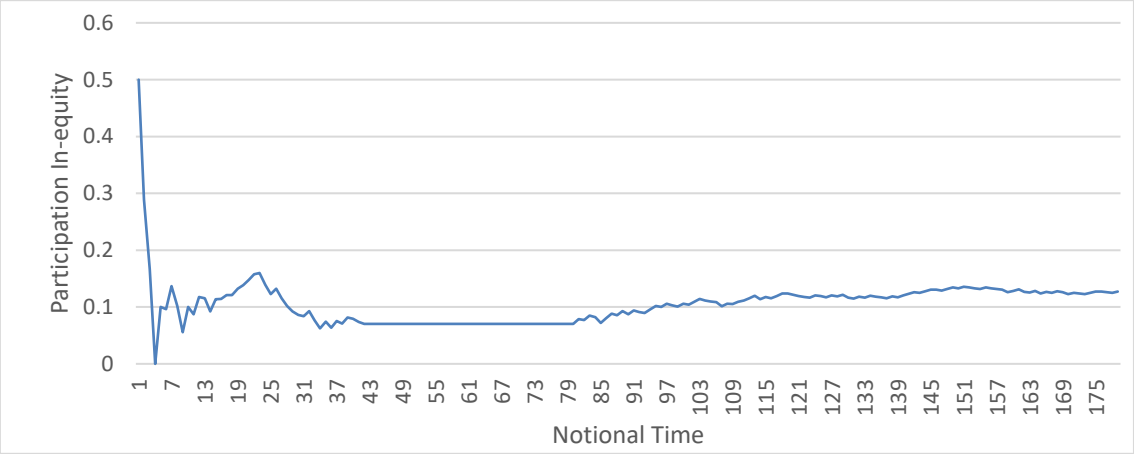


Figure 4.10: The average standard deviation of Control Chat Group 2

Control Chat Group 2's graph indicates a standard deviation line that climbs (Notational time 78-176) as the chat continues. This can be contributed to the contrast between one participant (G4L4), who contributed a significantly greater amount of utterances than the average amount of utterances as the chat progressed and another participant (G4L3), who contributed a significantly lower number of utterances as the chat progressed. The flow of utterances in Control Chat Group 2 is indicated in the figure below:

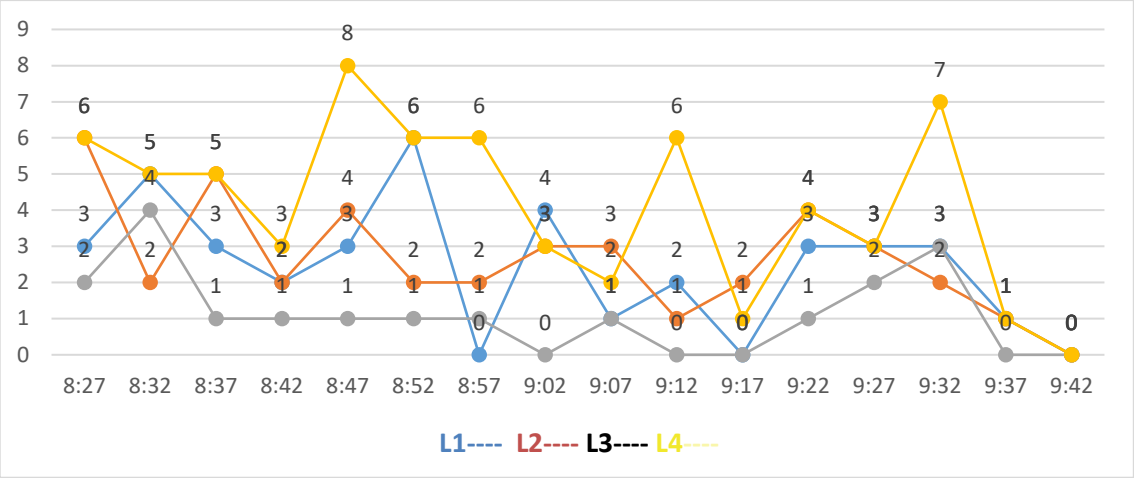


Figure 4.11: Amount of utterances made per participant in 5-minute intervals for Control Chat Group 2

b. Measure 2: Productivity

The table below gives us insight into the productivity of Control Chat Group 2's chat:

Table 4.16: Productivity of Control Chat Group 2

Control Group 2's productivity		
Number of productive utterances made in chat	**Number of available seconds in chat**	**Productivity measure (Average amount of seconds between utterances)**
160	4800	30

This group has 5 Non-Task utterances. At the end of the chat the total number of utterances is 165. When you subtract the Non-Task utterances, from this number it comes to 160 utterances spent on resolving the given real-life challenge. By dividing 4800 seconds by 160, the average number of seconds between utterances is 30.

c. Measure 3: Adherence

The table below indicates which utterances made by the participants of Control Chat Group 2 were in line with the optimal utterances type distribution (indicated by the cells highlighted in green).

Table 4.17: Measure of adherence for Control Chat Group 2

Phase	Time	PA	PC	CD	SD	SE	NT	OO
Phase 1	8:27	0	0	0	0	0	1	16
	8:32	12	2	0	0	0	0	2
	8:37	0	0	0	9	5	0	0
Phase 2	8:42	0	0	0	4	4	0	0
	8:47	1	2	0	8	4	0	1
Phase 3	8:52	0	0	0	6	9	0	0
	8:57	0	0	0	1	3	0	5
	9:02	0	0	0	3	2	0	5
Phase 4	9:07	0	0	0	2	3	0	2
	9:12	0	0	0	3	4	0	2
	9:17	0	0	0	3	0	0	0
	9:22	0	0	0	6	4	0	2
	9:27	0	0	0	8	3	0	0
	9:32	0	0	0	7	3	1	4
	9:37	0	0	0	0	0	3	0
	9:42	0	0	0	0	0	0	0

When you count the total amount of utterances that fall within the green cells, you get the following:

- 18 (16+2) utterances in the first phase correspond with the optimal distribution of utterance types;
- 4 (1+2+1) utterances in the second phase correspond with the optimal distribution of utterance types;
- 10 (5+5) utterances in the third phase correspond with the optimal distribution of utterance types and
- 56 (2+3+2+3+4+2+3+6+4+2+8+3+7+3+4) utterances in the fourth phase correspond with the optimal distribution of utterance types.

In total, 88 of the 165 utterances made by Control Chat Group 2 was in line with the optimal distribution of utterance types. This translates to a percentage of 53.33% for the measure of adherence.

d. Measure 4: Challenge

The difficulty rating per participant in Control Chat Group 2 is indicated in the table below:

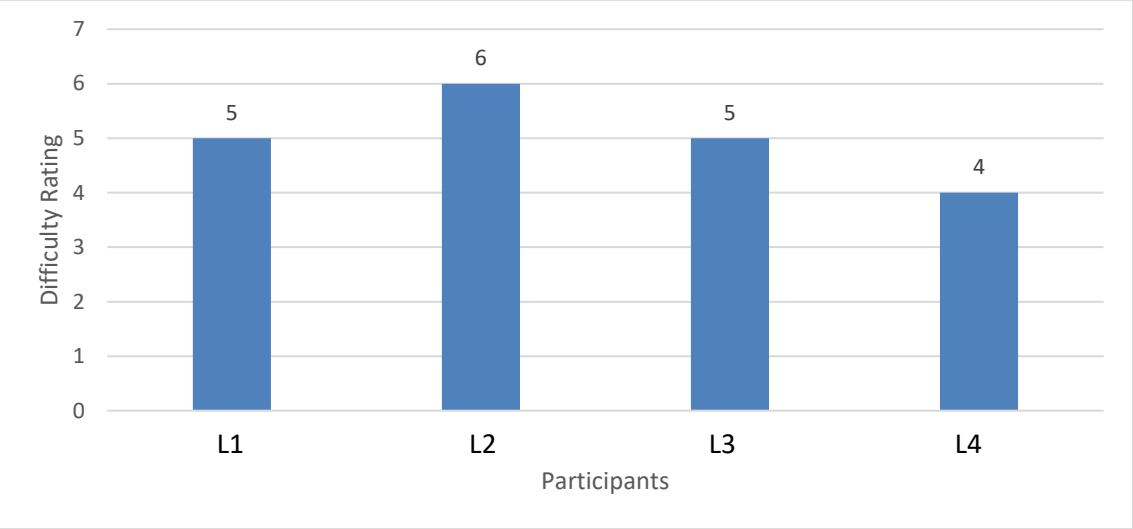


Figure 4.12: Control Chat Group 2's difficulty rating per participant

Studying the survey data for Control Chat Group 2, we see that their average difficulty level rating of the challenge is 5.

e. Learning quality

A summary of the learning quality findings for Control Chat Group 2 can be seen in the table below:

Table 4.18: Measurement of analysed data for Control Chat Group 2 indicating learning quality

Measure	Findings
Measure 1: Participation In-equity	• The participation in-equity in the group (indicated by the standard deviation) is 19.65.
Measure 2: Productivity	• There were 5 Non-Task utterances within the given time-frame of the online chat, which were subtracted from the total amount of utterances made (165). • On average they made an utterance every 30 seconds.
Measure 3: Adherence	• In total, 88 of the 165 utterances made by Control Chat Group 2 were in line with the optimal distribution of utterance types. This translates to a percentage of 53.33% for the measure of adherence.
Measure 4: Challenge	• The group rated the level of difficulty of the challenge to be 5 out of a maximum amount of 10.

4.3.5 Control Chat Group 3

a. Measure 1: Participation In-Equity

Control Chat Group 3 made an average of 97.5 utterances during the group chat. The total amount of utterances per participant can be seen in the table below:

Table 4.19: Total amount of utterances per participant in Control Chat Group 3

Participant	L1	L2	L3	L4
Utterances	69	64	48	84

The amount of utterances made by participants in Control Chat Group 3 ranged between 48 and 84, which contributed to a standard deviation of 14.84 for the group. The figure below shows the average standard deviation for Control Chat Group 3:

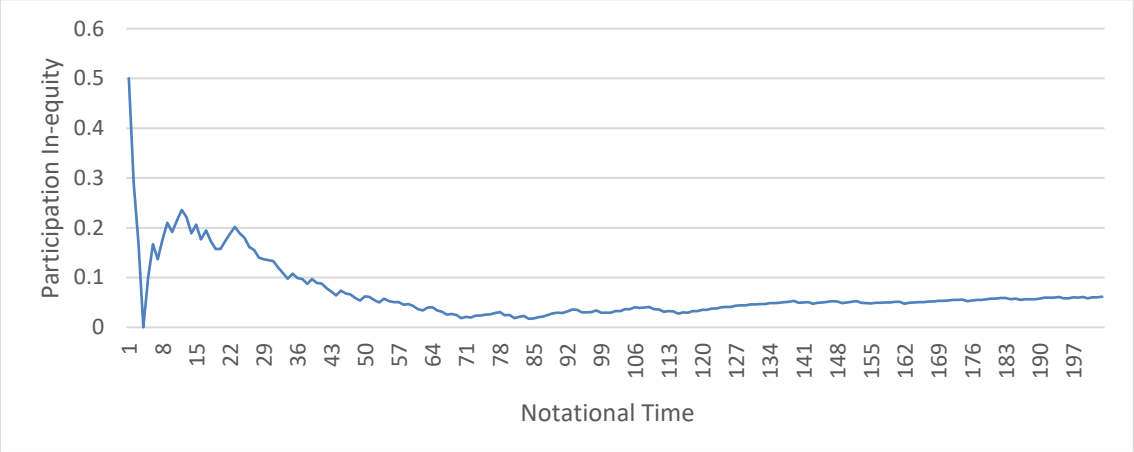


Figure 4.13: The average standard deviation of Control Chat Group 3

Control Chat Group 3's graph indicates a standard deviation line that rises dramatically at the start of the chat (Notational time 1-13), then dramatically dips to a level slightly above 0 (Notational time 13-79) and then gradually rises to a point just below 0.1 (Notational time 79-299). This fluctuation can be contributed to a participant L2 who made very little utterances at the start of the chat in contrast to many utterances made by both L1 and L4. As the chat progresses and the number of utterances made by L2 increases, the standard deviation lowers, only to start rising again as participant L3's contribution declines over the

course of the chat. A graphic representation of the amount of utterances made over the course of the chat can be seen below:

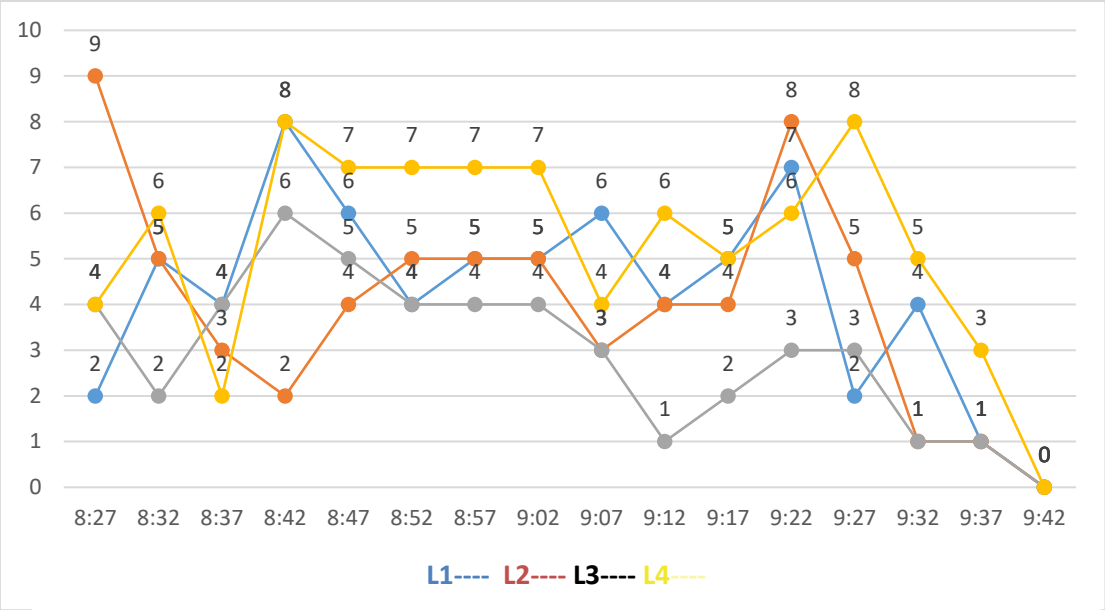


Figure 4.14: Amount of utterances made per participant in 5-minute intervals for Control Chat Group 3

b. Measure 2: Productivity

The figure below gives us insight into the flow of utterances over the course of Control Chat Group 3's chat:

Table 4.20: Productivity of Control Chat Group 3

Control Chat Group 3's productivity		
Number of productive utterances made in chat	**Number of available seconds in chat**	**Productivity measure (Average amount of seconds between utterances)**
260	4800	18.46

This group had 4 Non-Task utterances. At the end of the chat the total number of utterances is 264. When you subtract the Non-Task utterances from this number it comes to 260 utterances spent on resolving the given real-life challenge. By dividing 4800 seconds by 260, you come to 18.46 seconds, which is the average amount of seconds between the posting of utterances in this chat.

c. Measure 3: Adherence

The table below indicates which utterances made by the participants of Control Chat Group 3 were in line with the optimal utterances type distribution (indicated by the cells highlighted in green).

Table 4.21: Measure of adherence for Control Chat Group 3

Phase	Time	PA	PC	CD	SD	SE	NT	OO
Phase 1	8:27	1	0	0	0	0	0	18
	8:32	10	5	0	1	1	0	1
	8:37	1	2	0	2	5	0	3
Phase 2	8:42	0	0	2	6	13	0	3
	8:47	0	0	0	7	13	0	2
Phase 3	8:52	0	0	0	10	10	0	0
	8:57	0	0	0	11	10	0	0
	9:02	0	0	0	8	10	0	3
Phase 4	9:07	0	0	0	3	9	0	4
	9:12	0	0	0	9	6	0	0
	9:17	0	0	0	7	8	0	1
	9:22	0	0	0	13	10	0	1
	9:27	0	0	0	9	8	1	0
	9:32	0	0	0	3	4	3	1
	9:37	0	0	0	2	1	0	3
	9:42	0	0	0	0	0	0	0

When you count the total amount of utterances that fall within the green cells, you get the following:

- 22 (18+1+3) utterances in the first phase correspond with the optimal distribution of utterance types;
- 5 (3+2) utterances in the second phase correspond with the optimal distribution of utterance types;
- 3 (3) utterances in the third phase correspond with the optimal distribution of utterance types and
- 102 (3+9+4+9+6+7+8+1+13+10+1+9+8+3+4+1+2+1+3) utterances in the fourth phase correspond with the optimal distribution of utterance types.

In total, 132 of the 264 utterances made by Control Chat Group 3 was in line with the optimal distribution of utterance types. This translates to a percentage of 50% for the measure of adherence of Control Chat Group 3.

d. Measure 4: Challenge

The difficulty rating per participant in Control Chat Group 3 is indicated in the table below:

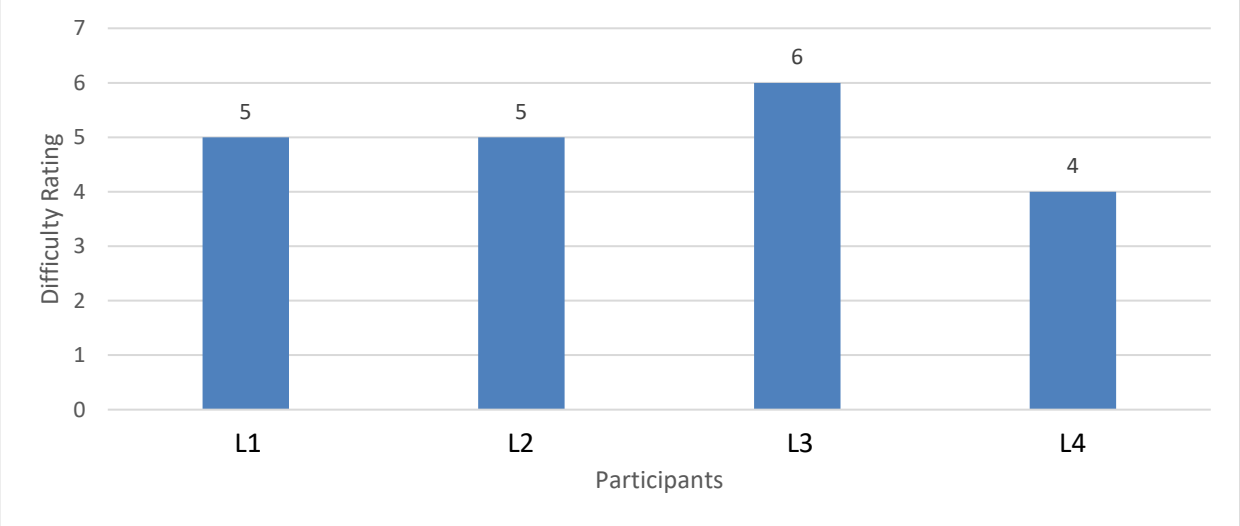


Figure 4.15: Control Chat Group 3's difficulty rating per participant

Studying the survey data for Control Chat Group 3, we see that their average difficulty level rating of the challenge is 5.

e. Learning quality

A summary of the learning quality findings for Control Group 3 can be seen in the table below:

Table 4.22: Measurement of analysed data for Control Chat Group 3 indicating learning quality

Measure	Finding
Measure 1: Participation In-equity	• The participation in-equity in the group (indicated by the standard deviation) is 14.81.
Measure 2: Productivity	• Control Group 3 had 4 Non-Task utterances within the given time-frame of the online chat. • On average they made an utterance every 18.46 seconds.

Measure 3: Adherence	• In total, 132 of the 264 utterances made by Control Group 3 was in line with the optimal distribution of utterance types. • This translates to a percentage of 50% for the measure of adherence of Control Group 3.
Measure 4: Challenge	• The group rated the level of difficulty of the challenge to be 5 out of a maximum amount of 10.

4.3.6 Control Chat Group 4

a. Measure 1: Participation In-Equity

Control Chat Group 4 made an average of 52 utterances during the group chat. Due to technical difficulties there were two 5-minute timeslots in the chat where participant L2 struggled to post utterances on the chat. In an attempt to maintain the integrity of the data for this group, an average amount of utterances was established for the timeslots where L2 did not have any technical difficulties. This average amount of utterances in these working timeslots was then used for L2 in those timeslots where technical difficulty was experienced. The total amount of utterances per participant can be seen in the table below:

Table 4.23: Total amount of utterances per participant in Control Chat Group 4

Participant	L1	L2	L3	L4
Utterances	62	30	48	68

The amount of utterances made by participants in Control Chat Group 4 ranged between 30 and 84, which contributed to a standard deviation of 16.89 for the group. The figure below shows the average standard deviation of Control Chat Group 4:

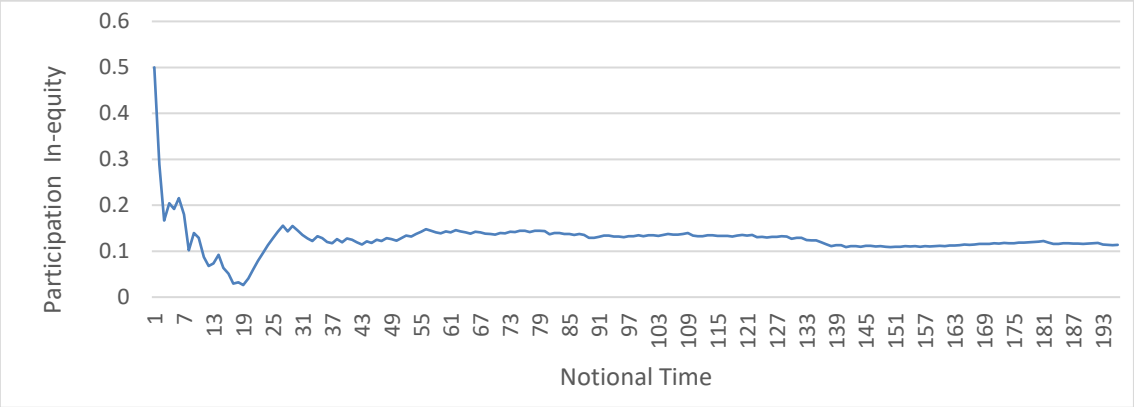


Figure 4.16: The average standard deviation of Control Chat Group 4

Control Chat Group 4's graph indicates a standard deviation line that eventually stabilises midway between 0.1 and 0.2 (Notational time 55 - 127), but then dips by the end of the conversation to a level slightly above 0.1 (Notational time 139 - 193). This indicates consistent participation patterns between participants, where a constant level of input into the group chat was maintained for each participant.

b. Measure 2: Productivity

The figure below gives us insight into the productivity of Control Chat Group 4's chat:

Table 4.24: Productivity of Control Chat Group 4

Control Group 4's productivity		
Number of productive utterances made in chat	**Number of available seconds in chat**	**Productivity measure (Average amount of seconds between utterances)**
182	4800	26.37

This group had 11 Non-Task utterances. At the end of the chat the total number of utterances is 193. When you subtract the Non-Task utterances from this number it comes to 182 utterances spent on resolving the given real-life challenge. By dividing 4800 seconds by 182, you come to 26.37 seconds, which is the average amount of seconds between the posting of utterances in this chat.

c. Measure 3: Adherence

The table below indicates which utterances made by the participants of Control Group 4 were in line with the optimal utterances type distribution (indicated by the cells highlighted in green):

Table 4.25: Measure of adherence for Control Chat Group 4

Phase	Time	PA	PC	CD	SD	SE	NT	OO
Phase 1	8:27	1	0	0	0	0	0	18
	8:32	10	5	0	1	1	0	1
	8:37	1	2	0	2	5	0	3
Phase 2	8:42	0	0	0	7	5	0	0
	8:47	3	2	0	2	5	0	2
Phase 3	8:52	0	1	0	2	7	0	4
	8:57	0	0	0	5	3	0	9
	9:02	0	0	0	6	3	0	3
Phase 4	9:07	0	0	0	4	6	0	1
	9:12	0	0	0	7	2	0	1
	9:17	0	0	0	5	7	0	1
	9:22	0	0	0	8	3	0	1
	9:27	0	0	0	5	3	0	1
	9:32	0	0	0	2	5	1	2
	9:37	0	0	0	1	0	7	1
	9:42	0	0	0	2	3	3	1

When you count the total amount of utterances that fall within the green cells, you get the following:

- 24 (18+1+3) utterances in the first phase correspond with the optimal distribution of utterance types;
- 7 (3+2+2) utterances in the second phase correspond with the optimal distribution of utterance types;
- 19 (5+10+4) utterances in the third phase correspond with the optimal distribution of utterance types and
- 72 (4+6+1+7+2+1+5+7+1+8+3+1+5+3+1+2+5+2+1+1+2+3+1) utterances in the fourth phase correspond with the optimal distribution of utterance types.

In total, 119 of the 196 utterances made by Control Chat Group 4 was in line with the optimal distribution of utterance types. This translates to a percentage of 60.70% for the measure of adherence for Control Chat Group 4.

d. Measure 4: Challenge

The difficulty rating per participant in Control Group 4 is indicated in the table below:

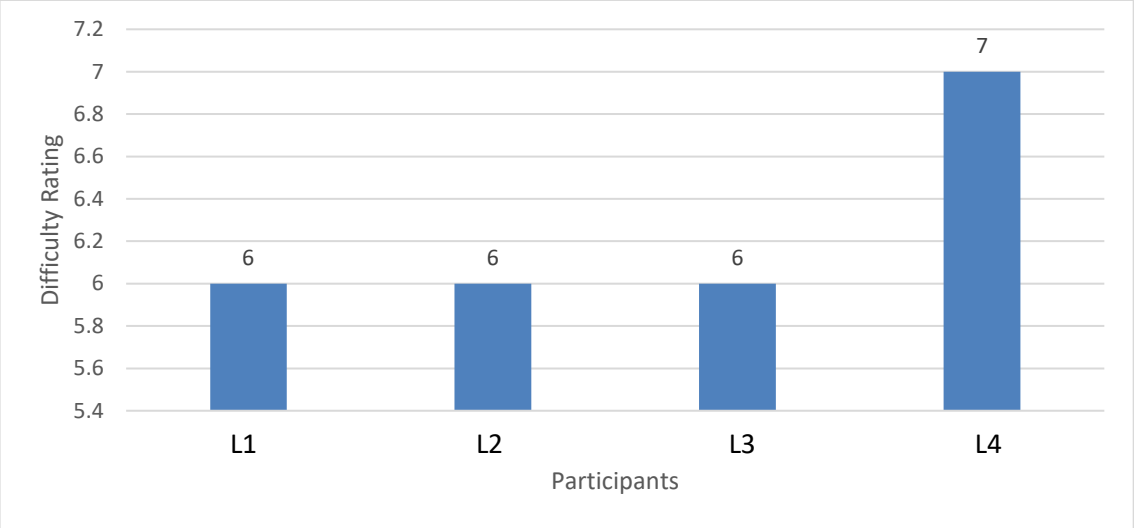


Figure 4.17: Control Chat Group 4's difficulty rating per participant

Studying the survey data for Control Chat Group 4 we see that their average difficulty level rating of the challenge is 6.25.

e. Learning quality

A summary of the learning quality findings for Control Chat Group 4 can be seen in the table below:

Table 4.26: Measurement of analysed data for Control Chat Group 4 indicating learning quality

Measure	Control 4 Findings
Measure 1: Participation In-equity	• The participation in-equity in the group (indicated by the standard deviation) is 16.89.
Measure 2: Productivity	• There were 11 Non-Task utterances within the given time-frame of the online chat. • On average they made an utterance every 26.37 seconds.

Measure 3: Adherence	• In total, 111 of the 193 utterances made by Control Chat Group 4 was in line with the optimal distribution of utterance types. • This translates to a percentage of 60.70% for the measure of adherence.
Measure 4: Challenge	• The group rated the level of difficulty of the challenge to be 6.25 out of a maximum amount of 10.

Having established the quality of learning of individual chats, I will now discuss the qualitative data collected in this study with the purpose of understanding the learning quality rankings. Doing so provides insights into the ranking of the groups according to their learning quality and explain the impact of LTF-statements made during the experiment.

4.4 Qualitative data analysis

As has been indicated in Chapter 3, the data analysis will be thematic in nature. In an overall sense thematic data analysis was conducted because it "works both to reflect reality and to unpick or unravel the surface of 'reality'" (Braun & Clarke, 2006).

4.4.1 Priori coding of transcribed interviews

My thematic analysis of the qualitative data consisted of a process where I started off by inductively coding the transcribed interview data within the context of the most appropriate broad theoretical frameworks as they are described in corresponding paragraphs in Chapter 2. I have done this priory coding for all relevant chat groups separately (which is presented in Appendix Z); the first focus group interviews with all chat groups; the second (amended) focus group interviews with only the experimental chat groups. These experimental chat groups were subjected to the Facilitating Learning intervention of learning task feedback by the facilitator of learning.

As indicated in Chapter 3, my co-researcher participated in the coding phase of the data-analysis. Leading this process, the next step in my thematic analysis of both first and second focus group interviews was to identify longer or shorter quotations of coded participant responses that could be used as representative

or illustrative of a particular code and through similar interpretations of any number of coded participant responses, sub-themes emerged. Finally, related sub-themes could be combined in different categories from which the themes could be derived. This formed the pivot by which subsequent findings could be supported and/or corroborated. To enhance credibility and trustworthiness referencing the origin of the priori coding data in its analysis is important. An identifier is used to refer to a particular group and a specific participant (learner) in that group (e.g. G2L3). However, when the original six 'as similar as possible chat groups' were later randomly selected into the experimental and control groups, these groups were labled with a new group identifier, as is indicated in the table below:

Table 4.27: Link between Chat Group names and identifiers used in experiment

Chat group names and numbers allocated for the purpose of executing the experiment	Data collection, coding and analysis identification of its corresponding chat group name and number
Experimental Chat Group 1	G2
Experimental Chat Group 2	G3
Control Group 1	G1
Control Group 2	G4
Control Group 3	G5
Control Group 4	G6

From this point forward, the distinction between the data analysis of first and second focus group interviews is necessary.

4.4.2 First focus group interviews – all groups

I inductively priory coded the interviews of the first focus groups within the more particular context of the theoretical framework of this study. This entailed a framework including Facilitating Learning (FL) and the closely associated Zone of Proximal Development (ZPD), as well as cooperative learning on the Computer Supported Collaborative (CSCL) platform and the MakerSpace environment. Although I have done this coding for all chat groups separately, I have included all this data obtained over all six chat groups as one set for further analysis because I was interested in their shared experience: all of them were subjected

to the same requirement of resolving a demanding real-life challenge on a CSCL platform in a MakerSpace environment.

Since the experimental chat groups were included in this first focus group interview it was anticipated that their experiences of an additional Facilitating Learning intervention, through the learning task feedback statements posted by the facilitator of learning, would be tainted. As such, I expected them to provide a narrative at odds with the experiences of the control groups. To my surprise, the differences between the interview data of control and experimental groups were not particularly significant. Nonetheless, to compensate for discrepancies where participants of the experimental groups referred to those experiences that only they were exposed to, it was recognised and taken note of, but not further entertained. These responses of experimental group participants, though, were included and accommodated in the second amended focus group interviews with them only. Thus the combined data sets of interview data collected from experimental and control chat groups were merged in one thematic analysis dedicated to understanding the shared experiences of all participants in the experiment. In order to increase the authenticity of the data, direct quotes are provided as received from the participants and are presented as-is with any possible language errors.

4.4.2.1 Emerging themes revealed by the interview data

A detailed Narrative Thematic Analysis of the data collected in the first focus group is presented in Appendix Zzza_NarrativeThemAnal. Although I originally planned the inclusion of this analysis within this report, the limitations on the length of the report motivated me to rather include it as an appendix. Also, the intensive extent to which this narrative was populated with quotes from the data significantly decreased its readability and I was wary of overwhelming the reader. In its stead, the result of the process is summarised in the table below. It contains an illustrative quote taken from the coding of the interviews and a short contextual interpretation of the quote from which a corresponding sub-theme was identified. The last column contains a theme that is derived from combining related

subthemes subsequently categorised as “the themes derived from the analysis” (Maree, 2010, p. 108).

Table 4.28: Summary of the thematic analysis of the first focus group interview data: all groups

ILLUSTRATIVE QUOTE FROM THE PRIORI CODING OF INTERVIEWS	CONTEXTUAL INTERPRETATION OF THE QUOTE TOWARDS A SUB-THEME	SUB-THEME	THEME
"I saw it as an opportunity to fix the community" (Appendix Z, line 3)	Seeing the real-life challenge as a service to the community	Real-life challenges serve the community	1: Understanding the real-life challenge
"I also thought it was on a bigger scale because at school our problems are small" (Appendix Z, line 9)	Normal school challenges are not as challenging as a real-life challenge	Real-life challenges are demanding	
"I thought it would be a good way to impact the environment" (Appendix Z, line 14)	The solution to the real-life challenge enhances the environment	Real-life challenges improve the environment	
"… it's a problem that you know really exists" (Appendix Z, line 14)	The real-life challenge is recognised as being authentic	Real-life challenges are authentic	
"… it was still about people" Appendix Z, line 10)	The real-life challenge focuses on people	Real-life challenges have a human focus	
"You had to compromise" (Appendix Z, line 104)	The security of individual freedom had to be compromised in favour of cooperative vulnerability	Cooperative learning requires the utilisation of intrapersonal resources	2: Challenges of cooperative learning
"I came up with three ideas and you all just shot them down" (Appendix W, line 26).	Healthy conflict will neccessarily be present when different people share their understanding of reality within a community of truth	Cooperative learning requires the utilisation of interpersonal resources	
"… with everyone's ideas it became more of a picture so you know how to do" (Appendix Z, line 114)	Sharing individual ideas provides an opportunity to deliver better communal results	Sharing ideas bring better results	3: Achieving significant learning outcomes
"It was very hard to decide as a group when you have your own idea" (Appendix Z, line 94)	The importance of doing metalearning first and the conflict entailed in sacrificing your own idea	Overcoming the metalearning -cooperative learning dilemma	
"… we can use everyone's creative sides and use it" (Appendix Z, line 30)	Participants developed their creativity	Development of creativity	
"… the more you think and you think yourself into that situation then you can think of what you are shorting" (Appendix Z, line 45)	Immersion in the real-life challenge makes participants aware of their personal deficiencies	Personal (holistic) development is paramount	

"… eventually we are going to get out of school and when we do we need to plan to take action" (Appendix Z, line 48)	Participants realised that what they are learning goes beyond school	Conquering the challenges of real-life	
"So in that way you can grow as a person" (Appendix Z, line 57)	Participants needed to attain intra-personal competencies	Attaining intrapersonal human qualities	
"instead of shouting at each other and saying NO! NO! you should do THAT or you should do THAT, we can cooperate with each other" (Appendix Z, line 58)	Realising the importance of interpersonal qualities like communication skills	Attaining interpersonal human qualities	
"… its very important that we start training, getting the skills and knowledge" (Appendix Z, line 60)	Participants acknowledge the value of acquiring knowledge and skills when resolving a real-life challenge	Acquiring knowledge and skills	
"… then you realise oh, so I am very much more privileged than other people" (Appendix Z, line 201)	Exposures to the real-life challenges led to participants attaining an attitude of gratefulness	Acquiring an attitude of gratefulness	
"The solution that we had to come up with, it needed to be a good thing…"	Participants felt responsible for the quality of the solution	Acquiring an attitude of responsibility	
"At first I thought it was going to be hard" (Appendix Z, line 70)	Some participants initially experienced the real-life challenge as difficult	The real-life challenge was experienced as something beyond the current ability to resolve	4: Initial perception of real-life challenge level of difficulty
"... I knew it was gonna be easy" (Appendix Z, line 76)	Some participants initially experienced the challenge as easy	The real-life challenge was experienced as something within the current ability to resolve	
"I was ... interested in this. I was optimistic about it" (Appendix Z, line 212)	Participants were optimistic about resolving the real-life challenge	Positive emotions experienced by participants	5: Resolving the real-life challenge was an emotional experience
"… I am a very insecure person, and … I am scared to be judged" (Appendix Z, line 216)	Participants were scared by the cooperative learning	Negative emotions experienced by participants	

The summary of the thematic analysis indicated in the table above revealed the themes that have been identified across all the groups of the experiment.

4.4.3 Second (amended) focus group interviews

I inductively coded the interviews of the second (amended) focus groups within the particular context of Facilitating Learning (FL) and the specific framework of learning task feedback. This manifested in Facilitating Learning through the learning task feedback statements that I constructed as the Facilitating Learning intervention introduced by the facilitators of learning during the experiment.

The coding for the experimental chat groups was done across the data of both groups as one set for further analysis because I was interested in the shared experiences of the experimental chat groups. However, as was the case with the presentation of the analysis of the first focus groups, it was also important that I distinguish the data between these two groups, keeping in mind the eventual role that this analysis would play in Chapter 5.

4.4.3.1 Emerging themes revealed by the interview data

An analysis of these second focus group interviews brings us to the heart of the study. As the aim of the study is to understand the impact of FL in an online environment, these amended focus group interviews (where the online chats were recreated) was the one place in this study where I could delve into the experiences of the participants with a laser focus on the intervention of Facilitating Learning. Where the copious amount of data generated by six interviews allowed for the categorisation of data into sub-themes, the smaller amount of data generated in only two interviews meant that a single sub-theme could constitute a theme. As was the case in paragraph 4.4.2.1, the following table will present the process followed to arrive at the themes identified for this second round of interviews:

Table 4.29: Summary of the thematic analysis of the second (amended) focus group interview data: Experimental groups

ILLUSTRATIVE QUOTE FROM THE PRIORI CODING OF INTERVIEWS	CONTEXTUAL INTERPRETATION OF THE QUOTE TOWARDS A SUB-THEME	SUB-THEME	THEME
"I felt like it made us work harder, it helped us think a little bit more out of the box" (Appendix Q, Group 3, line 89)	LTF-statements encouraged participants to think creatively and increase the amount of different solutions	LTF-statements engendered participants to think in novel ways	1: FL brought about a shift in thinking
"Uhm, well what sir put on the group - it changed my mind of thinking" (G2L1, Appendix Q, line 74)	LTF-statements influenced the train of thought of participants, which serves as proof of successful facilitation	LTF-statements engendered a shift in the thinking of participants	
" … but after he said that you really do question yourself more" (Appendix Z, line 238)	LTF-statements encouraged participants to think about their own thinking, thereby heightening the quality of the learning	LTF-statements engendered metalearning	2: FL encouraged intra-personal growth
" … you have put in the concepts of an expert" (Appendix Z, line 237)	LTF-statements increased the perception of participants regarding the required standard of the solution that they had to come up with	LTF-statements engendered 'thinking like an expert'	
" … we just started talking about many ideas over and over again, so I think that [LTF-STATEMENT] helped us" (G3L2, Appendix Q, Group 3, line 92)	LTF-statements encouraged participants to share their ideas multiple times in order for them to get to a point of consensus	LTF-statements guided participants' interactions with each other	3: FL encouraged inter-personal growth
" … so then it became kinda became hard and difficult" (Appendix Z, line 232)	LTF-statements made participants realise that the expected standard of the solution was such that it could not be easily resolved	LTF-statements increased the perceived level of difficulty of the real-life challenge	4: FL had an impact on the perceived level of challenge

As can be seen in the table above, four themes emerged from the data concerning the impact of LTF-statements. To distinguish these themes from the themes identified in the first focus group interviews, they will be labelled alphabetically (A,B,C,D) instead of numerically.

4.4.3.2 Narrative thematic analysis

Following is the narrative thematic analysis of the first focus group interviews with all groups by themes. To guide us into an additional narrative analysis of the themes indicated above, it will also be helpful to know exactly which statements were made by the facilitator of learning during the chats of both experimental chat groups. The table below indicates the statements made, along with the timestamp of each statement for each group:

Table 4.30: LTF statements made in experimental chat groups

Learning task feedback statement	Timestamp	Learning quality measure targeted by LTF statement
Experimental Chat Group 1		
AN EXPERT CANNOT START SOLVING A PROBLEM WITHOUT A GAME PLAN	8:36	Measure 3: Adherence
AN EXPERT QUESTIONS EVERYTHING	8:42	Measure 4: Challenge
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:45	Measure 1: Participation in-equity
AN EXPERT NEEDS TO FIRST IDENTIFY THE REAL PROBLEM	8:47	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	8:52	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	8:55	Measure 3: Adherence
AN EXPERT CAN QUICKLY EXPLAIN HOW TO MAKE THE SOLUTION	9:05	Measure 2: Productivity
AN EXPERT QUESTIONS EVERYTHING	9:21	Measure 4: Challenge
AN EXPERT NEEDS THE INPUT OF EVERYONE	9:22	Measure 1: Participation in-equity
Experimental Chat Group 2		

AN EXPERT CANNOT START SOLVING A PROBLEM WITHOUT A GAME PLAN	8:35	Measure 3: Adherence
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:36	Measure 1: Participation in-equity
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:42	Measure 1: Participation in-equity
AN EXPERT QUESTIONS EVERYTHING	8:44	Measure 4: Challenge
AN EXPERT NEEDS TO FIRST IDENTIFY THE REAL PROBLEM	8:50	Measure 3: Adherence
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:56	Measure 1: Participation in-equity
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	8:59	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	9:09	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	9:20	Measure 3: Adherence
AN EXPERT NEEDS THE INPUT OF EVERYONE	9:23	Measure 1: Participation in-equity
AN EXPERT CAN QUICKLY EXPLAIN HOW TO MAKE THE SOLUTION	9:24	Measure 2: Productivity

Below is a figure of the percentage of learning task feedback statements made per learning quality measure in experimental chat groups. This figure provides the opportunity to interpret the themes in terms of the percentage of learning task feedback statements made per learning quality measure per group.

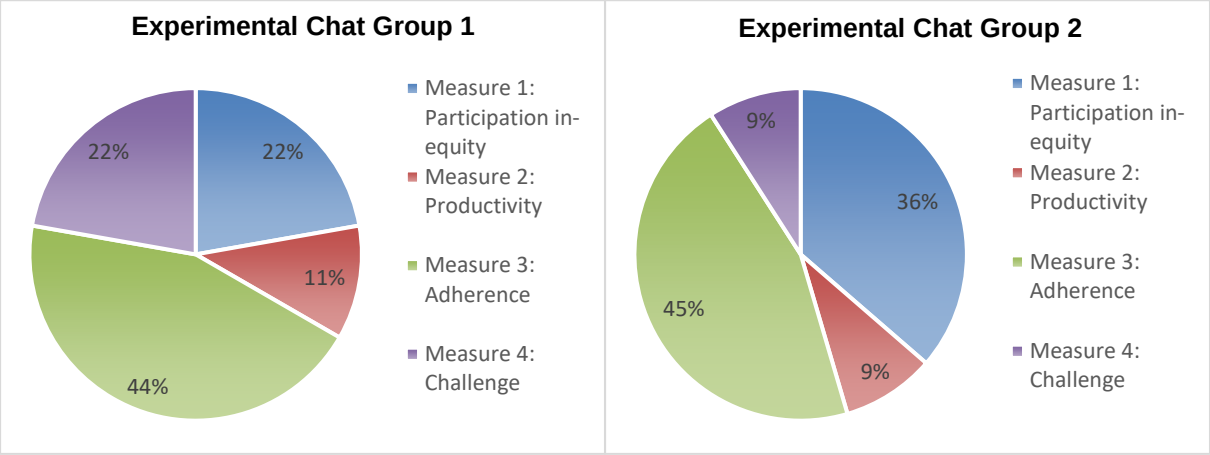


Figure 4.18: Percentage of learning task feedback statements per learning quality measure in experimental chat groups

Studying the figure above, it becomes clear that in Experimental Chat Group 1, most LTF-statements targeted the learning quality measure of adherence. The learning measure which was focused on the second most is a tie between participation in-equity and challenge. Similarly, the bulk of LTF-statements made in Experimental Chat Group 2 concerned adherence, while participation in-equity was second in terms of the percentage of LTF-statements.

To understand the impact of these statements, a thematic analysis was conducted across participant responses for both experimental groups regarding the learning task feedback in the chat. The filter with which I identified the sub-themes in these two transcribed interviews was once again FL, with a particular focus in this instance on any direct reference to Facilitating Learning as conducted by the FOL during the course of the chat. The quotes below serve as an illustration of such an instance:

> “Maybe it didn't influence me but it did influence the group? As it was not my home language I didn't understand it” (Appendix Q, Group 3, line 88).

> "Like, when he commented on certain things, you had to think back to a certain situation and then include everyone and their opinions into one whole, so if you were to say like, think how an expert thinks, everyone should combine their ideas and be like, but there is a problem with this, there is a problem with this. For which we took a long time just to get to one solution. His comments made quite a big impact" (L3G2, Appendix Y, line 222).

Although the amount of data to analyse was considerably less than the data generated in the first focus group interview, I believed that the quality of the data would become evident through the quotes provided.

a. **Theme A: FL brought about a shift in thinking**

Several participants of Experimental Chat Group 1 stated that the learner feedback statements brought about a shift in their initial thinking. This constituted the themes referring to the impact of LTF-statements, as is demonstrated in the following quotes:

> "Sir it really made me change my mind" (G2L2, Appendix Q, line 73).

> "Uhm, well what sir put on the group - it changed my mind of thinking" (G2L1, Appendix Q, line 74).

Similar comments were found in Experimental Chat Group 2, as demonstrated by participant G3L1 who suggested that the learning task feedback statements had brought about a shift in thinking, as can be seen in the following quote:

> "I felt like it made us work harder, it helped us think a little bit more out of the box" (Appendix Q, Group 3, line 89).

b. **Theme B: FL encouraged intrapersonal growth**

There were several comments in both groups referencing internal development engendered by LTF statements made by the facilitator of learning, as can be seen below by participants in Experimental Chat Group 1:

> "… we can't solve a problem without a game plan. We have to think about the problem first and then we have to solve it in other ways" (G2L2, Appendix Q, line 80).

> "And also, sir said we have to look at all the things that maybe could go wrong to make sure this will work and we also have to make sure that we have everything we need" (G2L2, Appendix Q, line 81).

> "It's helping us to actually find our way through this, through the exam ... trying to figure out what we all need to do, what's our part in this and what's going to happen eventually" (G2L1, Appendix Q, line 82).

A similar comment was made by a learner in Experimental Chat Group 2:

> "Some of them [learning task feedback statements] were like hints in my head to like, to tell us we were going on the right path and some of us were like, there, to help us like decide" (G3L2, Appendix Q, Group 3, line 91).

c. **Theme C: FL encouraged interpersonal growth**

All the participants stated that the feedback statements engendered growth in terms of the social skills required to function within the group, as can be seen in the statements below from participants in Experimental Chat Group 1:

> "I thought like, we should stop thinking about only ourselves cause we don't want something that only benefits ourselves. We have to think about others and sir also said that we have to get the input of everyone" (G2L2, Appendix Q, line 76).

> "We must actually work together, and not work against each other, trying to work as a group - not always individuals … " (G2L1, Appendix Q, line 77).

> "Some of us may have closed off to certain ideas but it made us realise that we have to include everyone and everyone's ideas" (G2L3, Appendix Q, line 78).

> " … before I started speaking to the group I, it was a very one-minded idea, this whole thing, then you have questions from other group members that makes you very much open minded and it gives you sense of, there's more conclusions …" (G2L4, Appendix Q, line 79).

Two participants in Experimental Chat Group 2 made specific reference to the way the LTF-statements helped their group to function:

> "Well it impacted me because I tend to do things by myself, and normally I work by myself, but it reminded me that it is a group thing and that I had to take other people's ideas into consideration" (G3L3, Appendix Q, Group 3, line 90).

> "An expert can explain quickly - that one helped me a lot because I realised that we had a bunch of ideas but we didn't start deciding on any of them, we just started talking about many ideas over and over again, so I think that helped us" (G3L2, Appendix Q, Group 3, line 92).

d. **Theme D: FL had an impact on the perceived level of challenge**

The participants of Experimental Chat Group 1 gave a nuanced description of how the feedback statements affected their perception of the level of difficulty of the challenge, as can be seen in the comments below:

> "It made it easier, yet in the same sentence more difficult. Because we had to think more, we had to act more like grown-ups, start working together – not like we usually do – but also easier cause its hints and tips to make us think as one" (G2L2, Appendix Q, line 69).

> "I think it made it easier in certain situations but also made it more challenging in other situations because we had to put more effort into it" (G2L3, Appendix Q, line 70).

> "I'd say it made it easier because it started getting us on the right track, getting everyone on the same page, not anyone strays further and has to drag the others and then the others also have to catch up and force the people who were ahead to actually slow down and explain it more sensibly to the others" (G2L1, Appendix Q, line 72).

Looking at the three quotes regarding the level of challenge, it is clear that two of the quotes state that the learner task feedback statements increased the level of difficulty, while one participant stated that these statements made it easier. Ultimately, while a direct link between LTF statements and the quantitative data analysis was lacking in the quantitative data set, going through a transcript of the chat with the group provided valuable insights. Most notable is the fact that this group had experienced a huge amount of growth during this experiment, despite their low learning quality ranking relative to the other groups.

As the group that had the second-lowest quality of learning, it is noteworthy that via the learning task feedback statements these participants still perceived an increase in the quality of the group's chat, even when this increase in quality does not manifest in the quantitative data collected in this study. Referring to the introduction of this study (Chapter 1.1.), this phenomenon can be indicative of the 'hidden nature' of the quality of learning. Thus, where the qualitative data explained the quantitative data in the case of the previous groups, here we have qualitative data unveiling hidden truths not visible in the quantitative data. As

stated by the participants, the FOL made them work harder, encouraged them and facilitated group dynamics.

In contrast, the participants of Experimental Chat Group 2 had mixed feelings on whether the learning task feedback statements had made the chat easier or more difficult. While G3L2 felt that the statements made things “easier” (G3L2, Appendix Q, Group 3, line 97), G3L3 felt that they had made things “harder” (G3L3, Appendix Q, Group 3, line 98). This statement reflects the aim of FL to a great degree, as a facilitator of learning will either increase or decrease the level of difficulty in a real-life challenge depending on the experiences of the participants.

4.5 Conclusion

In this chapter the analysed data for this study was presented. Firstly, the quantitative data was analysed for the eventual purpose of ranking the chat groups according to learning quality. I attempted to be as transparent as possible regarding the process that was followed (in the hope that the reader will have confidence in the interpretation of the data). A deliberate effort was made to keep the reader informed as to the origin of the data being analysed by using direct quotations and by referencing where the source material can be found in the appendix in order to further heighten the trustworthiness of this chapter.

Secondly, the analysis of the qualitative data was presented with the purpose of understanding the generic experiences of participants across all the chat groups (both control and experimental groups) and also specifically understanding how the two experimental groups had experienced Facilitating Learning – especially through the deliberate intervention of the learning task feedback statements by the facilitator of learning.

The next chapter will effectively represent the merging of essential quantitative and qualitative data analysis towards the findings of this research. Its primary focus will consist of interpreting the ranked learning quality positions of the chat groups through the lens of the analysed qualitative data. This will provide deeper

insights that will allow us to determine the impact of Facilitating Learning – particularly through the intervention of learning task feedback on a CSCL platform in a MakerSpace environment when resolving a real-life challenge.

With the collected data presented and analysed, additional 'dark matter' is illuminated in the visual metaphor representing this study shown below:

Figure 4.19: Galaxy Cluster MCS J0416.1-2403 with an indication of 75% dark matter (European Space Agency, 2015)

CHAPTER 5: FINDINGS

5.1 Introduction

From the extensive data and its relevant analysis which was the feature of the previous chapter, the purpose of this chapter was to reveal those findings obtained from the data and its analysis that are of particular relevance to the study. Prompted by Kapur, et al.'s (2007) study I also obtained quantitative data in an attempt to measure the learning quality of an online Computer Supported Collaborative Learning process. In the case of my research, this learning process entailed the resolution of a demanding real-life challenge within a Makerspace context. A deviation from the work of Kapur was also evident in the introduction of an pedagogical intervention into certain chat groups, which allowed me to make a comparison between the control groups and the experimental groups. The hypothesis for this experiment was that the learning quality of the experimental groups will be greater than that of the control groups due to the presence of the pedagogical intervention.

As the outcome of the experiment rested on obtaining the relevant quantitative data as a measure of the quality of the learning process in a way that was both valid and relevant, the complexity of this research (relayed in Chapters 3 and 4) compelled me to additionally analyse the data produced by the experiment qualitatively. If conducted in a manner that was both credible and trustworthy, this additional analysis would ensure a clearer understanding of the quantitative measurements. Therefore, this 'findings' chapter was an example of that part of a Multiphase Partially Mixed Sequential Equal Status mixed research design where the quantitative and qualitative data and its analysis are merged (Creswell & Plano Clark, 2017, p. 71). The aim of this merging was to come to a "more complete understanding" (Maree, 2010, p. 267) towards answering the research questions of this study.

5.2 Merging quantitative and qualitative data analysis into findings

As mentioned in the introduction, the purpose of this chapter was to merge the quantitative and qualitative data analysis in order to arrive at the findings required to answer the research questions. Since this research was inspired by the quantitative data analysis in the research conducted by Kapur, et al. (2007), it seemed most appropriate to follow suit with my research. However, my qualitative data analysis extended the quantitative analysis adopted from Kapur. Not only did this additional analysis provide deeper insight into the findings of the quantitative data analysis, but also aided in providing explanations for any discrepancies that might have crystallised in the findings from the quantitative data analysis.

5.2.1 Findings crystallised from the quantitative data analysis

Although my quantitative data analysis has been elaborately provided in paragraph 4.3, this paragraph was purposed to reveal the relevant findings that have crystallised from that source. It necessitated a reflection on and explanation for the way in which the quantitative data analysis allowed me to measure the learning quality of the respective participative chat groups in this research.

5.2.1.1 Towards the findings of the learning quality of the respective chat groups

a. The purpose of the learning quality measures

According to Kapur (2008, p. 58) the extent to which the amount of interactions made by participants in a group are equal has a significant impact on the performance of that group. In my design of learning quality measures, this became my first measure namely: Participation in-equity. As was the case in the study of Kapur, et al. (2007), the focus of this measure was on the amount of in-equity between the participation of chat group participants. As the level of participation in-equity rises, the learning quality of the chat group decreases. In order to determine this measure, the amount of utterances was counted for each participant per chat group. The standard deviation was then calculated between

these total utterances of the participants. A higher standard deviation indicated a higher level of participation in-equity. Additionally, I consulted the literature in order to find other measures that can be used to measure learning quality in order to increase the validity and reliability of the ranking of chat groups.

The work of Saorin et al. (2017) indicates that the greater the amount of divergent (contrasting) opinions in a group, the higher the quality of the discussion. In terms of my research, I realised that I could translate this finding made by Saorin into a learning quality measure named ‘Productivity’. As more divergent utterances lead to an increase in the amount of utterances made in the group, I determined that by counting the amount of utterances for all participants and dividing this amount by the total amount of seconds available in the experiment, the average amount of seconds between utterances can be determined. The greater the amount of seconds between utterances, the lower the productivity of the group and correspondingly the learning quality decreased. As the average amount of seconds between utterances decreased, the productivity of the group rose and subsequently, the learning quality also increased. With a second learning quality in place, a third learning measure was constructed based on the work of Poole and Holmes (1995).

According to Poole and Holmes (1995), any problem-solving group discussion can ideally be broken up into a sequence of specific phases. Having knowledge of these phases, I realised that a facilitator of learning within a chat group could attempt to guide the participants of the group in such a manner that their chat reflected these identified phases. Ideally, the quantitative data would be able to show the extent to which learning task feedback statements increased the adherence of the experimental chat groups to these phases. This line of investigation thus lead to the determination of the learning quality named ‘Adherence’. As stated in Chapter 3, the first step was to allocate specific time-slots of the 80 minute experiment to the ideal steps identified by Poole and Holmes (1995). The end result of this is indicated in the table below:

Table 5.1: Optimal distribution of utterance types

PHASE	TIME	TYPE 1	TYPE 2	TYPE 3	Time
1	8:25	OO			5
	8:30	OO			5
	8:35	OO			5
2	8:40	PA	PC	OO	5
	8:45	PA	PC	OO	5
3	8:50	CD	OO		5
	8:55	CD	OO		5
4	9:00	SD	SE	OO	5
	9:05	SD	SE	OO	5
	9:10	SD	SE	OO	5
	9:15	SD	SE	OO	5
	9:20	SD	SE	OO	5
	9:25	SD	SE	OO	5
	9:30	SD	SE	OO	5
	9:35	SD	SE	OO	5
	9:40	SD	SE	OO	5

As can be seen in the table above, up to three different utterance types were expected in one of the 5-minute slots of the experiment. The acronyms above referenced the following utterance types:

- PA - Problem analysis;
- PC - Problem critique;
- OO – Orientation;
- CD - Criteria development;
- SD - Solution development and
- SE - Solution evaluation.

Secondly, by coding transcripts of the group chat's utterances, I was able to count how many of the chat group utterances fell within these ideal time-slots. By counting these ideal utterances and dividing this amount by the total amount of utterances made, an adherence percentage was determined. The higher this percentage, the greater the adherence of the chat group to the ideal phases of a problem-solving process and thus the learning quality increased. The last

learning quality measure emerged from my understanding of the theoretical framework of this study.

Challenge forms an essential part of learning when viewed through a Vygotskian lens (Vygotsky, 1938; 1967). In order to ascertain the level of challenge perceived by participants in each chat group, a questionnaire directly after the experiment required that the level of difficulty to be rated by each participant on a scale from 1 (not difficult at all) to 10 (most difficult). The average of these difficulty ratings provided the learning measure of 'Challenge' for the group. The higher this number, the greater the amount of challenge as perceived by the participants and consequently the higher the quality of learning.

As indicated at the beginning of this paragraph, the purpose of these learning quality measures was not only to find the learning quality of the respective chat groups but also to increase its validity and reliability.

b. Using the learning quality measures to determine the learning quality of the six respective chat groups

The first step in finding the learning quality of the six respective chat groups was to combine and/or compare the corresponding data collected. Table 5.2 below was the first attempt at consolidating the data analysis of each of the learning quality measures for each of the chat groups towards finding the learning quality of the six respective chat groups for comparative purposes.

Table 5.2: Learning quality measures across the six chat groups

Chat Group	Learning quality measure 1: Participation in-equity as standard deviation (lower is better)	Learning quality measure 2: Productivity in seconds (lower is better)	Learning quality measure 3: Adherence as percentage (higher is better)	Learning quality measure 4: Challenge on scale of 1-10 (higher is better)
Experimental Chat Group 1	21.21	21.42	49.5	6.25
Experimental Chat Group 2	51.07	12.3	60.2	6.5
Control Chat Group 1	3.78	22.32	51.6	5.5
Control Chat Group 2	19.65	30	53.33	5
Control Chat Group 3	14.81	18.46	50	5
Control Chat Group 4	16.89	26.37	60.70	6.25

Although all four learning quality measures represented a valid learning quality, the four learning quality measures are all different in their particular property and its corresponding units of measurement. Such discrepancies made it impossible to utlilise the learning measures for its intended purpose of finding an overall learning quality measure for each of the six respective chat groups.

In order to utilise the different learning measures for its intended purpose, I first had to find a way to normalise them. Of the different normalisation methods available in measurement theory, using an ordinal scale was best suited for this specific task in my research. An ordinal scale does not consider different quality properties nor its corresponding units of measurement but instead allocates values to measurement variables based on their ranking with respect to one another in a given data set.

Through normalising my data set of learning quality measures across all chat groups into an ordinal scale, I was able to compile a ranking order of the learning quality measures across the chat groups with the lowest ranking number representing the highest learning quality that transformed Table 5.2 above into Table 5.3 below:

Table 5.3: Learning quality ranking for each of the four learning measures per chat group

Chat Group	Ranking according to learning quality measure 1: Participation in-equity	Ranking according to learning quality measure 2: Productivity	Ranking according to learning quality measure 3: Adherence	Ranking according to learning quality measure 4: Challenge
Experimental Chat Group 1	5	3	6	2
Experimental Chat Group 2	6	1	2	1
Control Chat Group 1	1	4	4	3
Control Chat Group 2	4	6	3	4
Control Chat Group 3	2	2	5	4
Control Chat Group 4	3	5	1	2

Calculating the average ranking across all four learning measures for each of the chat groups resulted in finding the learning quality ranking of each chat group as indicated in the table below:

Table 5.4: Overall learning quality ranking per chat group

Chat Group	Ranking according to learning quality measure 1: Participation in-equity	Ranking according to learning quality measure 2: Productivity	Ranking according to learning quality measure 3: Adherence	Ranking according to learning quality measure 4: Challenge	Average ranking number over four measures	Overall learning quality ranking
Experimental Chat Group 1	5	3	6	2	4	**5**
Experimental Chat Group 2	6	1	2	1	2.5	**1**
Control Chat Group 1	1	4	4	3	3	**3**
Control Chat Group 2	4	6	3	4	4.25	**6**
Control Chat Group 3	2	2	5	4	3.25	**4**
Control Chat Group 4	3	5	1	2	2.75	**2**

Thus, we find that according to statistically analysed data across the four learning quality measures, the group chat which had experienced the highest quality of learning was Experimental Group 2. Interestingly, the other facilitated group, Experimental Group 1, had the second lowest quality of learning. This was

contrary to my initial expectations and it initially gave me serious pause to see that one of the groups where a facilitator of learning had been present had the second lowest level of quality of learning in the experiment. Suspecting a flaw in my research I was compelled to go back through my data and experiment structure in order to verify that I had not made an error which had now led to these 'apparently' skewed findings. By thoroughly retracing the steps followed in my analysis and going back as far as the design of the learning quality measures, however, I could only conclude that the findings produced by the experiment were indeed valid, albeit contrary to my initial expectations.

c. Researcher expectation regarding learning quality rankings

Based on my own bias as a teacher, my initial hypothesis regarding the learning quality measures was that across all four learning quality measures, the experimental groups would have the highest positions. I thus expected that the experimental chat groups (where a facilitator of learning was present) would have a higher learning quality than the control chat groups. I had also suspected that chat groups who were visibly struggling to resolve the real-life challenge during the experiment would have a lower learning quality. Much to my surprise, and my initial consternation, the ranking according to learning quality was not in line with my personal expectation and perception of learning quality during the experiment. An investigation of the aggregate rankings of the control chat groups vs. the experimental chat groups will now follow in order to confirm or disprove the experiment hypothesis.

5.2.1.2 Confirmation of experiment hypothesis

As stated at the start of this research, the hypothesis to be confirmed or disproved for the experiment of this study was follows:

> H_0: If the online CSCL educational experience of my learners in resolving a demanding authentic real-life challenge is not intervened by the professional practice of facilitating learning, the quality of their learning process will not be enhanced.

> H_1: If the online CSCL educational experience of my learners in resolving a demanding authentic real-life challenge is intervened by the professional practice of facilitating learning, the quality of their learning process will be enhanced.

Although the individual ranking of the six groups was surprising, the aggregate ranking of experimental groups compared to that of the aggregate ranking of the control groups was more in line with my initial expectations. The results are displayed in the table below:

Table 5.5: Comparison between aggregated rankings of control and experimental chat groups

Group Type	Measure 1: Average ranking of Participation	Measure 2: Average ranking of Productivity	Measure 3: Average Adherence ranking	Measure 4: Average Challenge	Average ranking (lower is better)
Control Chat Groups	2.5	4.25	3.25	3.25	3.3125
Experimental Chat groups	5.5	2	4	1.5	3.25

The aggregated rankings of the control and experimental groups show that the experimental groups ultimately had a slightly higher ranking in terms of the average ranking of all four learning quality measures. Thus the hypothesis of the experiment is confirmed.

Having established the learning quality of the chat groups based on the ranked position of their four learning quality measures, these findings were merged with the qualitative analysis discussed in Chapter 4. What follows is a discussion of the qualitative data collected in this study with the purpose of understanding the learning quality rankings. In doing so I hope to shed insights into the ranking of the groups according to their learning quality and explain the impact of LTF-statements made during the experiment.

5.2.2 Findings crystallised from the qualitative data analysis

The somewhat radical discrepancies between the expected and actual findings that crystallised from the quantitative data analysis regarding the learning quality between the participating chat groups were obvious. It subsequently required investigation for which the findings that crystallised from the qualitative data analysis provided the means. This was the object of this paragraph. As the merging of the data regarding the experimental groups lay at the heart of this study, the order in which the chat groups were discussed was as follows: firstly I discussed the control chat groups' learning quality starting with the chat group with the lowest quality of learning. Then I progressed to the control chat group with the highest quality of learning. To this effect, the sequence of control chat groups discussed was: Control Chat Group 2, Control Chat Group 3, Control Chat Group 1 and finally Control Chat Group 4. Thereafter the learning quality of the experimental chat groups were discussed, once again starting with the experimental chat group which had the lowest learning quality. Thus, the sequence of learning chat groups was: Experimental Chat Group 1 and then Experimental Chat Group 2. By conducting the discussion on the learning quality of the group in this sequence, my analysis of the groups built towards the climax of this study where the influence of learning task feedback statements in the experimental groups were be analysed against the backdrop of the learning quality of all the other groups in the experiment. It should be noted that the ranked position for all four learning quality measures were listed at the start of the discussion of each chat group as an introduction to the discussion on the group's learning quality rating.

5.2.2.1 Interpretation of Control Chat Group 2's quantitative data

Table 5.6: Control Chat Group 2's learning measure rankings

Group	Measure 1: Participation in-equity ranking	Measure 2: Productivity ranking	Measure 3: Adherence ranking	Measure 4: Challenge ranking	Average Ranking as Learning Quality Rating (less is better)
Control Chat Group 2	4	6	3	4	**4.25 (6th place)**

Control Chat Group 2 had the lowest quality of learning of all the groups. To be clear – when compared to the learning quality of the other groups in the experiment, Control 2 ranked the lowest. This does not, however, mean that the group did not have a high level of learning quality. Interestingly, analysing the group data told the story of a well-functioning group. They had an average measure of adherence (3rd in the experiment) and a slightly below-average level of participation in-equity and challenge (they were rated 4th in measures 1 and 4).

a. Insights gleaned via a qualitative lens provided by the first focus group interview

A study of the qualitative data confirms that this group experienced an ample amount of growth through resolving the real-life challenge of the experiment. The data indicated a healthy engagement with the real-life challenge as the participants understood that by resolving this challenge they could contribute to the lives of others. They experienced cooperative learning positively and were also grateful for the anonymous nature of the discussion which, according to the participants, benefited the discussion in various interesting ways. An example being the fact that the anonymity decreased the amount of joking and helped to keep the participants focused on the challenge.

Participants also expressed an appropriate emotional response to the real-life challenge. Evidence suggested a suitable amount of frustration experienced by participants, transitioning into joy when the challenge was resolved. How does one then account for the fact that this group was rated as the group with the lowest quality of learning? Looking at the quantitative data through the lens of the qualitative data, the emerging answer to this question was as follows: the participant who made the most utterances during the discussion had previously encountered this real-life challenge.

Participant G4L3's grandparents used to live in a shack. Having previously experienced the real-life challenge posed by the experiment, participant G4L3 was thus already equipped with skills, attitudes and values with which to resolve

the challenge. By accessing skills located in the Static Domain of Actual Development, the level of difficulty for this participant was quite low. Through the cooperative nature of the experiment, this participant was able to 'help' the other participants in the group which lowered the quality of learning. Evidence of the detrimental effect of this 'help' can be seen in the group's level of productivity, with the bulk of the group discussion ending 65 minutes into the experiment. It can also be seen in the fact that participant G4L3 made most contributions to the discussion, with the percentage of utterances relative to the group increasing over time and the contribution of other participants relative to the group decreasing over time.

To conclude, analysing the quantitative data of Control Chat Group 2 through the lens of the qualitative data has proven invaluable in explaining what initially appeared to be a contradiction of a highly functional group getting rated as having the lowest quality of learning. Traditionally a group that functions well without any obvious signs of struggle would be indicative of high learning quality. In fact, I would argue that traditionally teachers would wish for all the groups in their classes to tackle problems in such a manner that struggle is minimised and challenges are resolved quickly and efficiently. However, an understanding of the process of learning according to Vygotskian tenets highlights the fallacy of equating a lack of struggle with quality learning. In fact, the opposite is true as can be seen in the case of Control Chat Group 2.

As the leader of the group (so classified due to the most utterances made) experienced the challenge within the Static Domain of Present Development, there was no need for growth or development of any kind as the human attributes needed to resolve the challenge was perceived to already be present. In discussing the challenge with fellow group members, G4L3 then shared these previously acquired attributes with group members which negated the need for them to struggle with the challenge any further. The group then simply took its cue from the experiences of G4L3 and quickly resolved the challenge accordingly. Thus, we find that a group that had outwardly appeared to have been functioning

better than other groups in the experiment had, in fact, not experienced a great amount of struggle in resolving the challenge. Thus, the quality of learning in this group was lower than that of other groups.

5.2.2.2 Interpretation of Control Chat Group 3's quantitative data

Table 5.7: Control Chat Group 3's learning measure rankings

Group	Measure 1: Participation in-equity ranking	Measure 2: Productivity ranking	Measure 3: Adherence ranking	Measure 4: Challenge ranking	Average Ranking as Learning Quality Rating (less is better)
Control Chat Group 3	2	2	5	4	**3.25 (4th place)**

Control Chat Group 3 had the highest quality of learning across all groups when rated only by Measure 1 and Measure 2. A low level of adherence moves them down the ranking as this group spent most of their utterances throughout the discussion on mainly type SD- and type SE-utterances. By rating the perceived level of difficulty of the real-life challenge as being 5, the quality of learning drops further as this group initially experienced the level of challenge as being low.

a. Insights gleaned via a qualitative lens provided by the first focus group interview

It was interesting to see that the main insight gleaned from a merging of the quantitative and qualitative data of Control Chat Group 3 concerned the response to the real-life challenge. Participants of this group appreciated the fact that the real-life challenge was located within their lived experience of reality, as opposed to the problems they are usually presented with at school which all tend to be abstract. The group attributed their strong emotional response, which can be seen where participants worry about the hygiene of people living in shacks, to this 'real-life' nature of the challenge. It is this emotional response that seemed to be at the root of Control Chat Group 3's high level of participation and productivity. The participants felt that the challenge was important enough for them to be active participants in resolving it. Their perception of the importance of the challenge can also be seen in the fact that they initially experienced the discussion as being

challenging and then their anonymity gave them enough confidence to quickly move past their initial point of struggle to a place where they were more comfortable, from whence the relatively low level of challenge reflected in the data.

Seen in isolation, the data describing the quality of learning for this group paints a very positive picture. It is only in relation to the other groups that the quality of learning is lower – mainly due to the low level of adherence. It would have been interesting to see the extent to which learning task feedback statements (as the pedagogical intervention proposed by Facilitating Learning) could have increased the adherence rating of this group. Being a control group where Facilitating Learning was purposefully withheld does, however, serve as an argument for the case that Facilitating Learning should always be present to ensure that optimal learning takes place. By leaving a group to struggle without Facilitating Learning, you as the facilitator of learning are gambling with the quality of learning as the quality becomes wholly dependent on the participants' performances. Without Facilitating Learning it is still possible for a strong group to have a high measure of adherence, but as we see here it is just as likely that the group spends the predominant amount of their time focusing on only one or two discussion types. Thus, I maintain that it is irresponsible to conduct learning without Facilitating Learning.

As was the case with Control Chat Group 2, I was shocked when a study of the data revealed the level of learning quality for this group to be lower than some of the other groups as this ran contrary to my observations during the experiment. This was an indication that I had to re-assess my biases when it came to identifying the highest quality of learning within the classroom.

5.2.2.3 Interpretation of Control Chat Group 1's ranking

Table 5.8: Control Chat Group 1's learning measure rankings

Group	Measure 1: Participation in-equity ranking	Measure 2: Productivity ranking	Measure 3: Adherence ranking	Measure 4: Challenge ranking	Average Ranking as Learning Quality Rating (less is better)
Control Chat Group 1	1	4	4	3	**3 (3rd place)**

Control Chat Group 1 had the third-highest quality of learning in the experiment, which can mainly be contributed to their low level of participation in-equity (at 1st place they had the lowest level of participation in-equity between all the groups).

a. Insights gleaned via a qualitative lens provided by the first focus group interview

Of all the groups in this study, the participants of Control Chat Group 1 showed the greatest amount of appreciation for the value of diverse viewpoints during the discussion of the experiment. In their focus-group interview they implicitly refer to different viewpoints of participants and how these viewpoints shaped the group's understanding of the real-life challenge. The participants also communicated that the anonymous nature of the experiment had equipped them to be highly functional participants in the discussion section (no judgement, no shyness, etc.), which in turn contributed to a positive sense of teamwork. This can explain the fact that this group had the highest participation equity in the experiment. Aside from the participation equity, the data also provided a deeper understanding of how this group experienced the real-life challenge's level of difficulty.

The participants of this group collectively rated the challenge of the experiment as being 5.5 (which was the 3rd highest difficulty rating in the experiment). Based on the quantitative data we are thus left to conclude that this group's perception of the difficulty of the challenge was 'average'. However, when viewed through the lens of the qualitative data we glean valuable insights into the experiences of

the participants represented by this 'average' number. Firstly, the data suggests that the experienced level of difficulty shifted for these participants.

Initially, they found the challenge to be daunting, especially the fact that they would be required to work together as a group to resolve the challenge. Emotive adjectives like 'scared' and 'afraid' suggested a high level of emotional investment where participants feared not being able to succeed in resolving the real-life challenge. This explained the relatively high challenge rating of 6 given by two of the participants of the group. As the experiment progressed the level of difficulty seemed to shift as the participants became more comfortable in the discussion, which explained the comparatively low challenge of 5 given by the other two participants. I believe that this movement from a high level of challenge to a lower level of challenge can be seen as an expanding Dynamic Domain of Self-Transcendence, where a challenge is initially perceived to fall within the Static Domain of Proximal Development (outside of the participants current set of expertise), and then subsequently as development takes place the participant acquires that which is needed to resolve the challenge. In terms of the visual aid provided by the DOST (see below), this process would be indicated as an increase in the amount of area covered by the Dynamic Domain of Self-Transcendence.

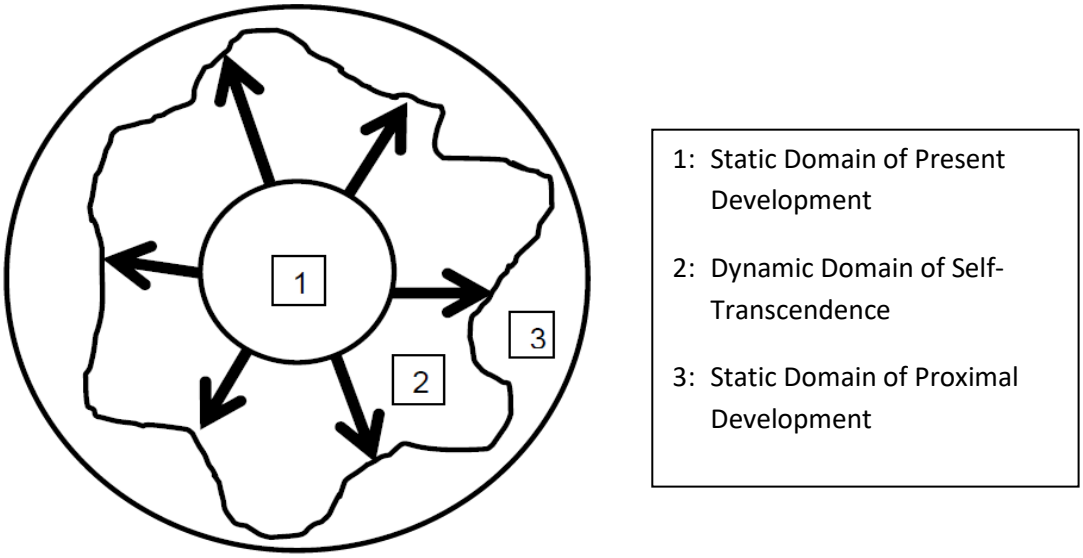


Figure 2.2: The Domain of Self-Transcendence

To put it differently, the potential growth that it is possible for a participant to experience at present (represented by the Static Domain of Proximal Development) is being realised/utilised/claimed (represented by the growing Dynamic Domain of Self-Transcendence) through the engagement of the real-life challenge posed to participants in this experiment.

So, we can conclude that Control Chat Group 1's overall ranking of 3rd place in terms of learning quality can firstly be accredited to the fact that the group authentically engaged with the real-life challenge. This engagement set the scene for participants to make use of the group's anonymity in order to cooperatively struggle with the challenge and develop the necessary human attributes which allowed them to resolve the challenge. Evidence of these attributes, representing the quality of learning and the amount of growth experienced by participants, can be found in the qualitative data (in the form of participants comments) referring to the development of skills, knowledge, attitudes and values which includes references to divergent thinking, .metalearning, critical thinking and empathy gain.

5.2.2.4 Interpretation of Control Chat Group 4's quantitative data

Table 5.9: Control 4's learning measure rankings

Group	Measure 1: Participation in-equity ranking	Measure 2: Productivity ranking	Measure 3: Adherence ranking	Measure 4: Challenge ranking	Average Ranking as Learning Quality Rating (less is better)
Control Chat Group 4	3	5	1	2	**2.75 (2nd place)**

As can be seen in the table above, despite an average level of participation in-equity (this group was ranked 3rd amongst 6 chat groups) and a low level of productivity (in 5th position this group's productivity was the second-lowest of all 6 groups) this group had the highest overall quality of learning of all the control groups and the second-highest quality of learning in the experiment. Studying the learning measures, this high level of learning can be contributed to the high

measure of adherence (in 1st position this chat group had the highest adherence amongst all 6 groups) and a high level of challenge (2nd place between all groups).

a. Insights gleaned via a qualitative lens provided by the first focus group interview

The primary insight gained regarding the experiences of the participants of Control 4 was that they had experienced an immense amount of struggle when resolving the real-life challenge posed to them. More than any other control group, the participants of Control 4 commented on how difficult it was to come to a consensus on the solution for the real-life challenge. A range of different solutions proposed by the participants led to conflict where one participant verbalised that all three of the ideas put forward by the participant were rejected by the group. Ultimately the group was forced to vote on the best solution and even then, only 3 of the 4 participants agreed with the chosen solution.

On an emotional level, we see that initially there was a great deal of frustration in the group. The intensity of the emotions experienced could be traced to the fact that the participants were emotionally invested in the real-life challenge – the resolving of which, according to the participants, would impact the actual lives of others. They appreciated the fact that it was a challenge beyond the bounds of the school environment and saw the value in struggling with a challenge in preparation for the day when they were going to leave school. The initial amount of struggle experienced also indicated that the group perceived the challenge to be located within the Static Domain of Proximal Development. As the discussion progressed and they started to resolve the challenge, the frustration gave way to a sense of accomplishment. This indicated that development (represented by the Dynamic Domain of Self-Transcendence) took place to the extent that they were able to resolve a challenge which was initially beyond the complexity of any existing experiences. This emotional arch from a struggle to a sense of achievement thus reflects Vygotsky's ZPD learning theory.

In acquiring a wide range of skills, knowledge, attitudes and values (identified by participants in the qualitative data), these participants affirmed the high level of

learning that took place during the experiment. As a side note, it is worth mentioning that many of the acquired skills were the direct result of the conflict experienced between the participants.

5.2.2.5 Interpretation of Experimental Chat Group 1's quantitative data

Table 5.10: Experimental Chat Group 1's learning measure rankings

Group	Measure 1: Participation in-equity ranking	Measure 2: Productivity ranking	Measure 3: Adherence ranking	Measure 4: Challenge ranking	Average Ranking as Learning Quality Rating (less is better)
Experimental Chat Group 1	5	3	5	2	**4 (5th place)**

I came to an apparent paradox when analysing the data of Experimental 1. How can a facilitated group have the second-lowest quality of learning? I believed that the answer to this question was paramount to the findings of this experiment. Unravelling the paradox started with the study of the first quantitative measure. A high level of in-equality can be attributed to the fact that participant G2L1 made very few contributions to the group discussion.

In terms of Measure 2, the group made a total of 224 utterances with an average contribution per participant of 56. Despite being the participant who contributed most to the discussion, G2L2's 76 utterances were still significantly less than the most productive member of Control Chat Group 3 (84) and Experimental Chat Group 2 (151). Measure 3 was concerned with the adherence of the discussion types of utterances to an 'optimal' discussion pattern as envisioned by the facilitators of learning in this experiment. The facilitator of learning in this group made the following learning task feedback statements:

Table 5.11: LTF statements made in Experimental Chat Group 1

Learning task feedback statement	Timestamp	Learning quality measure targeted by LTF statement
Experimental Chat Group 1		
AN EXPERT CANNOT START SOLVING A PROBLEM WITHOUT A GAME PLAN	8:36	Measure 3: Adherence

AN EXPERT QUESTIONS EVERYTHING	8:42	Measure 4: Challenge
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:45	Measure 1: Participation in-equity
AN EXPERT NEEDS TO FIRST IDENTIFY THE REAL PROBLEM	8:47	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	8:52	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	8:55	Measure 3: Adherence
AN EXPERT CAN QUICKLY EXPLAIN HOW TO MAKE THE SOLUTION	9:05	Measure 2: Productivity
AN EXPERT QUESTIONS EVERYTHING	9:21	Measure 4: Challenge
AN EXPERT NEEDS THE INPUT OF EVERYONE	9:22	Measure 1: Participation in-equity

Looking at the statements introduced into the chat it was surprising that the facilitator of learning in this group failed to such a large extent to influence the discussion patterns. Looking at the graphs denoting the group's measure of adherence (Appendix C) we find that the greatest discrepancies with discussion types SD and SE. Whereas the facilitators of learning envisioned these discussion types only to take place later in the discussion, Experimental 1 started suggesting and evaluating solutions within the first 5 minutes of the discussion. To understand this apparent failure, I first attempted to gauge the impact of the learning task feedback statements by identifying responses made by the participants to specific learning task feedback statements.

a. **The effect of learning task feedback statements**

Despite the fact that there were nine learning task feedback comments posted into the discussion, these comments did not translate into a higher measure of adherence. In hindsight, I believe that this can in part be attributed to the fact that the optimal distribution of utterance types is an incredibly intricate pattern which is difficult to facilitate in a short amount of time. To illustrate this point: despite the presence of learning task feedback statements, the participants of Experimental 1 made 23 comments of type PC and CD between 8:27 and 8:37, whereas the

optimal distribution only expected utterances of these types between 8:42 and 8:47. By being less than 20 minutes early with these discussion types the measure of adherence for this group dropped from 60% to 50%. This drop moved their ranking in terms of the quality of learning from being tied in 3rd with Control 3, to being 5th. What this means in terms of this experiment is that the quantitative data was extremely sensitive to small temporal variances. In order to effectively increase the measure of adherence of a group, the response to a specific learning task feedback statement would have to be almost instantaneous, which does not accurately reflect the natural flow of a discussion where a point raised at one moment can 'bear fruit' much later in the discussion.

Studying the responses of participants, we also find that even where they had responded appropriately to learning task feedback, their responses were not extensive enough to reflect in the quantitative data. An example of this can be seen at the start of the discussion when the facilitator of learning noticed that the participants were not orientating themselves. Instead, they were identifying problems and already suggesting possible solutions. In response, at 8:36, the following learning task feedback was posted: "An expert cannot start solving a problem without a game-plan" (Facilitator of Learning, Appendix K, page 4, line 5). One minute later, at 8:37 G2L2 posted: "ok what's our gameplay then" (Appendix K, page 4, line 7). The group then continued to make a further 5 orientation utterances concerning the game plan. Even though their response was appropriate, the effect of 5 utterances was minimal in the context of a discussion with 224 utterances, making the effect of these utterances barely noticeable. Without being able to directly measure the impact of the learning task feedback statements quantitively, the last source of data to consult was the collected interview data. While the data collected in the first focus group interview of the experimental groups were used in establishing the thematic analysis of themes across all groups in the previous chapter, at this point the data collected from the second focus group interview will be used as the qualitative lens for the experimental groups. The reason being that we are now only interested in understanding the experiences of these participants in light of the learning task feedback statements they were exposed to. While any data regarding these

statements were ignored in the collected data of the experimental groups in the previous chapter, now the focus will shift to the second focus group interviews where participants were explicitly asked what the impact of the learning task feedback statements was.

b. Insights gleaned via a qualitative lens provided by the second focus group interview

The participants indicated that they had understood all the learning task feedback utterances, except for one: “An expert can list a set of criteria to evaluate a solution.” G2L2 found this statement especially confusing, as English is not his home language, stating: “I did not understand it” (G2L2, Appendix Q, line 30). It is thus to be expected that the CD utterances made in this group amounted to only 1% of the total amount of utterances made as the learning task feedback statement meant to promote more of these types of utterances was not effective.

In the face of these results, where the facilitator of learning seemed to have failed to bring about higher quality, I was tempted to come to one of the following conclusions:

- That FL does not have the amount of impact on the quality of learning which I had initially suspected.
- That the facilitator of learning within this group was not skilled enough to facilitate learning effectively.
- That the learning quality measures I had identified were flawed and did not accurately measure learning quality.

I was also confused by the ranking of this group in 5th place, as during the process of analysing the discussion I got the impression that this group was highly functional, in sync with one another as individuals and effective in resolving the challenge. Even when viewed through the lens of the qualitative data, the low learning quality rating of this group baffled me. I came to suspect that the conundrum of this group’s low ranking (while having been facilitated) lay at the

heart of this study. It was a mystery which to my mind hinted of unseen complexity – or to reference the first chapter of this study – the performance of Experimental Group 1 became a symbol for me of the dark matter surrounding the link between Facilitating Learning and a measurable increase in learning quality. However, it was only when I studied the merged findings of Experimental Chat Group 2, against the backdrop of the learning quality of all the other chat groups in the experiment, where the conundrum that is the learning quality of Experimental Chat Group 1 was finally addressed.

5.2.2.6 Interpretation of Experimental Chat Group 2's quantitative data

Table 5.12: Experimental Chat Group 2's learning measure rankings

Group	Measure 1: Participation in-equity ranking	Measure 2: Productivity ranking	Measure 3: Adherence ranking	Measure 4: Challenge ranking	Average Ranking as Learning Quality Rating (less is better)
Experimental Chat Group 2	6	1	2	1	**2.5 (1st place)**

Starting with the first learning measure, it is surprising to see that this group had the highest participation in-equity of all the groups. As this high participation in-equity in this chat group asserted itself quickly during the experiment I had the initial perception that this struggling group would not have a high learning quality at all. In contrast to the low level of participation equity, however, this group had the highest level of productivity (Measure 2). Moving on to the 3rd measure, we see that this group had the second-highest measure of adherence of all the groups. As the level of adherence was the main focus of the Facilitating Learning (in the sense that the facilitators of learning prompted their group to reflect on utterance types in an effort to get them to follow the optimal discussion pattern as laid out by Poole and Holmes (1995)), the question became: could I measure the extent to which this group's measure of adherence can be attributed to learning task feedback statements made by the facilitator of learning?

a. **The effect of learning task feedback statements**

The learning task feedback statements made by the facilitator of learning in this chat group can be seen in the table below:

Table 5.13: LTF statements made in Experimental Chat Group 2

Learning task feedback statement	Timestamp	Learning quality measure targeted by LTF statement
Experimental Chat Group 2		
AN EXPERT CANNOT START SOLVING A PROBLEM WITHOUT A GAME PLAN	8:35	Measure 3: Adherence
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:36	Measure 1: Participation in-equity
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:42	Measure 1: Participation in-equity
AN EXPERT QUESTIONS EVERYTHING	8:44	Measure 4: Challenge
AN EXPERT NEEDS TO FIRST IDENTIFY THE REAL PROBLEM	8:50	Measure 3: Adherence
AN EXPERT NEEDS THE INPUT OF EVERYONE	8:56	Measure 1: Participation in-equity
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	8:59	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	9:09	Measure 3: Adherence
AN EXPERT CAN LIST A SET OF CRITERIA TO EVALUATE A SOLUTION	9:20	Measure 3: Adherence
AN EXPERT NEEDS THE INPUT OF EVERYONE	9:23	Measure 1: Participation in-equity
AN EXPERT CAN QUICKLY EXPLAIN HOW TO MAKE THE SOLUTION	9:24	Measure 2: Productivity

Studying the 11 learning task feedback comments made by the facilitator of learning during this group's chat, utterances that are an obvious, direct response to learning task feedback statements are few and far between. One example can be found where the facilitator of learning posted the following statement in the discussion at 8:35: "An expert cannot start solving a problem without a game plan" (Facilitator of Learning, Appendix L, page 4, line 11). G3L1 responded to the statement by writing: "so guys we need a game plan" (Appendix L, page 5, line

2). This was the only utterance directly referencing the concept of the game plan. Some of the other learning task feedback statements did not have one single response that could obviously be linked with them.

To find a link between a learning task feedback statement and a specific utterance type which coincided with that statement, I attempted to correlate statements made with specific graphs showing adherence to utterance types (Appendix D). The facilitator of learning made five learning task feedback statements concerning orientation (type OO), one statement regarding problem analysis (type PA) and one statement regarding criteria development (type CD). Of these three utterance types, only the adherence graph for OO showed an increased measure of adherence. Type OO-utterances were, however, expected throughout the discussion in all the phases making it difficult to ascertain whether learning task feedback statements were the cause of this high level of adherence. Thus, any group which excelled at type OO-utterances (as was the case with this group) would have an increased measure of adherence. Thus, to my disappointment, I had to conclude that I was not able to quantitively measure the extent to which the Facilitating Learning influenced the measure of adherence of this group.

b. Insights gleaned via a qualitative lens provided by the second focus group interview

Working through the transcript of the second amended focus group interview it became apparent that three of the four participants felt that FL increased the quality of learning in the discussion by engendering the acquisition of intra- and interpersonal skills and by adjusting the level of difficulty throughout the discussion as was needed. Their answers also validated the quality of the LTF statements in stating that the statements made resolving the challenge both easier and harder. On the one hand, they found a measure of comfort in a form of guidance provided by the learning task feedback statements (where they were, for example, required to reflect on the discussion types of the utterances they were making), but on the other hand, these statements made them more aware of how great the level of challenge truly was, which in turn necessitated an

increase in the required energy and focus of participants. As the Facilitating Learning constantly required them to reflect (metalearning), we also see a possible reason for the high measure of participation in-equity. As participants were called to reflect, the willingness of certain participants to participate was stifled by learning task feedback statements that engendered a sense of uncertainty. Ironically, it seems to be this very sense of uncertainty that elevated the level of challenge experienced by the participants in the group which in turn increased the overall ranking according to the learning quality measures. This brings me to the innermost core of this study, namely: how did the presence of learning task feedback statements increase the quality of learning in the experiment?

c. How did the act of 'Facilitating Learning' bring about increased learning quality?

Analysing comments made by participants in the experimental chat groups, the data suggested that the act 'Facilitating Learning' engendered uncertainty within learners, requiring them to "think more", "act more like grown-ups" and "start working together - not like we usually do" (G2L2, Appendix Q, line 69). Thus, we see that the real-life challenge was moved by learning task feedback statements into the Static Domain of Proximal Development, which in turn required learners to grow in order to resolve it. In addition to this finding, another causal link presented itself in the data which goes even further in detailing how 'Facilitating Learning' brought about this uncertainty.

According to Table 4.3, participant G2L2 experienced the difficulty of the challenge in Experimental Chat Group 1 as being four out of a possible ten. Participant G2L2 also happened to be the participant who contributed the most utterances to the chat and was thus the most influential participant in the group. Following a hunch, I went to the quantitative data of the other groups to determine who the most influential participants were and how difficult these participants experienced the challenge. My findings are represented in the table below:

Table 5.14: Level of difficulty experienced by most influential participants

Chat Group	Most influential participant	Experienced level of difficulty
Experimental Chat Group 1	G2L2	4
Experimental Chat Group 2	G3L3	8
Control Chat Group 1	G1L3	5
Control Chat Group 2	G4L4	4
Control Chat Group 3	G5L1	5
Control Chat Group 4	G6L4	7

If we sort the groups according to the experienced level of difficulty, we find the following:

Table 5.15: Sorted level of difficulty experienced by most influential participants

Group	Most influential participant	Experienced level of difficulty
Experimental Chat Group 2	G3L3	8
Control Chat Group 4	G6L4	7
Control Chat Group 1	G1L3	5
Control Chat Group 3	G5L1	5
Experimental Chat Group 1	G2L2	4
Control Chat Group 2	G4L4	4

Interestingly, the order of the groups in the table above mirror the ranking order of the groups according to their overall learning quality to a great extent, as can be seen in the table below:

Table 5.16: Casual link between learning quality ranking and the level of difficulty as experienced by the most influential group member

Position	Discussion	The level of difficulty as experienced by the most influential group member
1st (highest quality of learning)	Experimental 2	8
2nd	Control 4	7
3rd	Control 1	5
4th	Control 3	5
5th	Experimental 1	4
6th (lowest quality of learning)	Control 2	4

Thus, we see an incredibly strong correlation in the data between the level of difficulty experienced by the most influential participant in a group and the overall learning quality ranking of that group. At the risk of oversimplifying this causal link, the data seemed to suggest that the quality of learning in a group was greatly influenced by the extent to which the most influential member of the group percieved the challenge as being difficult. The easier the perceived level of challenge by the most influential participant, the lower the quality of learning in the group. It is the link that helped to explain the low level of learning quality in Experimental Chat Group 1.

d. Explaining the low learning quality of Experimental Chat Group 1

From the start of the transcription of Experimental Chat Group 1's dialogue during the experiment, it was apparant that G2L2 not only provided a great amount of insight into the challenge (and the solution to resolve the challenge) but that a large amount of utterances made by G2L2 were aimed at managing the interactions of fellow participants, as can be seen in the following examples: "Great … give us your idea" (Appendix K, page 4, line 8), "Sounds good" (Appendix K, page 4, line 10) and "I'm talking about your idee …" Reading through the transcript of the discussion, I saw that the flow of the conversation was quite constant with very little hiccups or impasses, which could be contributed in part to the managing role played by G2L2. So, the following underlying truth started to emerge: In Experimental Chat Group 1, an influential participant (G2L2) experienced the challenge to be located firmly within his/her Static Domain of Present Development, allowing this skilled learner to assist his group through mediating a discussion which led to a resolution. Using skills, attitudes and values that were already developed, this participant did not experience the level of difficulty as being very high and found the challenge 'easy' to resolve, similar to the case of Control Chat Group 1.

Remarkably, even though the other participants in the group experienced the challenge as being difficult (between the three of them they gave the challenge an averaged difficulty rating of seven out of ten) the efficiency/flow/synergy of the

discussion rather reflected the experience of G2L2. In studying the transcription of the discussion I had the distinct sense that the challenge was easily resolved by this group. As was the case in Control Chat Group 1, the skills needed to resolve the challenge was already present within the existing framework of the 'leader' who shared his/her experiences with the other participants in the group. This, in turn, meant that the amount of growth needed to resolve the challenge was not that extensive, which in turn lead to a comparatively low quality of learning. Thus, the low learning quality of Experimental Chat Group 1 can be attributed to the fact that the learning task feedback statements made by the facilitator of learning failed to increase the perceived level of challenge of participant G2L2. To put it differently, the real-life challenge was located within the Static Domain of Present Development of G2L2 and the learning task feedback statements could not shift the challenge towards the Dynamic Domain of Proximal Development.

One way of ascertaining the credibility of the explanations for ranking of these chat groups was to conduct a literature control, where my findings were compared with existing literature (Mouton, 2006). Once the literature control was completed, the findings could then be used to answer the main research question of this study.

5.3 Literature control

At the heart of this research lies the question of the extent to which a pedagogical intervention (learning task feedback statements) impacts the quality of cooperative learning in an online environment. Aside from using quantifiable measures to rate the quality of learning of groups aided by FL versus groups without it, qualitative data was also gathered to gain deeper insights into the quantitative results. Thus the literature control will compare the merged quantitative and qualitative data with highlights from the existing literature. As the interpretation of the quantitative data had been done according to the rankings of a group's learning measures, the literature control will correlate examples from

the existing literature with the generated data of this study grouped according to these learning measures.

5.3.1 Literature that supports the findings in this research

As discussed in my literature review, the format of the experiment was crucial if it were to meet the criteria of the highest quality of learning and there is a strong correlation between that which is proposed by the literature and the data generated in this study. The correlation between the views put forth by the literature and the data generated in this study will be grouped according to two themes, namely: 'The type of challenge presented to participants' and 'The effect of learning task feedback statements'. Between these two headings all the literature concerning this study can be used to reflect either on the nature of the challenge posed in experiment (experienced by both control and experimental groups) or the effect of FL (experienced only by the experimental groups). These correlations are detailed in the table below:

Table 5.17: Correlation between findings of the study and existing literature

Theme	Author and year	Existing literature	Correlation in findings
The type of challenge presented to participants of the experiment	Jonassen, 2000	Ill-structured problems (used by Kapur) require learners to make judgements.	Participants described the cooperative learning in the experiment as a space where they had to "decide as a group" (G1L3, Appendix R, line 8) what the solution would be. "you would have to like, learn what to get rid of" (G3, Appendix T, line 13).
	Barnett, 2004	The challenge presented to learners should reflect a super-complex world.	The nature of the real-life problem required groups to come up with "new ideas" (G3, Appendix T, line 3). "It requires many understandings towards a real-life situation. It's not you against the world, it's us against the world's problems" (G2, Appendix S, line 3). Other participants noted that a real-life challenge needs "creativity to be solved" (G4L4, Appendix U, line 8).

	Claxton, 2007	Real-life is a necessary requirement for learning.	Some participants in Control 1 described the real-life challenge as “an opportunity to improve the lives of others” (G1L2, Appendix R, line 78) and a “life problem” (G1L3, Appendix R, line 83). It “affects the world globally” (G1L4, Appendix R, line 89). “I thought it was very cool and creative, considering that a lot of South Africa lives in shacks/squatter camps” (G2L3, Appendix S, line 2).
	Lombardi, 2007	Authentic challenges focus on real-world, complex problems.	
	Lam and Low, 2016	Real-world problems are needed for learning.	
	Claxton, 2008	Challenges presented to learners must elicit uncertainty.	“It felt a bit weird, because uhm ... it’s a real-life problem, and you have to try and make a solution for it so it is a bit tricky if you think about it” (G4L2, Appendix U, line 41).
	Bozhovich, 2009	The problem given to learners needs to be novel.	“I knew that like, uhm, it would be a little bit difficult, like, in some cases because to think of something new is really hard because all the nice things have already been thought of” (Appendix U, line 27). The experiment “was much different from other exams” (G5L2, Appendix V, line 5).
	Slabbert, et al., 2009	Authentic real-life challenges elicit a high level of intra-personal motivation since they can link the challenge with their own everyday experiences. The aim of the learning task presentation is to bring about an emotional response towards the real-life challenge.	“… it was an eye opener to see how people lived” (G3L1, Appendix T, line 5). “I began to feel privileged” (G1L4, Appendix R, line 55), “don’t take small things for granted” (G1L3, Appendix R, line 56), “there is [are] people barely making it out there” (G1L4, Appendix R, line 62). The group “was really bothered about hygiene in townships” (G5L1, Appendix V, line 3). “I also thought it was on a bigger scale because at school our problems are small, this is someone’s life that you are playing with” (G6L1, Appendix W, line 6).
	Tan, 2016	Learners need to be compelled to search for possible solutions in the problem space.	
	Zull, 2011	Problems presented to learners must be challenging.	“it was a bit difficult because it’s a problem that you know really exists” (G4L2, Appendix U, line 18). It was “challenging” (G4L2, Appendix U, line 28; G4L3, Appendix U, line 29). Participants in this group seemed to have initially experienced the experiment as being “challenging” (G5L2, Appendix V, line 13).

			"I enjoyed the experience, it was a little difficult though" (G5L1, Appendix V, line 39).
The effect of learning task feedback statements	Slabbert, et al., 2009	The facilitator of learning makes specific comments that will increase the quality of learning.	"I felt like it made us work harder, it helped us think a little bit more out of the box" (G3L1, Appendix Q, Group 3, line 89). "I think it made it easier in certain situations but also made it more challenging in other situations because we had to put more effort into it" (G2L3, Appendix Q, line 70).
	Motta, 2016	Facilitating Learning needs to encourage learners to think about their own thinking.	"It's helping us to actually find our way through this, through the exam of ... trying to figure out what we all need to do, what's our part in this and what's going to happen eventually" (G2L1, Appendix Q, line 82).

As can be seen in the table above, the data gathered in this study closely mirrors high quality learning as defined in the literature. Ranging from the nature of the challenge presented to learners (Barnett, 2004; Claxton, 2007; Lombardi, 2007; Bozhovich, 2009; Zull, 2011; Lam and Low, 2016) to nature of the response expected from learners (Jonassen, 2000; Claxton, 2008; Slabbert, et al., 2009; Tan, 2016) it seemed that the experiment of this study correlated with the literature's understanding of highest quality of learning. There was also a strong correlation between the data gathered in this study and the litearture's stipulations of actions that define 'Facilitating Learning' (Slabbert, et al., 2009; Motta, 2016). These correlations increased the credibility of the experiment as being a learning task of the highest quality of learning in an online setting, which in turn added validity to the data gathered on the impact of FL in such a setting. However, there was also some dissonance to be found between the experiment of this study and the literature.

5.3.2 Literature that contrasts the findings in this research

Although the contrasts were not as numerous as the correlations, it was still valuable to note those areas where the findings of this study diverged from examples of existing literature. Interestingly, these contrasts only concerned one of the themes discussed in the correlating data, namely 'The effect of learning task feedback statements':

Table 5.18: Contrasts between findings of the study and existing literature

Theme	Author and year	Existing literature	Contrast in findings
The effect of learning task feedback statements	Kapur, 2008	There is a danger when facilitators of learning 'help' learners.	"It made it easier, yet in the same sentence more difficult. Because we had to think more, we had to act more like grown-ups, start working together - not like we usually do - but also easier cause its hints and tips to make us think as one" (G2L2, Appendix Q, line 69).
	Lee & Song, 2016	A facilitator of learning needs to encourage a group to create more resistance.	"We have to think about others and sir also said that we have to get the input of everyone" (G2L2, Appendix Q, line 76). "Some of us may have closed off to certain ideas but it made us realise that we have to include everyone and everyone's ideas" (G2L3, Appendix Q, line 78).
	Saoring, et al., 2017	A facilitator of learning helps learners to seek alternative, divergent solutions.	"I'd say it made it easier because it started getting us on the right track, getting everyone on the same page, not anyone strays further and has to drag the others and then the others also have to catch up and force the people who were ahead to actually slow down and explain it more sensibly to the others" (G2L1, Appendix Q, line 72).

The single greatest difference between this experiment and the study of Kapur, et al. (2007), which inspired me to embark on this study, is the presence of FL. Being founded on Vykotskian tenets, I concured with Kapur's point of view that any form of help can be detrimental to the quality of learning taking place in any learning endeavour. However, I also believed that it was irresponsible for a facilitator of learning to allow learning to take place without any form of facilitation, as this leaves the quality of learning that takes place up to chance – totally dependent on the abilities of the learners. Instead, I maintained that a specific type of facilitation (referred to in this study as 'Facilitating Learning') will increase

the quality of learning without 'helping' the learners. Evidence of this was indicated in the table above where participants attempted to describe the duality of FL which benefitted them as a group, but also simultaneously made things more difficult. Aside from Facilitating Learning being present, other contrasts with the literature concerned the role of the facilitator of learning.

As the aim of the study was to measure the impact of Facilitating Learning on an online discussion, the effect of learning task feedback statements should ideally have been measured by the learning quality of adherence. In contrast, Lee and Song (2016) maintain that the facilitator of learning needs to be concerned primarily with creating more group resistance (struggle) during the discussion as this would increase the quality of learning taking place. Although I agree that conflict provides the opportunity for a dramatic increase in the quality of learning taking place (Control Chat Group 4 had the highest quality of learning of all the control groups and specifically referenced conflict as a salient part of their discussion), the online context and subsequent time restrictions imposed on participants during this experiment did not leave room for Facilitating Learning to include goals in addition to that which was to be measured. Even though some of the utterance types would have naturally lent themselves to potential conflict (an example was the problem-critique utterances), the facilitators of learning were effectively restricted by the choice of intervention through pre-formulated learning task feedback statements that would engender contrasting points of view and the conflict that would arise from these contrast. In the same vein, Saoring et al. (2017) states that the facilitator of learning needs to promote divergent solutions in a group. Once again, aside from divergent thinking which was implicitly promoted in specific utterance-types, the time constraints in this experiment did not allow for the facilitators of learning to overtly promote divergent thinking.

5.4 Conclusion

The presentation of these findings could be seen as the final step towards the illumination of the dark matter which lay at the heart of this study, as was indicated in the image below:

Figure 5.1: Galaxy Cluster MCS J0416.1-2403 with an indication of 100% dark matter (European Space Agency, 2015)

By interpreting the quantitative learning measures of each group via their experiences as elicited in the qualitative data, a qualitative explanation of the learning quality per group was presented, building towards an explanation for the low learning quality of Experimental Chat Group 1. Finally, it became apparent that the learning quality of a chat group was determined by the extent to which the learning task feedback statements were able to increase the perceived level of challenge of the most influential member in the chat group. Having also completed the literature control, whereby the credibility of the findings was inspected, it now became possible to answer the main research question of this study using the findings which had crystallised in this research.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This final chapter contains the conclusions reached by responding to the research challenges of the study, meta-analysis of the conclusions (within the context of the holistic integration of the proposed and researched pedagogical intervention) and recommendations for research in the future. In doing so the aim of this research is addressed.

I started by addressing the conclusions of this research by constructing resolutions to the research challenges posed by the study. As is the norm, the research challenges of this study have been indicated in Chapter 1 with a primary research question that was segregated into a number of subsidiary research questions. In pursuing answers to these subsidiary research questions a resolution to the primary research question was attained. As such, the conclusions of this study revolved primarily around the answers to said subsidiary research questions and are presented within the format of the research questions.

6.1.1 Primary research question

The primary research question was formulated as follows:

> **What kind of pedagogical intervention is best suited to pursue the highest possible quality of learning outcome from Grade 9 learners when resolving authentic real-life challenges on a CSCL online platform in a MakerSpace environment?**

However, providing the conclusion regarding the primary research question at this point in time might be premature because it only came forth in the final culmination of the conclusions reached regarding the subsidiary research challenges and its associated subsidiary questions.

In addition, Chapter 1 also eluded to the indicative complexity of the proposed research and that it may be best served by a Multiphase Partially Mixed Sequential Equal Status Design mode of inquiry. In light of the mixed method nature of the inquiry, distinguishing between the quantitative research challenges and the qualitative research challenges seemed appropriate in view of the conclusions.

6.1.1.1 Conclusions regarding the quantitative research challenges

The quantitative research challenges are presented by the first two subsidiary questions and the hypothesis for the experiment, as depicted in Chapter 1.

a. Subsidiary question 1

As I have indicated in Chapter 2 it was the work of Kapur and his co-workers (2007; 2008) that prompted this research on three accounts. The first was an interest in the educational context of ill-structured, complex problems, which broadly corresponded with my educational context of confronting learners with demanding, authentic, real-life challenges. Secondly, we were working within a collaborative kind of learning process. Thirdly, we were interested in the quality of the collaborative learning process. Regarding the latter, it was Kapur and Kinzer's (2007) finding that inequities in individual member participation patterns during collaborative learning − especially in initial reciprocal exchanges − lowers the quality of the learning process and thus the overall learning quality outcome of the group. However, what finally moved me to utilise Kapur and his co-workers' experimental research, was the fact that they had proposed a way in which the quality of the collaborative learning process could be measured. In addition, the fact that all of this can be achieved on-line further coincided with my own drive to transfer my current education practice to the realm of online learning.

It was against this background that I could formulate my first subsidiary question:

> **How can I utilise Kapur and Kinzer's (2007) experiment on participation in-equity to determine the learners' learning**

quality when they resolve authentic, real-life challenges on a CSCL online platform?

The answer to this question was my first conclusion, although it was in fact only the prerequisite for conducting the research. I designed an experiment in which I was able to measure not only participation in-equity, but also productivity, adherence and perceived difficulty. I did this not only to enhance the validity and reliability of the experiment but also to extend the variety of measures that could be recorded throughout the experiment. This allowed me to utilise multiple measurements to determine the learning quality of the learners' learning process which ultimately induced the quality of their learning outcome.

b. Subsidiary question 2

Aside from the many corresponding aspects of this research and that of Kapur, there was an area of divergence between my work and Kapur's (2008) theory of Productive Failure which was confirmed by his experiment (repeated here for the sake of convenience):

> "In a computer-supported collaborative learning setting, eleventh grade science students were randomly assigned to one of two conditions to solve problems in Newtonian kinematics. In one condition students solved ill-structured problems in groups [without any support] followed by well-structured problems individually [with support]. In the other condition, students solved well-structured problems in small groups followed by well-structured problems individually. Finally, all students solved ill-structured problems individually … " (Kapur, 2008, pp. 379)

Students under the ill-structured condition outperformed the students in the well-structured condition, suggesting latent productivity in what initially seemed to be a failure. However, while unsupportive learning may have produced this result, this result was achieved when students were working 'individually'. In addition, Kapur (2008, pp. 379) acknowledges that "[G]roups who solved ill-structured problems expectedly struggled with defining and analyzing the problems,

resulting in poor quality solutions … [and] failing in their collaborative efforts … .” These remarks expose key deficiencies in the theory of Productive Failure and serves as a clear indication that it does not support the attainment of essential socio-constructivist, socio-psychological and interpersonal human qualities that only collaborative learning can produce.

The fact that these deficiencies, present in an unsupportive collaborative learning process (with its inevitable deficient learning quality outcome), had been exposed, afforded an opportunity to have them examined and addressed. I would even go so far as to state that within the context of education professionalism, it was an ethical imperative to intervene purposefully and appropriately to eliminate them. The question to be answered was not whether a pedagogical intervention during the collaborated learning process was necessary, but rather what the best and most appropriate pedagogical intervention would be during a collaborative learning process that will enhance the learning quality of the process and its corresponding outcome. These considerations, in addition to the inclusion of the first subsidiary question, brought about the formulation of the second subsidiary question. Although this question may be regarded as a qualitative research question, it was presented here because it represented the essence of the quantitative experimental work within the context of distinguishing between the experimental and control chat groups:

> **What would represent the theoretical and conceptual framework of/for a pedagogical intervention that explicitly pursues the highest possible quality of individual and collaborative learning that results in its corresponding intended outcome in practice?**

The answer to this question was presented in Chapter 2 where the theoretical and conceptual framework of/for the Professional Practice of Facilitating Lifelong, Authentic Learning (conveniently abbreviated to Facilitating Learning and represented by FL in the text) was explored. Its holistically integrated nature reflects its explicit pursuance of the best and most appropriate pedagogical

intervention in order to produce the highest possible quality learning process, individually and collaboratively with its corresponding outcome.

c. The hypothesis for the experiment

The quantitative investigation of this mixed method research required, within the context of its experimental character, a hypothesis. In view of subsidiary questions 1 and 2, the following hypothesis for the experiment was formulated:

> H_0: If the online CSCL educational experience of my learners in resolving a demanding authentic real-life challenge is not intervened by the professional practice of facilitating learning, the quality of their learning process will not be enhanced.
>
> H_1: If the online CSCL educational experience of my learners in resolving a demanding authentic real-life challenge is intervened by the professional practice of facilitating learning, the quality of their learning process will be enhanced.

In order to test the hypothesis, I designed an experiment with experimental and control groups. While the control groups were subjected only to the contextual experience of being confronted with the task of resolving a demanding authentic, real-life challenge, the experimental groups were additionally subjected to the pedagogical intervention of Facilitating Learning.

According to the findings of this research the average of the joint rankings indicated that the experimental chat groups had a lower overall ranking than that of the control chat groups. This indicated that their learning quality was enhanced above that of the control chat groups and thus the hypothesis was confirmed. On face value, this was an encouraging (and expected) finding.

However, a deeper investigation into the individual performances of the chat groups revealed a surprising discrepancy. Although one of the experimental chat groups was ranked in the first position of the overall ranking of all chat groups (as I had expected), the other experimental chat group was ranked in the fifth of the

possible six ranking positions. This somewhat radical discrepancy demanded an interpretation of the findings beyond its face value, taking into account the larger context of the experiment.

To this effect, such cautionary interpretations have already been alluded to at the beginning of this research when its limitations were exposed and their relevance were reflected on in a meta-analysis of the major findings. In addition to the meta-analysis containing reflections regarding various aspects of the execution of facilitating learning within the experiment of this study, the limitations of the study was also revisited before recommendations towards future research were made at the end of this chapter.

6.1.1.2 Conclusions regarding the qualitative research challenges

With the result of the quantitative research within the context of the hypothesis effectively pending, it was necessary to resort to the conclusions of the qualitative part of the research in order to find clarity about the confirmation of the hypothesis. The qualitative part of this study was directed by the challenges posed by the third and fourth subsidiary questions.

a. Subsidiary question 3

Subsidiary question 3 pertains to the qualitative experiences of all participants in all of the chat groups:

> **What are the experiences of participants in all of the chat groups when being confronted by a demanding, authentic, real-life challenge that they need to resolve?**

There were five themes that emerged in a thematic analysis of the findings of the focus group interviews with all the chat groups:

1. General Theme 1: The reaction to a ‘real-life’ challenge
2. General Theme 2: Navigating cooperative learning
3. General Theme 3: Learning outcomes acquired
4. General Theme 4: Different initial perceptions

5. General Theme 5: An emotional experience

Combined, I submit that the themes provided a convincing argument for a nuanced quality of learning that took place during the course of the experiment irrespective of the pedagogical intervention of Facilitating Learning. The presence of each theme is an indication of the quality of a different aspect of the experiment. The successful identification and implementation of a real-life challenge within the experiment can be seen in the evidence of an emotional engagement with the challenge. As one of many learning outcomes identified, evidence of the requirement of participants to navigate their cooperative learning confirmed the presence of multiple divergent views, which in turn indicated that the 'chats' were highly successful as examples of cooperative learning. The themes even indicated a strong resonance between the experiment and Vygotsky's ZOPD, where some participants experienced the challenge to be within their Zone of Present Development, while others experienced the challenge as being within their Zone of Proximal Development.

To summarize, in all chat groups the participants in this experiment experienced a high quality of learning. The data contributed this high quality to the effective implementation of a real-life challenge where participants were intrinsically (emotionally) motivated to engage in a collaborative setting in order to resolve the real-life challenge.

b. Subsidiary question 4

Subsidiary question 4 pertains to the qualitative experiences of only the participants in the experimental groups who were additionally subjected to the pedagogical intervention of the professional practice of facilitating lifelong authentic learning.

> **How did participants experience Facilitating Learning in the experimental chat groups while being confronted by a demanding, authentic, real-life challenge that they needed to resolve?**

Analysing the findings of the focus group interviews with the two experimental chat groups who were additionally subjected to the pedagogical intervention of the professional practice of facilitating lifelong authentic learning, led to the following emergent themes:

1. Facilitating Learning Theme 1: FL brought about a shift in our thinking
2. Facilitating Learning Theme 2: FL encouraged intra-personal growth
3. Facilitating Learning Theme 3: FL encouraged inter-personal growth
4. Facilitating Learning Theme 4: FL had an impact on the perceived level of challenge

The emergent themes above served two purposes in this study. Firstly they were an indication of whether Facilitating Learning was successfully conducted in the experiment to the extent that the responses of participants corroborated the professional practice theory of and for facilitating authentic, lifelong learning as presented in Chapter 2. In this regard, these themes suggested that the Learning Task Feedback statements encouraged both intra- and interpersonal growth by bringing about a shift in the thinking of participants. Going back to Vygotsky's ZOPD, it was also evident that the statements moved participants' initial perception of the real-life challenge from their Zone of Present Development to their Zone of Proximal Development, thereby lifting the ceiling of the possible amount of growth they could achieve in the experiment.

To conclude: even though the format of the learning task statements impaired their effectiveness when compared to a facilitator of learning who was physically present within a chat group (and free to make any appropriate statement), it does seem like the statements succeeded in heightening the quality of learning in the groups. As discussed in the limitations of this study, however, the data did suggest that the introduction of learning task feedback statements (in the format conducted in this experiment) did not have a greater impact on the learning quality than other aspects of Facilitating Learning. This challenged my previous view (based on a physical classroom) where I had come to the conclusion that the act of giving learning task feedback had, among all the different aspects of

Facilitating Learning, the single greatest effect on the learning quality. The fact that the measurable learning quality of the control groups was very close to that of the experimental groups served as an indication to me that either the limitations posed on the facilitators of learning (to only use specific pre-formulated learning task feedback statements) OR the virtual nature of and online-chat group evident in this experiment had in fact decreased the effectiveness of learning task feedback statements. This sentiment was echoed in the fact that the learning quality measure of adherence could not successfully indicate a direct link between learning task feedback statements made and comments made by participants as a result of those statements.

6.1.1.3 Conclusions regarding the primary research question

As a reminder, the primary research question is repeated here:

> **What kind of pedagogical intervention is best suited to pursue the highest possible quality of learning outcome from Grade 9 learners when resolving authentic, real-life challenges on a CSCL online platform in a MakerSpace environment?**

In order to answer the primary research question, I needed to unearth the ‘hidden nature’ of the effect of FL in this research. To do this, quantitative data was collected with the aim of indicating whether FL did in fact increase the learning quality of the experimental groups in the experiment. Qualitative data was also collected in order to understand the quantitative data provided by the experiment and thus indicate how the pedagogical intervention of FL brought about the effect indicated by the quantitative data. To this end, a merging of the quantitative and qualitative data was conducted in order to provide a more complete understanding of the experiences of participants in this experiment. To fully answer the main research question, the effect of FL is discussed in two phases. Firstly, the measure of the effect of FL is presented as was made evident through

the analysis of the quantitative data. Secondly, an explanation follows describing how FL achieved this effect.

a. What is the measurable effect of 'facilitating learning' where Grade 9 learners are resolving an authentic, real-life challenge on a CSCL platform within a MakerSpace environment?

The average ranking of the learning quality measures taken across the two experimental groups compared to the average ranking of the learning quality measures taken across the control groups indicated that overall the experimental groups had a lower (therefore better) ranking, as is indicated in Table 6.1 below.

Table 6.1: Comparison between aggregated learning quality of control and experimental groups

Group Type	Average Ranking (lower is better)
Control Chat Groups	3.3125
Experimental Chat groups	3.25

b. How did the action of 'Facilitating Learning' bring about this effect?

The quality of learning in this experiment was improved to the extent that the facilitator of learning was able to raise the most influential participant of the experimental groups' perceived level of difficulty of the real-life challenge. In addition to answering the main research question, a meta-analysis of the information generated by this research led to several secondary findings regarding the online learning process.

6.2 Conclusions reached by conducting a meta-analysis of the findings

In the process of constructing the theoretical scaffolding of this study, including the design of the experiment, I was continually confronted with un-anticipated insights on Facilitating Learning when conducted in an online learning environment. As such, a meta-analysis was conducted on the findings of this research which led to valuable insights. These findings were presented according

to four key functions of facilitating learning as they also are related to in the learning process of paragraph 3.2.3.

6.2.1 Findings regarding the Learning Task Design

The figure below indicates the participation in-equity average for the 'well-structured' and 'ill-structured' groups in Kapur, et al.'s (2007) study:

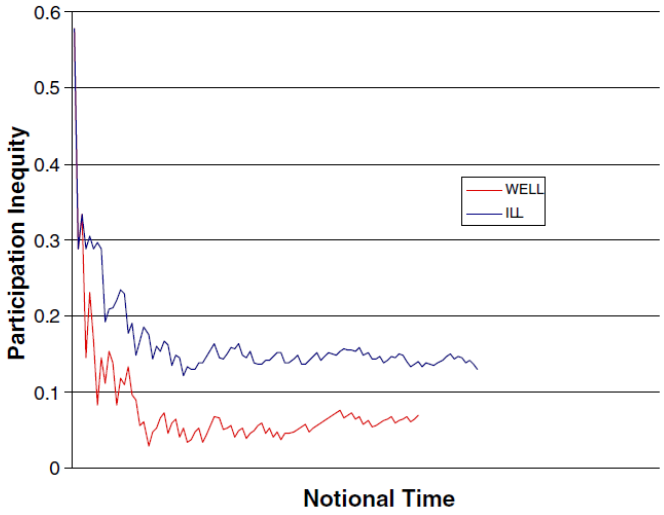


Figure 6.1: Evolution of participation in-equities across problem types (Kapur et al., 2007, p. 58)

The average participation inequity between the experimental and control groups within my experiment is shown in the figure below:

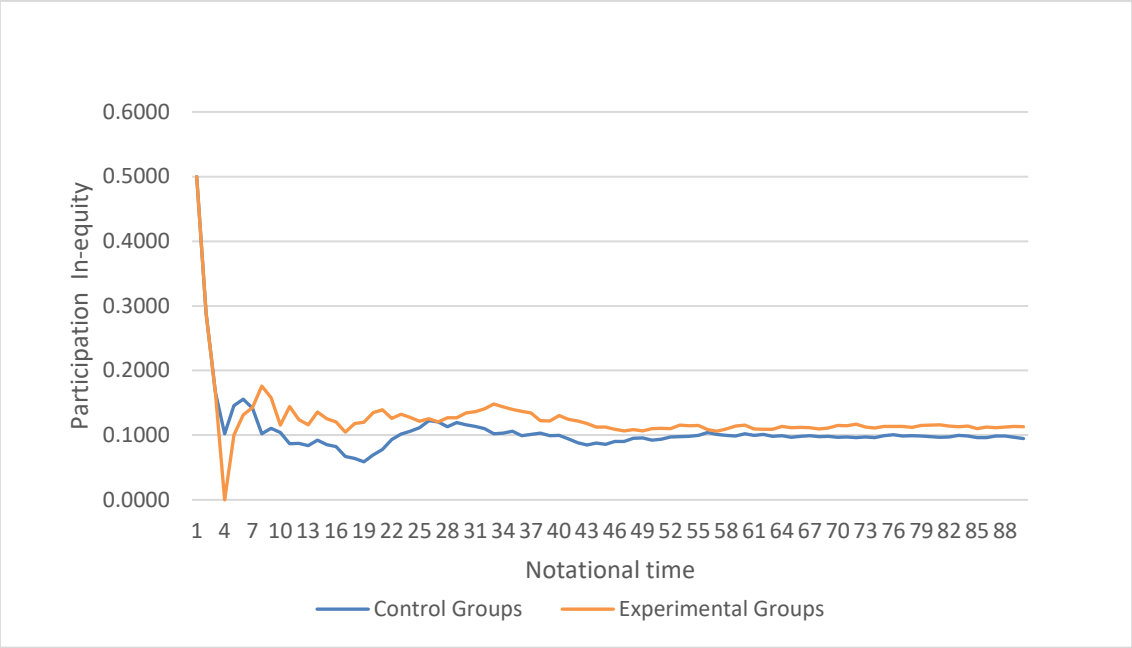


Figure 6.2: Participation in-equities across group types

Between the two figures, there are three lines that represent groups that were in no way facilitated while they were struggling to resolve a challenge. In the case of Kapur, the two lines refer to well-structured and ill-structured problems, both of which are unfacilitated. In the same vein the control chat groups' line in the figure above shows the average of the control groups in this experiment, which were also not facilitated. In his article titled "Productive Learning" (2008), Kapur calls for more research which would enable a form of Productive Failure where groups confronted with ill-structured problems (which he argues deliver better results in the long run) have the same or even lower participation in-equity than groups confronted with a well-structured problem.

What is interesting is the fact that the level of participation in-equity in the control groups of this experiment was significantly lower than the participation in-equity present in the ill-structured groups of Kapur. This means that the real-life challenge presented in this experiment, and the structure surrounding the learning in this experiment, had in fact produced a scenario where learners were faced with an authentic real-life challenge (close in nature to the ill-structured problem of Kapur), yet still produced a low level of participation in-equity during a group discussion.

I ascribe this decrease in participation in-equity to the way in which the learning of this experiment had been designed. More specifically, the sequence where participants were first confronted with the real-life challenge individually (metalearning) before entering the group discussion (cooperative learning). By first giving participants an opportunity to formulate their own opinion on the real-life challenge, there was a lower level of participation in-equity during the group chat.

6.2.2 Findings regarding the Learning Task Presentation

The importance of the learner's authentic engagement with the real-life challenge cannot be overstated, as is made evident by this research. An example can be seen in paragraph 4.4.1.a where the participants of the Control Chat Group 4 had experienced an intense emotional connection to the challenge presented to them. Since they were so emotionally invested in the real-life challenge they responded authentically to the experiment. This highlighted the importance of the presentation phase, where a facilitator of learning must take care that the real-life challenge devised for a learning task will be presented in such a way that it will succeed in eliciting an authentic engagement by learners. This will in turn trigger an intrinsic motivation within the learners to resolve the challenge.

6.2.3 Findings regarding the Learning Task Execution

By successfully executing the learning, a facilitator of learning should expect to see the development of intra- and interpersonal life skills as learners first struggle with the real-life challenge individually and then as a group. For myself, the experiment conducted in this research unveiled a hidden prejudice concerning my perception of quality learning in the classroom.

Even though I have been in the process of becoming a scholar on the highest possible learning quality for almost ten years, this study highlighted my inner bias regarding my perception of what 'quality learning' looks like when learners are in the process of resolving a demanding real-life challenge. As the initial metalearning phase of FL (where learners acquire intra-personal life skills such

as meta-cognition) entails a more private form of learning, this inner bias mainly presented itself during the second phase of FL, namely cooperative learning (where learners acquire inter-personal life-skills such as effective communication). As the learners are required to interact in this phase it becomes easier for a facilitator of learning to gauge the learning quality taking place in a group.

During the quantitative data analysis phase (Chapter 4.3) I was shocked on more than one occasion to see that a group which had appeared to be learning very effectively during the experiment had in fact been ranked as having a low quality of learning. Where my own schooling background and years of teaching have primed me to equate ‘well-functioning’ groups to ‘high quality learning’, the very opposite was revealed by the study to be true. The reason for a group to appear as ‘well-functioning’ can be that the most influential member of that group is experiencing the real-life challenge as being ‘easy’. Thus, only those tools already present within the Static Domain of Present Development are utilised and in fact shared with the rest of the group, lowering the level of challenge for the group. The corresponding need to transcend their current domain of development to resolve a challenge that is at present beyond their current skill level, is also lowered. It was a poignant reminder for me to renew my thinking during the learning task execution phase to be able to more accurately identify groups that require my intervention during the execution phase of a learning task.

6.2.4 Findings regarding the learning task feedback statements

At the end of my Master’s degree I had come to the conclusion that the action of FL (referring specifically to the introduction of learning task feedback statements into group discussions) was the single greatest ‘teaching activity’ that can increase the quality of learning in a group. My visual representation of the Domain of Self-Transcendence, presented as Figure 6.3 and shown below, applies:

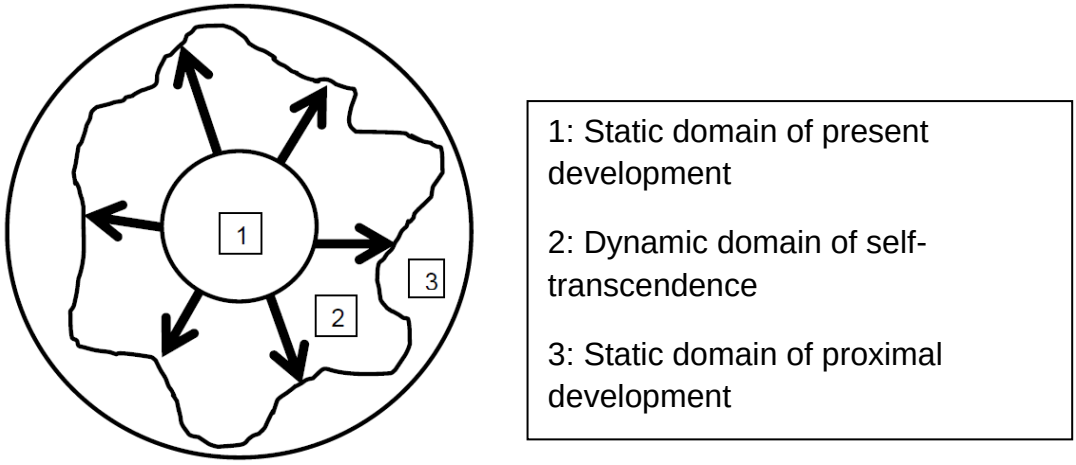


Figure 6.3: A visual representation of the DOST

After my Master's study, I had concluded that Domain 2 would cover the amount of Domain 3 to the extent that the facilitator of learning was capable of introducing appropriate learning task feedback statements. The more knowledgeable the facilitator of learning and the higher the quality of the statements, the greater the amount of possible learning that would take place. Having conducted this research, however, my view on the effect of feedback statements has been altered.

Even though these statements form the primary means in which the facilitator of learning can direct the learning process as learners are engaging with a real-life challenge, the activities of the facilitator of learning which pre-empts this moment are just as important, as is the structure of the learning task. It was interesting to note that even though the graph depicting participation in-equity was similar in form to that of Kapur, et al. (2007), the level of participation in-equity was lower for all groups. Thus, groups had a lower level of participation in-equity irrespective of whether they had a facilitator of learning influencing their chat. I contribute this lower level to the structure of the experiment, where participants first had to struggle with the challenge as individuals. So, we find an increase in the quality of learning that has nothing to do with feedback statements. Aside from the structure of the learning task, the challenge presented to learners also plays a vital role in the learning quality.

As was seen in the qualitative data, most of the participants in this study experienced an intrinsic motivation to resolve the challenge posed to them. According to the data, this can be contributed to the real-life nature of the challenge. As it was a novel challenge, never experienced before, participants were forced to resolve the challenge by extending their Dynamic Domain of Self-Transcendence until it encompassed the challenge located in their Static Domain of Proximal Development. Where participants had already previously struggled with this challenge, we find a stark decrease in learning quality as the challenge was located in their Static Domain of Present Development, which in turn means that they did not need to develop in order to resolve the challenge.

Aside from introducing feedback statements into a group, these other factors that influence the quality of learning have brought me to conclude that all the actions of a facilitator of learning throughout the major purposes of FL (initiating learning and maintaining learning) have an equal status in terms of their influence on the quality of learning. In fact, if there were to be a hierarchy of the influence of these different factors of a learning task on the quality of learning, I now maintain that the findings of this study point to the real-life challenge as being the greatest determinant of the learning quality – which is a possible avenue of research to be investigated in the future.

6.3 Limitations of this study

Despite my research experience and the preparation for engagement into fulfilling this task, I freely admit that I was caught ill-prepared for research that became the most complex that I had ever come across. The complexity, unfortunately, had brought with it unexpected challenges, some of which I had not foreseen and others that I had to contend with according to the choice of correspondence with the work of Kapur (2008) that prompted this research. Certain limitations within this study, therefore, were known to me from the start, while others emerged over time. I was able to anticipate and prepare for the former, but as the latter only emerged as challenges during the research design and data collection, I needed to identify them and acknowledge them in order that they will be addressed appropriately when future research within this context or other related contexts

are considered. A relatively large number of limitations to this research has been exposed of which only those that I deemed to be the most significant are addressed in this paragraph.

Firstly, I realised from the start that the small sample size was going to be problematic in terms of the validity and perhaps the reliability of my quantitative data and its analysis, even though the experiment included the entire cohort of learners within the Makerspace offering at my school. Despite the fact that relevant and appropriate calculations could be executed of which the results provided some form of reference and/or comparison for this study, an in-depth statistical analysis would have been functionally impossible and its results subsequently insignificant.

The most affordable CSCL platform through texting as communication mode only has been utilised within the challenging context of the South African schools having access to enough computers, connectivity limitations, exceptional cost of data and other relevant technological restrictions. The choice of the most affordable CSCL platform had the advantage that it could be configured in a way that individual learners in a group were unknown to each other which allowed for an uninhibited mutual communication between them. They were also referring to anonymity as an advantage in the interview data. However, this perceived advantage simultaneously contains a serious limitation in that it prevents learners from being confronted by the reality of communication in such a way that the essential interpersonal human qualities can be attained within an already volatile social cohesion challenge in South Africa.

Furthermore, although the dilemma about the learning quality measure variations in properties and units of measurement could be compensated for by a normalised data set in the format of an ordinal scale, the absence of a scale to distinguish the value between sequential rankings as is the case in my study, may have caused an inaccurate interchangeability between rankings. It was also unfortunate that the respective weight that each of the learning quality measures contributes to the sum of the learning quality has been incalculable. In addition,

even if an appropriate scale was available, it seemed as though the scale would have been too small to represent subtle nuances that the data could have reflected. If an appropriate scale and corresponding calculation were available, it would have certainly assisted with some contribution to a better resolution towards the confirmation of the hypothesis.

When the final rankings of the chat groups were viewed through the lens of the qualitative data, another limitation emerged as an unanticipated side effect of the uncertainty generated by the learning task feedback statements. The qualitative data clearly indicated that there was a decrease in the willingness of certain group members to participate whenever such a statement was introduced to the chat. This call to reflect, which can in some instances be identified in the quantitative data as a 'pause' in the contribution of participants, caused the participants to doubt whether they were on the right track. Although these feedback statements were primarily posted by the facilitators of learning in order to get the group discussion to mirror the utterance types identified by Poole and Holmes (1995), a noteworthy side effect of the reflection (and uncertainty) induced by these statements was the fact that they actually increased the amount of struggle experienced by participants.

Studying the qualitative data closely, it seems that when a facilitator of learning made a statement that suggested that participants reflect on their discussion, most of the participants immediately assumed that they were on the wrong track. To put it in terms of Piaget's theory on learning, disequilibrium was introduced with these statements. To progress, participants first had to go through the necessary mental (to think about the statement) and social (to talk to each other about the statement) processes before they could achieve a higher level of 're-equilibrium'. This is a limitation in the sense that the pedagogical intervention (learning task feedback statements) decreased the learning quality measure of productivity.

The last limitation of this study that I want to address also emerged during the data analysis stage where I attempted to quantitatively measure the increase in learning quality that can be attributed to FL. Part of the goal of this research was

to determine the extent to which FL increases the learning quality of a group. By including a learning measure focused on the extent to which groups adhered to a specific sequence of utterance types during their online discussion, I had hoped to find an increase of this measure in groups where facilitators of learning were posting learning task feedback statements to this effect. Upon analysing the data, however, I could not find a correlation between specific statements and an increase in the level of adherence in discussions. Based on my understanding of the qualitative data generated by the experimental groups, I attribute the absence of this correlation to the fact that the length of the experiment (thus the length of the discussion) was not enough to be duly influenced by these statements. It was thus not possible for me to quantitatively measure the exact extent of improved learning quality that can be attributed to FL.

As is the case in qualitative studies, including the mixed method methodology that was followed in this study, the credibility and trustworthiness, not only of the data but also of the researcher as the primary research tool, is of critical importance. By listing the limitations of the study in a forthright manner I hoped to have increased this essential foundation of my research element. These limitations were also the ground on which my recommendations for future research were based.

6.4 Recommendations for further research

In the same vein as with the limitations of this study, the recommendations for future research are also numerous. Besides the obvious recommendations that are evoked by the limitations of this study, there are also recommendations that arose straight from the data generated in this study. Again I address only those recommendations that I deemed to be the most significant within the context of this study and its closely related contexts not in any particular order as follows:

- Whenever the quantitative part of this research is replicated in whichever way, the sample size should be enlarged at least to the extent that the quantitative data would qualify for statistical significance.

- The measure used to rate the quality of learning in groups can be refined to address the identified conflict between the introduction of learning task feedback statements and the learning quality measure of productivity.
- Learning task feedback statements should be carefully reviewed in all respects in order to ensure that they will fulfil their function not only to increase participation equity in general but also in accordance with the particular purpose that each of them are proposed to fulfil, nonetheless in the shortest possible format – a critical challenge.
- A more enhanced online platform should be investigated with attributes/functionality that can further support the inclusion of appropriate learning task feedback statements.
- In close association to the preceding, a different CSCL platform could and possibly should be used. There are quite a number of CSCL platform packages or a specific platform according to particular needs could be configured. The addition of communication through sound would constitute an advanced level although individual earphones and microphones would have been necessary within the context of this study. The improvement of the immediacy and speed of group communication could be achieved by including touch tables for each small group. However, within the context of this study, it would have defeated the purpose of having individual members of groups unknown to one another in order to support uninhibited mutual communication. Visual accessibility between learners mutually and the facilitator of learning respectively would add another critical communicative improvement. Multiple and mobile remote-controlled cameras of all kinds may provide access to facial expressions and body language of all participants which is essential to detect the subtle nuances of meaning that is being communicated and provides for the best and most appropriate response between communicators. In fact, reality could be reproduced to the extent that the only but significantly important deficiency is a face-to-screen

instead of a face-to-face relationship if distance is the ultimate limitation. In fact, we should exploit whatever is at our disposal to achieve what reality itself can offer with the advantage of all the technological support possible. However, we need to stay cognisant of the fact that with every step in the attempt to approach reality as authentically as possible the cost of the technology to be employed will be increasing extensively.

- In view of the unexpected exceptional discrepancy in the results of this study regarding the most influential participant in a group, research around the socio-dynamics of participants in a group and how to manage the maintenance of participation equity is necessary.
- More research can be done focussing specifically on ways in which to identify the most influential participant in a group and the extent to which FL should be focused only on this individual.
- Research can be done to determine the weighting of the different learning quality measures in terms of their contribution to the overall learning quality of a group.
- An investigation can be made to ascertain whether the lesser impact of learning task feedback statements in this experiment can be attributed to the virtual nature of online learning or simply the specific learning task feedback statements in this study.

6.5 Conclusion

This study was an attempt to shed light on the ‘dark matter’ of the teaching profession – referring to the highest possible quality of learning. By making the case that educational reform has historically been driven by outcomes dictated by a shifting political, social and technological landscape I presented this research as an attempt to refocus curriculum design on optimal classroom pedagogy. The implementation of such a pedagogy, which engenders the highest possible quality of learning, could then be used to optimally deliver the outcomes required by external educational stakeholders. In doing so I join the ranks of

academics such as Kapur (2008) who has attempted to quantify learning quality, allowing him to measure the influence of pedagogy there-on.

By focusing on the influence of facilitation on learning quality, Kapur demonstrated that by 'teaching' or 'helping' learners, the quality of learning is decreased (2008). As a solution to this conundrum, Kapur suggests that learners are first left to struggle with a challenge un-aided up until the point of failure. Only after they have failed is the theory required to resolve the challenge 'taught' to the learners. I consider the study conducted by Kapur as being of great importance and a flagship in demonstrating the need to delve deeper into the effect of classroom practice on learning quality. Even though I fundamentally disagree with the decision to take the facilitator of learning out of the moment where the learner struggles to resolve a challenge, I fully acknowledge that 'help' would decrease the quality of learning. As an alternative to Kapur's suggestion that the facilitator of learning be absent, I suggested in this study that the type of facilitation (phrased in this research as 'facilitating learning') needed to be of such quality that its presence only increases the quality of learning.

In an attempt to demonstrate the influence of FL, the aim of this study is described as being an investigation in the ability of a facilitator of learning to intervene in the learning process in order to address factors impeding the quality of learning (as identified by Kapur (2008)), without having the presence of this intervention decrease the quality of the learning. With this aim in mind I set about constructing an argument for a learning task that can be representative of 'the highest quality of learning' in an online environment. I also created my own set of specialised criteria with which to measure the learning quality in this learning task and subsequently used these criteria to determine the impact of FL.

Quantitatively the findings in the experiment showed an increase in learning quality when FL is present. By interpreting these results through the lens of the qualitative data it became apparent that this increase in quality can be attributed to the introduction of uncertainty in a group via a call to reflection. This call to reflection then increased the perceived level of difficulty of the leader in the group, which raised the overall quality of learning. As was the case with the study of

Kapur (2008), this study demonstrated strategies which allows us to quantitatively measure learning quality, which in turn allows us to make better pedagogical decisions.

In addition to shedding light on 'how' FL increases the learning quality, the qualitative data also increased the credibility of the quantitative data by justifying the quantitative findings through an analysis of the experiences of participants. Referring to my goal to shed light on the 'dark matter' of the highest quality of learning, however, it was the reflection of the participants captured in the qualitative data that unpacked the learning experiences within this study. Not only did the participants affirm Vygotsky's explanation for the way in which learning takes place, but they also affirmed the value of an authentic "life problem" (G1L3) which has the potential to "really change lives" (G1L2) as it "affects the world globally" (G1L4).

Although the ranking of learning quality provides the base answer to the main research question, the qualitative findings supporting the quantitative results are valuable ends in themselves as they add empirical data to the field of research pertaining to the heart of the teaching endeavour. If we are to bring about a future where institutionalised pedagogy helps learners to "grow as a person" (G1L3), we will need more research into those actions conducted by a facilitator of learning which would lead to an "excellent experience" (G1L2) in the classroom.

As professional educators it is imperative that we take charge of curriculum reform, supported by sound research to ground our profession in good teaching practice which would translate in the classroom into learning tasks that are "very cool and creative" (G2L3). Irrespective of the external pressure brought to bear on education systems to deliver citizens that fulfil the current socio-political need, we have to strive towards an intellectual consensus on the type of learning tasks and actions taken by a facilitator of learning which will equip young people to thrive in an unknown future (Slabbert, et al., 2009). It is a type of learning yearned for by the participants in this study who "would love to continue to have such amazing experiences and opportunities to learn" (G6L3) as they "provide learners

with the enriching knowledge and skills they need to become leaders and innovators" (G6L3).

This study profoundly shaped the way in which I view the future of education. It made me realise that it is imperative that the educational community be the loudest voice in the design of institutional pedagogy − especially in the arena of online learning. We must as an international community band together to ensure that the highest quality of learning takes precedence over all agendas in the design of future curriculums. Every decision needs to be grounded in a deep understanding of the nature of learning and considered in the light of the tenets laid down in the literature on the highest quality of learning. Only then will our inevitable digitized educational landscape of the future take a step forward towards an authentic learning experience where learners can achieve required learning outcomes by resolving real-life challenges.

As a teacher caught up in the international hype of virtual learning, this study also challenged me to take stock of the effect that a 'virtual' environment has on the authenticity of learning. I have no doubt that as technology advances virtual reality will be able to replicate real-life to a greater and greater extent, and yet it will still only be an imitation of the real-world. If I were to attribute the detrimental effect that a virtual space has on learning task feedback and the quality of our current virtual classroom technology, one can only wonder if an improvement in virtual classroom technology will lead to a more effective learning task feedback experience. As it stands, I maintain that current technology cannot supplant face-to-face human interaction and the critical relationships that exist between learners and facilitators of learning in a physical classroom. Against the background of this truth, it now becomes even more imperative that one strives to heighten the quality of learning within an online learning environment as far as possible in order to ensure that the digitized future of learning does not completely sacrifice learning quality on the altar of learning convenience.

The progression of the indication of 'dark matter' used as a metaphor in this study can be seen in Figure 6.4:

Figure 6.4: Galaxy Cluster MCS J0416.1-2403 with an indication of 0% - 100% dark matter (European Space Agency, 2015)

In the same way that modern technology allows astronomers to observe the dark matter once postulated in theory by Zwicky (1937), the text-based discussion of learners in an online learning platform gave me a vantage point from which to empirically observe the learning theories put forth by Vygotsky (1938;1967). As was the case with the photos taken by the European Space Agency in Figure 6.4

above, I found the act of learning depicted in this study to be in itself a thing of beauty. As scientists tasked with the study of ‘dark matter’ are required by virtue of their calling to stare at mesmerizing starscapes, I was also rewarded in this study with a view of some of the intricacies surrounding the act of learning. At the end of this journey, I am humbled by the sheer complexity of the teaching profession and proud to be a part of the noble teacher-researcher fraternity. I am also once again reminded of the enormous responsibility that we have towards the children in this study and their peers at learning institutions across the world; to shed light on education literature in a super-complex, increasingly digitized age in order to highlight the ‘dark matter’ of ‘learning quality’. This is the only way in which we can ensure that a digitized, online-learning future education will include, as a fundamental requirement, the highest possible quality of learning.

CHAPTER 7: LIST OF REFERENCES

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