Clicking: A constructivist grounded theory for developing quantitative literacy for learning mathematics in an enabling course in tertiary education

Dr Gemma Elizabeth Mann

BSc(Hons) PhD

Dissertation submitted in fulfilment of the requirements for the degree of

Masters of Education (CA73)

School of Education and the Arts

Bruce Highway, Rockhampton, Queensland 4702, Australia

Central Queensland University

20 July 2018

Principal supervisor: Dr Teresa Moore

Associate supervisor: Professor Bobby Harreveld

Abstract

Clicking is a theory that explains how students in this study developed quantitative literacy for learning mathematics in an enabling course at university. Using a grounded theory methodology, thirteen students from an enabling course at one institution were interviewed about what helped or hindered them in learning mathematics in a tertiary environment. Students who come to enabling courses often have had barriers and disruptions in prior learning experiences. While most come to enabling courses with the aim of improving their skills, progressing on to bachelor degrees and then professions, they often struggle in the formal learning environment. This is particularly so with mathematics with many students reporting that they do not like, or are not good at the subject. Despite the best intentions for this 'second chance' learning, numerous students continue to struggle, withdraw, or fail. This attrition is detrimental to students' confidence, and also undesirable for the university. Even for those who remain, or are able to pass some assessment, they are still not confident in their ability to learn mathematics. Through this study, the concept of 'clicking' was found to be central to students' understanding of the content, in particular, developing literacy practices that resonated with a literacy resource model for learning. Seven interrelated categories reported by the students were theorised through this model, with the key category of clicking emerging as a process for explaining how quantitative literacy was constructed by learners themselves. Clicking for quantitative literacy was constructed through a student learning cycle of relating, holding interest, exploring ways, taking time, practising, and working through confusion; with tailoring of ways of learning mathematics provided by teachers and others such as peers, family, friends. When used alongside adult learning principles, these findings offer a practical guide for teachers in enabling courses to use with their students to develop their knowledge of how to learn mathematics. For students, being quantitatively literate in 'learning how to learn mathematics' through clicking, has implications for success in mathematics learning in their chosen professional studies at university.

Acknowledgements

ACKNOWLEDGEMENT OF SUPPORT PROVIDED BY THE AUSTRALIAN GOVERNMENT

This RHD candidature was supported under the Commonwealth Government's Research Training Program/Research Training Scheme. I gratefully acknowledge the financial support provided by the Australian Government.

ACKNOWLEDGEMENT OF PROFESSIONAL SERVICES

Professional editor, Dr. Karin Stokes, provided copyediting and proof-reading services, according to the guidelines laid out in the University-endorsed national guidelines, 'The editing of research theses by professional editors'.

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PERSONAL ACKNOWLEDGEMENT

I would first like to thank my supervisors, Dr. Teresa Moore and Prof. Bobby Harreveld of the School of Education and the Arts at CQUniversity for your unwavering support. You were especially encouraging of my 'less than conventional' analysis techniques. I am extremely grateful for your professional mentorship while I manoeuvred my way through the project.

Thank you also to my colleagues and friends, some of whom have followed this journey closely and offered thoughtful insights and advice. Or simply laughed with me as I lost the plot.

A very special thank you to my parents for paving the way in both teaching and in higher education. I am grateful for the inspiration to pursue educational research, and to continually strive to improve my own practice.

Finally, I must express my very profound gratitude to my partner for providing me with unfailing support and continuous encouragement throughout the process of researching and writing this thesis. I am thankful for your patience with seemingly endless weekends of writing, and for the invigorating conversations we have had around the analysis and results. This accomplishment would not have been possible without you. Thank you.

Declaration of authorship and originality

I, the undersigned author, declare that all of the research and discussion presented in this thesis is original work performed by the author. No content of this thesis has been submitted or considered either in whole or in part, at any tertiary institute or university for a degree or any other category of award. I also declare that any material presented in this thesis performed by another person or institute has been referenced and listed in the reference section.

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Table of Contents

List of Figures

List of Tables

List of acronyms

AC	Access Coordinator (academic position in the STEPS course)
AQF	Australian Qualifications Framework
FMU	Fundamental Mathematics for University (unit in STEPS)
GTM	Grounded Theory Methodology
IMU	Intermediate Mathematics for University (unit in STEPS)
OECD	Organisation for Economic Co-operation and Development
OP	Overall Position (used by Queensland Tertiary Admissions Centre)
PISA	Programme for International Student Assessment
PSU	Preparation Skills for University (unit in STEPS)
QL	Quantitative literacy
STEPS	Skills for Tertiary Education Preparatory Studies
TMU	Technical Mathematics for University (unit in STEPS)
4RM	Four Resource Model (for literacy)

Chapter 1 Introduction

Clicking is a theory that explains how students develop quantitative literacy for learning mathematics in an enabling course at university. Through this study, the concept of 'clicking' was found to be central to students' understanding of the content, in particular, developing literacy practices that resonated with a literacy resource model for learning. Clicking is the process that students go through as they are developing quantitative literacy. It represents something like an 'aha' moment, a transient moment in time.

The Australian Council for Adult Literacy (2001, p. 8) defines Quantitative Literacy (QL) as

> the knowledge and skills required to apply arithmetic operations, either alone or sequentially, to numbers embedded in… materials, such as balancing a chequebook, figuring out a tip, completing an order form or determining the amount of interest on a loan from an advertisement.

This definition indicates that QL is more than being able to do arithmetic or calculations. This also means that QL is more than what is generally accepted as the definition of numeracy. However, the definition also implies a broader element in QL, that is, a conceptual understanding of the meaning of numbers in the context of the real world. The ability to learn how to apply mathematical understanding to new situations implies a knowledge of and skill in the actual mathematical content, such as being able to perform calculations, but also requires a quantitative literacy for learning. As such, quantitative literacy for learning mathematics can become a transferable skill for studying, everyday life, and careers.

1.1 The problem

The comprehensive model in place currently at CQUniversity offers all levels of courses from Certificate I to PhD in line with the Academic Qualifications Framework (AQF) (2013) offering multiple pathways for students thinking of tertiary level or post-school education. One option that is available to gain entry directly to a Bachelor degree (AQF level 7) is to do an enabling[1] course (Pitman & Trinidad, 2016) that has been specifically designed to facilitate entry to tertiary level

[1] Enabling courses are sometimes called bridging courses or alternative pathways. At CQUniversity, enabling courses are designated as 'non-award' as they are not mapped to an AQF level. They are designed to provide prerequisite levels for entry into AQF 7.

education at the undergraduate level. At CQUniversity Australia, this is the Skills for Tertiary Education Preparatory Studies (STEPS) course.

While most come to enabling courses with the aim of improving their skills, progressing on to bachelor degrees and then professions (Bunn & Westrenius, 2017), they often struggle in the formal learning environment. This is particularly so with mathematics with many students reporting that they do not like, or are not good at the subject. Wolff, Wood-Kustanowitz and Ashkenazi (2014) have studied students entering certain post-secondary school, college courses in the USA and have argued that mathematics proficiency is a strong predictor of engagement and success. Despite the best intentions for this ‘second chance’ learning, numerous students continue to struggle, withdraw, or fail. This attrition can be detrimental to students’ confidence, and also undesirable for the university. Even for those who remain, or are able to pass some assessment, they are still not confident in their ability to learn mathematics. This then, has impacts on undergraduate study (Hiatt, 2008; McNeilage, 2014). The continued struggles and withdrawals of some students, in particular from mathematics, suggests that there is a gap in the way enabling courses prepare many students for learning mathematics both within the course and for further study.

CQUniversity prides itself on being an institution that embraces students from all walks of life including those from low socio-economic backgrounds, Indigenous backgrounds, migrant backgrounds plus many mature age students seeking a change in careers and occupations. If students enter this university environment from a background that has not given them adequate preparation, this may have negative impacts on their experiences and learning during their study. In Australia, most students who enter at the Bachelor, or undergraduate level (AQF level 7), do so through the Queensland Tertiary Admissions Centre or admissions centres from other States. To determine if a student is eligible to be offered a place, these centres assess school grades including OP (overall position) or ATAR (Australian Tertiary Admission Rank), other qualifications or coursework including certificates and diplomas, and work experience.

More and more students do not have the necessary school background for entry directly to degree courses for a variety of reasons. For example, they have not gained passing grades, they have gaps in certain areas such as numeracy, they opted not to aim for an OP through senior school because of a legacy of poor results, or they withdrew from school all together. Over the last few years, Australian high school students have dropped behind students in other OECD countries in regard to levels of mathematical proficiency. The Programme for International Student Assessment (PISA) 2015 report shows that even though Australia had an average score in mathematical literacy, achieving 494 with the average being 490, they were outperformed by nineteen other countries, coming in at twentieth (Thomson, De Bortoli, & Underwood, 2017). This is down from seventeenth in 2012 (Stephens, 2013). PISA has six levels of mathematical proficiency, where they use the term proficiency as a measure of mathematical literacy. The international baseline for being able to use mathematics to actively participate in real-life situations is at level 2. In 2015, approximately 22% of Australian students did not reach this minimum level (Thomson et al., 2017), an increase from 20% in 2012 (Thomson, De Bertoli, & Buckley, 2012). The national baseline for students is set at level 3 and in the 2015 report, 45% of students were below this level, up from 42% in 2012.

Students who come back to formal study and happen to have low levels of mathematical proficiency, may have high motivation levels and commitment to begin with, but they can be haunted by a legacy of prior poor experiences and failures. If they face obstacles that they are not yet equipped to deal with, they may revert to negative thought patterns. This can, in turn, result in falling back on the previous learned behaviours of retreating and withdrawing in order to save the pain of yet another failure. It seems that students coming into enabling courses often do not know how to build their learning capabilities to develop resilience and cope with the increasing difficulty of the content they are so keen to study (Seary & Willans, 2004).

1.2 The aim

This aim of this study was to investigate how students learn mathematics, and specifically focussed on the question of how they develop their quantitative literacy for learning mathematics, including as a strategy for progressing to further study.

The first part of this study was to explore what helped or hindered students in learning mathematics. This involved investigating previous and current experiences, both positive and negative, across formal schooling, informal learning, work, hobbies, and within the STEPS environment. The aim was then to examine in more detail how these experiences influenced and formed the processes of learning in mathematics study within the enabling course. Hence the first research question was:

- What learning processes are involved for students learning mathematics within the STEPS course at CQUniversity?

In order to construct a theory around these processes of learning mathematics, the more detailed area of literacy was explored. As mentioned, literacy then becomes the ability to learn how to develop the learning process, explicitly for mathematics by understanding the content, meaning and relationships of the discipline. Thus the second research question was:

- How do students develop a quantitative literacy for learning mathematics?

Through these questions and the analysis of the data, the overall intention of the study is to construct a theory that explains the process of how students develop this quantitative literacy for learning mathematics.

A constructivist grounded theory methodology was used, with interviews as the data collection method. Thirteen students were recruited from an enabling course at a single institution. From coding, categorisation, and theoretical analysis of the data, categories were interpreted around the learning processes for students studying mathematics.

Seven interrelated categories reported by the students were theorised through this model, with the key category of clicking emerging as a process for explaining how quantitative literacy was constructed by learners themselves. Clicking for quantitative literacy was constructed through a student learning cycle of relating, holding interest, exploring ways, taking time, practising, and working through confusion; with tailoring of ways of learning mathematics provided through teachers and others such as peers, family, friends.

1.3 Significance

For the students in STEPS, the enabling course constitutes their current 'real world' with their immediate future reality seen as successful entry to an undergraduate course. Quantitative literacy in this context is a conceptual understanding of the learning processes required for the transference and application of how to learn mathematics into their chosen undergraduate courses.

Because of the construction of degrees within CQUniversity (CQUniversity, 2018), there is a range of units that include mathematical concepts and these units sit across a range of courses[2]. For students to fully participate in degree courses, they will need to both understand and engage with these mathematical concepts. Aware of the research and reports that show the status of mathematical proficiency, and conscious of past experience of student performance, many Heads of Course at CQUniversity have requested that the STEPS course for their students include at least one mathematics unit in order to complement existing student knowledge.

When used alongside adult learning principles, as discussed in Chapter 5, these findings offer a practical guide for teachers in enabling courses to use with their students to develop their

[2] At CQUniversity, a 'unit' is a single subject, and a 'course' is a bachelor's degree, diploma or certificate made up of several units.

knowledge of how to learn mathematics. For students, being quantitatively literate in 'learning how to learn mathematics' through the theory of 'clicking' has implications for success in mathematics learning in their chosen professional studies at university. The broader significance is later discussed in the 'Implications' section in the Conclusion (Chapter 6).

Chapter 2 provides the contextual framework for this study into QL development in an enabling course. Section 2.1 describes the importance of the broader scope of literacy theory in general and introduces the concept of multiliteracies. This narrows the focus to the tertiary education environment and discusses the multiple layers of learning students undergo while transitioning into tertiary education. In particular for this study, it outlines the educational philosophies behind enabling courses, the level of self-directedness expected for these courses. Section 2.2 then discusses the particular case of mathematics and QL, what it means for teaching and how it relates to investigating QL in the STEPS context.

Chapter 3 describes the methodology and methods of Grounded Theory Methodology (GTM) that were used to collect and analyse the data. Section 3.1 details GTM aspects of philosophy, theoretical sensitivity and the highly situated nature of the research and emerging theory. One aspect of the situation that is critical in GTM is the researcher positioning which is described in section 3.2. Section 3.3 describes the data generation process and how it was governed by GTM. It is in this section that the participants are introduced, the nature of the interviews with those participants, and how the resulting data was managed. The data was then analysed using GTM principles and guidelines, first in a more thematic way, as described in section 3.4, and then in a theoretical way in section 3.5. The limitations within the GTM methodology are outlined in section 3.6 in terms of how they impacted on the design of data collection and analysis methods.

Chapter 4 presents and analyses the data. Chapter 4 takes the theoretical analysis from Chapter 3 and presents the evidence based, theoretical categories that emerged from the study. Seven sections are included in Chapter 4, (4.1 to 4.7) each detailing one of these categories and its properties. Relationships between the categories are also explained.

Chapter 5 presents resulting theoretical analysis and theory development. In section 5.1, the core category that emerged from the analysis is presented, and the section brings together all other categories from Chapter 4. This chapter frames the theory as a literacy in section 5.2 and within the situation of adult learning in enabling education in section 5.3. Section 5.4 summarises the findings. Chapter 6 presents the conclusion and opportunities for future research.

Chapter 2 Contextual Framework

Education in some form or another is part of everyone's lives for much of their lives. Therefore, researching the methods and impacts of education is an incredibly broad discipline and there is a vast array of educational theories in the field. These fall under many different research paradigms and the use of these depends on the viewpoint of the researcher, the issue being investigated, and the participants. Along the spectrum, researchers might consider such existing theories as mastery, the 'ideal student', goal setting, cognitive behavioural psychology, repetitive testing to investigate the efficacy of teaching practice, experiential learning, authentic learning, motivation theories, self-efficacy, or developmental psychology to investigate the learner's construction of understanding. Studies could investigate learning for understanding or aligning teacher and learner comprehension, such as think aloud strategies, problem based learning, gradual release of responsibility, or gamification.

While all of these theories have their place, the methodology chosen for this study, GTM, calls only for theoretical sensitivity, and as such, an in depth literature review of these existing theories and research into the field of mathematical education is not warranted. This is explained further in Chapter 3. Instead, this chapter will situate this study within a literacy framework in the context of tertiary education and specifically enabling education. It will then focus on quantitative literacy, and the discipline specific area of teaching mathematics for development of QL within the broad literacy context.

2.1 Literacy as a framework

During the 1990s, the term 'literacy' was expanded to apply to many different areas of life and learning, including, but not limited to word or text based, mathematical, quantitative, digital, technological, visual, social, and cultural realms (Cope & Kalantzis, 1997). While literacy was traditionally seen as the ability to read and write, as society's needs have changed, so too have the inherent demands about what it means to be literate across a wide range of circumstances or situations. Literacy is a socially mediated construct (Cook-Gumperz, 2006; Gee, 2012). It is through people's exposure or experience in wider socio-cultural settings that provides them with lived experience and understandings that they then bring to new contexts. To focus on literacy just as reading and writing, however, teachers may miss other prior knowledges that students bring in to the learning environment. Hence they work to the learners' deficits rather than using their strengths to build and expand literacies. QL has the potential to be one of these less traditional literacies. As such, it is important to frame the concept of QL within the greater context of the concept of literacy.

Learning is a multifaceted endeavour, with a complex interplay of what and how people learn, and draws upon many layers of metacognition. Learning therefore, cannot be seen, treated, or expected to be done in isolation, for example, focussed on a single discipline. In the enabling context of this study, students are learning many different literacies, often concurrently, and this learning is also embedded within their existing socio-cultural contexts. It is therefore important to explore the greater literacy framework for understanding how students develop their literacy skills before moving on to a discipline specific literacy.

The Australian Council for Adult Literacy gives a general definition of literacy as “the ability to understand and employ printed information in daily activities, at home, at work and in the community - to achieve one’s goals, and to develop one’s knowledge and potential” (2001, p. 8). This definition is very broad, yet it can be broadened even further if other literacies are considered, such as quantitative and digital literacies (Durrant & Green, 2000). One important point of this definition, however, is the mention of community and the relationship of a person’s knowledge and potential within that community and this also relates to the work of Cook-Gumperz, who views literacy as a social construction. The community centred interpretation of literacy was particularly described in the work of Freebody and Luke (1990) “since it is not possible to determine any final, categorical criteria for ‘adequate’ or ‘functional’ literacy, we can describe expectations only in terms of the shifting civil, socio-cultural… demands that any particular culture places on its members” (p. 7). As this type of literacy was not limited to word based text, the more broad concept of a ‘multiliteracies’ framework (Cope & Kalantzis, 1997) was developed by the New London Group in 1994. This group of ten literacy educators, including Luke, met in New London, New Hampshire, and “were concerned about how literacy pedagogy might address the issues of rapid and complex change in literacy as a result of globalisation, technology, and increasing social and cultural diversity” (Anstey & Bull, 2003, p. 77). The multiliteracies concept therefore situates all types of literacy in a sociocultural context. As mentioned above, if society itself provides the need for literacy, then as such, different societies contain different literacies. When people move between social contexts, it is their literacies that have the power to include or exclude them within those contexts. Literacy is therefore crucial to a person’s identity within society, especially if a particular part of society has been excluded from educational opportunities due to minority status (Cope & Kalantzis, 2009). As societies change and inclusion becomes a priority, it is necessary to address the literacies of the people within those societies.

Any society’s use of literacy will change over time as the society changes, in particular in regard to changing workplaces and career demands. “In our working lives we will be required to change tasks, multi-skill and/or change occupations and each of these changes will require us to acquire new literacy skills and interact in different ways" (Anstey & Bull, 2003, p. 39). With increased literacy, people have increased power, particularly over their future lives and job-readiness. This is not a simple process and involves "constantly extending one's lifeworld horizons and cross-lifeworld negotiations repertoire," (Cope & Kalantzis, 1997, p. 471) if one is to be ready for a rapidly changing and diversifying world of work.

Literacy in this socio-cultural context fits neatly in the interpretivist framework. For a person to be included in a societal context, text, symbols, and other forms of communication have to be interpreted in a similar way as others do in that context. Multiliteracies theory highlights the idea that information is open to different interpretations and that it is beneficial when people are open to alternate view points as this means they are more likely to be socially mobile. This, in turn, opens up greater opportunities in life and particularly in their careers.

2.1.1 Literacy in (of) tertiary education

One way people extend their 'lifeworld horizons' is to undergo further education and training, and one option is bachelor-level courses at university. Their aim is to be educated in a particular field, frequently with the ultimate goal of gaining employment. University education, however, involves not only reading literacy, but indeed ability across the scope of multiliteracies. Researchers at Flinders University in South Australia described the environment thus: "to succeed at university students need access to 'literacies' specific to universities (i.e. academic literacies) and specific to their chosen disciplines and career paths (i.e. discipline-specific literacies)" (Miller & Schulz, 2014, p. 78). As there are many different literacies students need to use during their study, including digital literacy, visual literacy, numerical literacy, and discipline specific literacy, the Flinders University researchers encouraged seeing the transition into university from a multiliteracies framework.

Importantly, and as a necessary context for this present study, these researchers discuss "institutional literacies: reading and understanding the institution" (Miller & Schulz, 2014, p. 79). This involves gaining a literacy of the university as a separate society in itself, with a wide range of areas, including but not limited to aspects such as "understanding layouts, structures, hierarchies, policies, jurisdictions, timetables… procedures, processes, protocols… locating and accessing institutional facilities and personnel… understanding the role and function of lectures, tutorials, workshops, seminars, practicals, examinations, etc." (Miller & Schulz, 2014, p. 80). This is a vital part of the culture and language that helps students engage with, feel comfortable in, and eventually succeed in the university environment because: "As passports to participation, institutional literacies act as ‘keys’ enabling students to unlock the university system and, once inside, open doors to possible futures” (Miller & Schulz, 2014, p. 80).

The context of this study was one enabling course offered at one tertiary institution, that is the STEPS course at CQUniversity, and therefore, literacy of tertiary education is important. Enabling courses are specifically designed to introduce students to the university environment in a manner that involves familiarising students with the processes and procedures (culture) and terminology (language) along with discipline knowledge (Pitman & Trinidad, 2016). As such these courses can be a place to engage students in learning the literacies of tertiary education. By increasing literacies of, and for university study, enabling courses offer students the opportunity to increase the likelihood of success in their futures. A 2015 review of enabling courses found that across 38 Australian universities, there was a diverse range of enabling programs available, varying in length, content, and mode of delivery (Pitman & Trinidad, 2016). They all aim to provide context and content specific learning and offer low-cost pathways that are not traditionally available to students to enter a university. All of the enabling courses were transition pathways to bachelor level courses and were alternatives to high school or vocational education and training. This was found by researchers in the CQUniversity STEPS enabling course where “characteristically, applicants wish to access higher education but find they lack the essential knowledge and skills to successfully gain entry to a tertiary institution” (Seary & Willans, 2004, p. 310). Seary and Willans (2004) also found that applicants had been “unable to or unsuccessful in completing the essential prerequisites to enter a tertiary institution [because they] have been hindered by both their past and present educational, social or cultural situations and most have serious misgivings about their academic ability and chance at success” (p. 310).

STEPS has been operating since 1986. Research by Seary and Willans conducted in 2004, was based on the experiences of staff over an eighteen year period and can still be seen as relevant in 2018. Their finding that “most seek to improve their quality of life through firstly improving their educational standing by undertaking a preparatory program…” (p. 310) is supported by the more current findings of researchers in enabling education from the University of Newcastle. Bunn and Westrenius (2017) also found that students aim to increase their education, gain the required skills for university and “fulfil psychological and social needs” (p. 61).

This study was conducted solely within the STEPS course at CQUniversity and this helped overcome the issues with differences across courses and institutions. People without the relevant prior study skills or qualifications can undertake STEPS to gain the necessary admission requirements for most CQUniversity bachelors courses, as well as developing skills and confidence. STEPS is a flexible course with up to twelve units available to be completed within a two-year time frame. Students are required to do the core unit, Preparation Skills for University (known as Preparation Skills or PSU), plus at least two other units (See Appendix A for unit outlines of all of the units in the STEPS course). Their overall study plan is developed with advice from an Access Coordinator (AC) who takes into account the undergraduate course they are aiming to enter and any prior studies. There is an AC for each campus[3] where STEPS is offered and one for students studying by online education. One role of the AC is to discuss expected outcomes with the student and align these with the required units in STEPS. Each undergraduate course has a set of STEPS units that are prerequisites, decided by the Head of Course for STEPS in collaboration with the undergraduate Heads of Course, and recommended or elective units negotiated between the AC and the student[4].

Because enabling courses serve as an introduction to tertiary education, it is vital that they address the different literacy needs of the students. STEPS can be seen as a course that is situated at the cross-roads for many people embarking on change in their working lives. As such, it is crucial to incorporate multiliteracies in the philosophy, curriculum and teaching practices within the STEPS course.

STEPS addresses the need for a literacy of tertiary education, because it is physically and technologically situated in the university environment and is tailored to learning skills appropriate and necessary for local undergraduate courses. The philosophy behind STEPS is that the course becomes the learning environment in preparation for what lies ahead:

> Set in an academic, institutional context, the STEPS program seeks to prepare prospective learners both academically and emotionally for the rigours of their intended academic life. It provides the structure and supportive frameworks to allow learners to engage in learning that will facilitate their development as lifelong learners. It raises participants' awareness that tertiary education is an achievable option for them and it facilitates ways in which they can deal with the perceived barriers to the transition to higher education. In the main, STEPS learners gain the essential prerequisites to facilitate their success in the tertiary arena (Seary & Willans, 2004, p. 310)

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[3] CQUniversity it a multi-campus university with STEPS being offered on-campus at ten campuses and also by Online Education (OE). Each of these campuses and OE has an Access Coordinator.

[4] Prerequisite, recommended and elective units through STEPS are only for students applying for entry to undergraduate courses through the STEPS enabling course.

STEPS provides students with opportunities to develop literacies around expectations associated with learning at the undergraduate level. Examples of these are aspects such as engaging with learning processes and materials, understanding the content and background, the connection between learning outcomes and standards and how they need to interact with the university environment. If the course achieves its aims, students will have the early steps to competence regarding the literacy of tertiary education even prior to commencing their three or four year bachelor degree as noted in a previous research project on STEPS:

> This participant's viewpoint… [of STEPS] in that his first attempt at undergraduate study many years earlier was thwarted by his lack of knowledge on how to *format and structure an essay*, while knowledge of his learning style preferences and personality type, collectively, were exceptionally useful concepts. He further relayed that he now *knows what to do to get around difficult things* with his study and *now knows to ask questions* (Seary, Willans, & Cook, 2016, p. 15)

Specifically, within STEPS, the core unit of study, PSU, targets literacies of tertiary education. Topics covered include active reading and listening (introduction to note-taking and paraphrasing), research skills (finding and evaluating scholarly information), oral presentation skills, career planning, stress management and resilience, assessment strategies, and critical thinking. Students read, discuss and reflect on these topics with the aim of "developing strong study habits and effective learning strategies; negotiating procedures and systems used at university; and developing communication skills appropriate for higher education" (Holden, 2018, p. 5).

Prior research highlighted the benefits of PSU as a unit for learning about, and how to succeed in the tertiary education environment:

> There was praise about transferrable benefits… I found that the Preparation for University course was the best possible start for university because that course gave me a down to earth look at how university runs. It was fantastic. The value of PSU in allaying apprehension was also appreciated… I would place this course at the top of the list for useful content as I have found that I use the skills that I learned every day in my undergraduate studies, and because of it I think that I am less anxious about the tasks I'm asked to complete. This is definitely a course that all students entering university should complete. Other respondents made reference to the more personal benefits of PSU, such as how it gave them a great understanding of ourselves and what we would be best suited to in future study. This theme of

> adequate preparation for future study was noted by another respondent, believing PSU to make you ready for the year ahead and for undergraduate programs that you wanted to get in the future. (Seary et al., 2016, p. 15)

The student responses in this quote show that students gain literacies such as knowledge of university procedures, or how the university runs, and in learning skills and how to do the tasks. The data presented in this study suggest that students gain a literacy of tertiary education from PSU.

2.1.2 Self-directedness as a literacy of tertiary education

The STEPS course also aims to develop another key aspect of students' abilities and that is to be self-directed. One of the guiding principles of STEPS is the work of Malcolm Knowles in adult learning, as highlighted in Chapter 5 (Seary & Willans, 2004). The structure of STEPS recognises that students bring with them a prior self-concept and build on this in "encouragement and celebration of self-directed and autonomous learners" (Seary & Willans, 2004, p. 313). A central aspect in STEPS therefore is to help students gain the ability to competently self-manage study. It is something that students commencing STEPS may have little experience in, and therefore have to learn and practise in order to master as with any other literacy.

The Preparation Skills unit overview states that the "unit is designed to help students become self-directed, active and confident learners… [including] time management and goal-setting; individual study" (Holden, 2018, p. 1). The unit has additional topics such as practical tips for effective learning, learning styles and personality types, designed to meet the learning outcomes of "become a confident and self-directed learner; apply critical thinking skills in a range of contexts, with a particular focus on critical self-reflection; set and manage goals for individual study" (Holden, 2018, p. 5). There is a socio-culturally defined 'language' and understanding surrounding education, in particular associated with being an adult participant, and literacy in this regard actively increases the potential for contributing to that society. The issue of self-directedness as an adult participant also became important in how the students studied mathematics and is discussed in Chapter 5.

2.1.3 Impact of literacies in teaching in tertiary education

In any classroom, there will also be differences in students' sociocultural backgrounds, but Kalantzis and Cope (2016) discuss the issues of a history of an educational system where "institutions… attempt to ignore, or elide, or write over these differences" (p. 118). They say that this causes problems when teachers "assume learners are the same" (p. 119). Before learning can occur, there is a need to create a common literacy rather than focus on the lack of literacy from students of certain backgrounds (ethnic or rural for example). and therefore "teachers need to adjust their pedagogy in order to cater for the diverse literacies" (Anstey & Bull, 2003, p. 37). "The question becomes one of *difference* rather than *deficit*" (Anstey & Bull, 2003, p. 42).

The problem with a deficit model when it comes to learning and literacies is that some students are able to excel while others are left behind. This gives those students already equipped to understand the literacy being used power, and takes away power from those who have not yet 'cracked the code' because of their backgrounds. Students with the latter entering position often flounder in the new environment, in ways that may not always be understood by their teachers: "Members of the mainstream culture (teachers) are often the least aware of this power, or that access to the rules of the mainstream culture makes the acquisition of power much easier" (Anstey & Bull, 2003, p. 43). Kalantzis and Cope (2016) also raise the problem of the power differential between the "knowing teacher" who "lectures the class" and the student who "attempts to give the answer they anticipate the teacher expects" and are then told "'yes, that's right', or 'no, try again'" (p. 118).

Kalantzis and Cope (2016) point out that in such a system where "knowledge is a hierarchically structured system of transmission" (p. 119) where students success is only measured by "the degree to which learners and their teacher have remembered the content prescribed in the syllabus" (p. 118), there is no scope for differences in learning. Anstey and Bull (2003) maintain that when diversity is not catered for, an unfortunate consequence is that teachers and education administrators tend to "interpret failure in terms of students' background" (Anstey & Bull, 2003, p. 42). These authors give the example where "the teacher steps back to let the students take control as particularly appropriate to students who, by virtue of their culture, already know the cultural rules of power. Non-mainstream students interpret this behaviour as non-teaching; they are, in fact, denied the very knowledge that they need in order to operate successfully in the culture of power" (Anstey & Bull, 2003, p. 44). Kalanstzis and Cope point out how nonsensical it is that "learning succeeds or fails to the extent that it engages the varied subjectivities of learners" because "behind the demographics are real people, who have always-already learned" (p. 118).

STEPS students, who have previously been unsuccessful in the classroom environment, are likely to lack the literacy to know how to learn in the new environment, and may be particularly vulnerable to the power differential and the risk of 'failing'. This need not, however, be the case. Kalantzis and Cope (2016) say that "the range of their learning possibilities are both boundless and circumscribed by what they have learned already and who they have come to be through their learning" (p. 118). They challenge that "education, then, needs to engage with difference at a far deeper level" (p. 118).

On the other hand, focusing on the differences in backgrounds and therefore literacies can help move the power from the teacher to the students, and once a teacher has "developed a method of identifying both types of literate practices and is giving each equal emphasis, then no-one is disadvantaged" (Anstey & Bull, 2003, p. 40). It is the teacher who makes "those pedagogical choices that… have the potential to empower some students and disempower others" (Anstey & Bull, 2003, p. 44).

Teaching students about their own literacies and showing them how and why literacies develop will also help students into the future. As Anstey and Bull (2003) describe, "while we could provide students with literacies appropriate to current times we could not predict the literacies they might need in the future; therefore we had to think of ways of equipping students to cope with change while at the same time providing knowledge that would become a basis upon which to build new literacies" (p. 77). This is particularly relevant in the STEPS situation where students are going on to study different degrees and engage in different professional working cultures.

2.2 Quantitative literacy (QL)

Much work has been undertaken in the education field to find a working definition of QL and how QL is developed. For the purposes of this study, a general overview of some of the features of QL that are mentioned in the literature is provided to give a preliminary notion of QL. Subsequently, a brief description is given on how this has been shown to impact on teaching, and this is brought into the context of the STEPS course.

2.2.1 Nature of QL

Work produced at a conference in Wisconsin brings together research by a variety of researchers including Richard J. Shavelson, Professor of Education and Psychology at Stanford University, and Robert Orrill, Executive Director of the National Council on Education and the Disciplines (USA) and Lynn Arthur Steen, Professor of Mathematics, St. Olaf College (Madison & Steen, 2008). Their interpretations of the nature of QL are presented here.

Shavelson (2008) suggests that QL is heavily psychological, situative, and sociological and describes these features. Psychologically there is a complete change in thinking needed to go from pure calculations to reasoned understanding of what is being calculated, why it is done that way, how it relates to other calculations, and what it actually means. In terms of the situative, while mathematics knowledge can be discrete, QL requires understanding and application to a situation, or context. Moreover, whereas mathematical processes can be pure calculation, QL is most often sociological because of the nature of the interpretation and application of knowledge in different contexts. The meaning is not always simple fact, but interpreted based on a particular social situation – something that is quite different from fact-based, single answer calculations. The meaning of 35km/hr is not inherently 'fast' or 'slow'. Societal norms mean that a person walking at this rate is 'fast' but a car travelling at this rate it is 'slow'. As such, whether students proceed to Accounting or Medical Science, they will need to interpret meanings differently depending on the situation and the society based context around the problems they will be attempting to solve. It is the combinations of all of these aspects that mean that developing QL involves psychological, situative, and sociological considerations, and has the potential to be very complex.

An added complexity that Shavelson (2008) argued was that a move to interpret numbers in words and to put verbal meaning onto concepts could take away from the ability of students to compute. Orrill (2008), however, countered that the two must go together and that QL is about both understanding the numbers *and* interpreting the relationships between them. Therefore, it is not about taking away the numbers all together, but presenting the numbers in such a way that students are able to apply their QL to new problems such as ones that the student will face in later courses. An example of this is estimation (Shavelson, 2008). It is very important to be able to estimate *mathematically*, among other important uses of estimation. It is not just estimating the size however, but using the estimate to ensure the calculations are correct.

2.2.2 Teaching for QL

Orrill (2008) and his colleagues from the conference in Wisconsin, discuss the ongoing debate about whether it is the role of the university to teach QL or simply equip students with the mathematical knowledge to gain qualifications in order to obtain careers. Steen (2008) states that mathematics is often taught with a focus on skills and content, whereas QL "depends far more on the processes of mathematics—reasoning, communication, representation, connections, and problem solving" (p. 15). When students encounter mathematical problems in their later study, they will be best prepared if they can relate content of mathematics to the context, that is, if they have strong QL. Shavelson (2008) agrees, stating that mathematics is heavily discipline specific, whereas QL is interdisciplinary.

Others have raised the issue of the relationship between teaching and student understanding (Burdette & McLoughlin, 2010; Butin, 2007; Fitzpatrick & Schulz, 2015; Marsh & Dredge, 2013; Rodrigues, 2012). The nature and influence, however, depends on many things, and could include the situation, the student cohort, the pedagogy and assessment styles, and the teaching style. In particular, Fitzpatrick and Schulz (2015) who investigated teachers of science, mention the contributions of a lack of teacher knowledge in regard to how to teach for understanding, pressures on time to teach all of the factual content, and the issue of not teaching for understanding. Marsh and Dredge (2013) also discuss the differences between teaching mathematics content, and teaching it for understanding, and that students often cannot recall content if they have not gained an understanding of the application of that content.

> Significantly, notion of transfer or application speaks right to the heart of the indignant claim that 'You didn't teach us this!' The statement often at a content level is untrue. The content was taught. However at a conceptual level, at an understanding level that demands that students apply their knowledge in a new situation, the statement may in many instances prove to be true (p. 23).

The importance of knowledge versus understanding will undoubtedly be mentioned in any study into the development of literacies in students and will be highly situational and socio-culturally dependent. Therefore, before considering the students' experiences focussed around learning mathematics, their experiences in the broader context of their literacy development is important.

2.2.3 Investigating quantitative literacy in STEPS mathematics

Enabling courses not only seek to increase students' skills in navigating the university environment and therefore their literacy of tertiary education, but also must provide students content knowledge in several disciplines, again dependent on the undergraduate degree they intend to pursue. This study is around the discipline of mathematics, and specifically quantitative literacy, but it is also important to acknowledge that there are other discipline literacies.

The STEPS course offers more specific units according to the content area, such as language, mathematics, biology, chemistry, physics, or digital systems knowledge, and these are required across a range of Bachelor level courses. As previously mentioned, apart from the core unit of Preparation Skills for University, STEPS has a suite of 11 other units: Computing Skills for University, Essay Writing for University, Technical Writing for University, Positive Learning for University, Fundamental Mathematics for University, Intermediate Mathematics for University, Technical Mathematics for University, Foundation Science, Introductory Biology, Introductory Chemistry, Introductory Physics (See Appendix A for more details). Students are usually required or recommended to study between two and seven of these additional units according to their study plan established in consultation with the AC.

Each of the disciplines will have its own literacy, concerning its own language, concepts, meanings and ways of using text-based communication, and so students are often immersed in more than one context at any given time during their STEPS study. Mathematics, like written words, is key across several disciplines, and in many Bachelor level courses. As such, there is a need to understand how students interpret the mathematical concepts they are learning and how they relate them to both prior knowledge and future applications. This is especially so in the enabling context where students come to STEPS with such vast differences in subject knowledge, both as a result of formal mathematics learning in a classroom as well as from using mathematics in general life situations. Also, as STEPS students are adult learners with their own experiences, motivations and skills in the world, this study was conducted in terms of both adult learning theory and in terms of multiliteracies.

The bigger picture involves tertiary education and institutional literacies of the university environment and learning centred literacies such as self-directed learning, both of which are useful for ongoing university study. In this study, however, the emphasis was on investigating how students develop their discipline specific knowledge, that is, learn mathematics, so that they are able to engage with the content, develop understanding, and potentially use this in future courses. In other words, it concentrated on quantitative literacy for and around learning mathematics.

While other studies have examined quantitative literacy in other courses and educational settings, the type of data desired for this study was students' experiences of learning mathematics within the particular context of the STEPS course. Therefore, the qualitative data collection and analysis techniques of GTM were used, and this is described in Chapter 3.

Chapter 3 Research Design

Research design in general, and particularly in education, is influenced by the ontology of the researcher, “the nature of reality” (Goertz & Mahoney, 2012, p. 207), the related epistemology, “way of understanding and explaining how we know what we know” (Crotty, 1998, p. 3) and the situation in which the research is conducted. This chapter will explore the research design for this study, from the philosophical aspects to the practical aspects; from the details of the methodology to the intricacies of the methods; and from the researcher to the participants.

If researchers have a positivist world-view, they believe that knowledge is definite and fixed. This is often seen in scientific studies on inanimate objects that seek to generate concrete data and facts to ‘prove’ or ‘disprove’ phenomena and therefore these studies use quantitative research methods. For research into education, this could mean proving or disproving the transfer of absolute knowledge using such methods as analysing test results and the use of statistics. On the other hand, if researchers have a constructivist view, they believe knowledge formation is primarily the domain of learners who form their own ideas, connections and understandings around the phenomena. This is often seen in the social sciences where the definition of a phenomenon is refined through experiences, whether individual (personal constructivism) or as a group (social constructivism). Research in education using a constructivist framework would likely concentrate on how the experiences of the learners shape their knowledge. Data collection might be personal accounts, and hence the use of qualitative research methods.

Between the differing views of the positivist and the constructivist are the post-positivist and the interpretivist. Post-positivist researchers align much of their view with the positivist, although they take the stance of being more open to critical analysis in regard to the concepts of ‘prove’ and ‘disprove’, and they argue that some phenomena cannot be ‘proven’, especially in research into the human condition. This is not necessarily because there is not a definitive answer, but because the situation is often too complex for controlled experiments. The interpretivist is a little more removed from the positivist position, and realises that some forms of knowledge are facts, but believes that the meaning or consequences of the facts especially in a social world are open to interpretation, similar to constructing meaning, but with limitations. This is useful in research in education involving sciences or mathematics, where a key part of learning is for students to align their interpretations of the facts with more broad scientific understanding. For example, one plus two does equal three, and, no matter what construction of understanding one uses, it cannot equal four. However, the way students interpret for themselves how to understand the meanings of ‘one’, ‘two’, ‘equal’ and ‘three’ are concepts they will form in their own minds. Data collection is often based on participants’ interpretations, and so is qualitative. Interpretivist researchers also acknowledge their own input in interpreting the data during analysis.

The ontology of the researcher will directly influence the type of new knowledge the researcher seeks to generate and hence where they will focus any research. In education, this might be teaching specifics at the more positivistic end of the spectrum, or knowledge acquisition through such aspects as social experiences or ability to express meaning at the more constructivist end.

In this study, I operated from an interpretivist/constructivist ontology. It was interpretivist in terms of meaning making through either individual or social understanding of the more concrete content knowledge of mathematics, yet constructivist in terms of social and learning theories. Therefore, I was able to focus on how students understand concepts that already have a very positivist-aligned value in the world, that is the mathematics they are learning, and still construct a grounded theory around the learning, being a theory of quantitative literacy for learning mathematics. Participants’ ways of understanding are conveyed through their experiences and as such, a qualitative research methodology allows the researcher to “understand, describe and sometimes explain phenomena ‘from the inside’ [where] experiences of individuals or groups are analysed” (Flick, 2018). In this case, I pursued an in-depth qualitative investigation specifically around the experiences of the STEPS students using Grounded Theory Methodology (GTM).

I used the definition of GMT provided by Charmaz (2014) who developed a comprehensive Grounded Methodology from the earlier work of Glaser and Strauss (1967). In her review of earlier work with GMT, Charmaz argues that Strauss’s later methodologies (which became very popular during the 1990s and 2000s) differed from the original presentation of GTM in that they favoured “applying additional technical procedures rather than emphasizing emergent theoretical categories… Strauss and Corbin’s procedures force data into preconceived categories [and] ignore emergence” (p. 11).

To maintain the focus on emerging categories, Charmaz (2014) adopted a more constructivist approach and “chose the term ‘constructivist grounded theory’ [which] brought relativity and subjectivity into epistemological discussions of grounded theory” (p. 13). In response to the suggestion that her theory might mean “an unwarranted intrusion of the researcher” (Glaser, 2012, p. 29), Charmaz argues that her “approach explicitly assumes that any theoretical rendering offers an *interpretive* portrayal of the studied world, not an exact picture of it” (Charmaz, 2014, p. 17). She advocates “building on the pragmatist underpinnings in grounded theory and advancing interpretive analyses" (p. 17). Her constructivist viewpoint is supported by Flick (2018) as "researchers never find data *per se*, but construct or interpret phenomena in specific ways so that they can be used as data in social research" (p. 4).

In this study, while I recognised and considered Glaser's concerns about forcing analysis, and letting the theory emerge from the data, I took the interpretive stance of Charmaz. It may be argued that this is a more realistic stance in that I am the one as the researcher, who composes the story, and constructs the theory, based on my interpretation of the emerging analysis and theorisation.

This chapter will be presented in a fairly linear fashion, although GTM is not particularly a linear process. As Charmaz displayed in her diagram, (see Figure 3-1), the traditional, linear pattern is shown on the left, from the bottom up. This chapter follows this linear layout. As on the right side of the diagram, however, in reality, the process continually goes back and forth between steps in the process. The jumpiness is due to the 'constant comparison' between data and emerging categories.

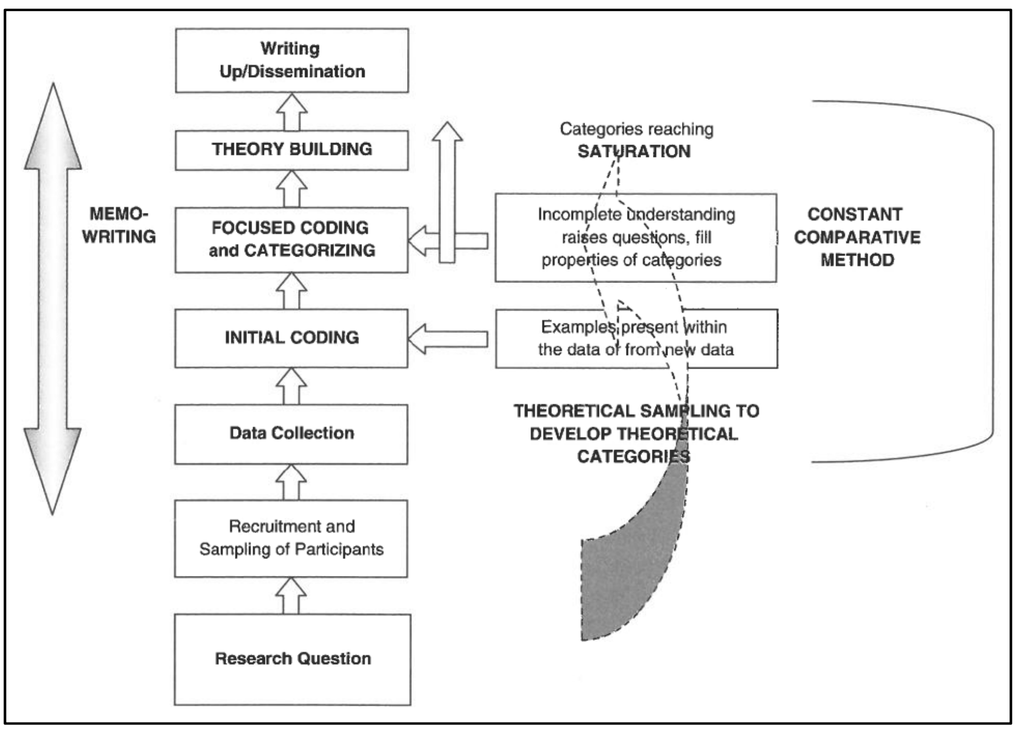

Figure 3-1 Charmaz's visual representation of the process of GTM (Charmaz, 2014)

In this chapter, section 3.1 describes the philosophical underpinnings and the interpretivist analysis (3.1.1) and also acknowledges the need for theoretical sensitivity of the researcher (3.1.2). It then details the context, recognising the highly situatedness of the analysis (3.1.3). Because of the highly interpretive stance of the researcher, section 3.2 outlines my position as a discipline expert (3.2.1) with prior research experience (3.2.2) and who conducted the interviews (3.2.3). Section 3.3

explains the data generation and management processes. The data analysis is detailed in section 3.4, describing coding (3.4.1), memo-making (3.4.2) and analytic categories (3.4.3). Theoretical analysis is undertaken in section 3.5. Section 3.6 examines the limitations of the study with respect to the methodology. This study required ethical approval and details are given in Section 3.7 and Appendix B.

3.1 Grounded Theory Methodology (GTM)

An interpretivist framework enabled me to conduct the study using a GTM as a foundation for analysis, with relevance to the particular situation, and also include acknowledgement of the impact of existing theories and my prior knowledge on the emerging theory.

3.1.1 Philosophy of GTM analysis

GTM has a level of theoretical development based on the analysis of the data and this has been compared with other theoretical development strategies, including induction, deduction, and abduction. Bryant and Charmaz (2010a) have likened GTM to induction but they criticise purely inductive methodologies, for being naïve and shallow saying that they are too generalised and uncertain as observation without analytical underpinning is unreliable. Researchers who use induction draw conclusions and theories from the data in a positivistic frame of reference. Induction is based more on physical, fact-based observation data, and Bryant and Charmaz (2010a) highlight that problem in the resulting theories is that they do not have any logical base that can be argued as to *why* that conclusion was drawn. Therefore, there is no way to test the theory, nor any logical way to account for exceptions or anomalies.

Deduction, on the other hand, has a very strong focus on logic. As Reichertz (2010) asserts, deduction produces conclusions and hence theories based predominantly on logical argument. These theories focus predominantly on the ‘why’. The theories can be tested logically through hypothesis testing in different cases and under different conditions. The problem is that anomalies tend to be ‘argued out’ and ‘explained away’, as long as most of the data fits, and the logic stands, the theory will remain. Ignoring anomalies risks missing some important aspects that may be critical to the theory. Deduction was traditionally used in the realm of the natural and physical sciences and therefore was a suitable method in this arena. It has been found wanting, however, in the social sciences. Human behaviour is not always logical, able to be deduced, scientifically tested, or adherent to statistical analysis, although prediction is often useful. Also anomalies are of more interest in social sciences and investigated further rather than argued away. The logic and connections in deductive reasoning are very beneficial in overcoming the 'naïve' nature of inductive reasoning, but neither quite meet the needs of grounded theory.

Abduction is a method that can overcome some of the issues with both induction and deduction while keeping features of each that are useful (Reichertz, 2010). Abduction places an importance on new knowledge and treats anomalies as new data to investigate and from which to draw inferences, similar to induction. Abduction also uses logic to decipher the data through systematic analysis and this in turn leads to an ordered approach to collecting new data. Therefore, the research needs some amount of design, as with deduction. As such, this process *guides* the generation of data. Reichertz (2010) asserts that abduction supports the GTM principles of 'everything is data', and guides the researcher to a theory, rather than a "(pure) reflection of reality" (p. 222) and subsequently agrees with the interpretivist paradigm.

Therefore, abductive thinking fits with GTM because it aims to produce a theory that describes, explains and justifies a process or situation at a conceptual level (Creswell, 2008). Creswell explains that GTM is an approach to form a theory that is grounded in the data, research, findings, situation, and actions and that a theory is something that relates aspects to each other and can be used to form hypotheses or predict an outcome. Creswell (2008) and Reichertz (2010) assert that a theory cannot be simply a description but is quite often based around actions or processes and includes conditions and qualifiers as necessary to produce "new and valid knowledge" (Reichertz, 2010, p. 216). As such, Reichertz (2010) goes on to say that a theory can be useful in helping people understand what will happen or what the outcomes will be if certain things happen, and can explain and predict cause and effect, the "design of a new rule" (p. 219).

With the development of a 'new' theory, it is important, however, to be aware of existing theories, and that is where theoretical sensitivity is key.

3.1.2 Theoretical sensitivity

In an interpretivist framework, having "theoretical sensitivity" (Charmaz, 2014, p. 244) as a result of substantial experience in qualitative research and analysis can be seen as beneficial in order for the researcher to have awareness of other theories when doing the analysis. Glaser requires researchers to be able to "develop theoretical insight into the area of research combined with the ability to make something of these insights… conceptualise,… make abstract connections…" (Glaser & Holton, 2007, p. 57). This theoretical insight, however, sits apart from the research, and serves only to inform the emerging theory. Dey (2010) presents this as a process. While researchers analyse the data, they do so "without accepting the preconceptions of the … literature" and to "read more widely" but that also allow "comparison and contrast, links and connections" (p. 173). Charmaz (2014) expands on GTM as a process driven methodology saying that "the acts involved in theorizing foster *seeing* possibilities, *establishing* connections, and *asking* questions" (p. 244). She states that theoretical sensitivity allows the researcher through these acts to "avoid importing and imposing packaged images and automatic answers from extant theories" (pp. 244-245).

An experienced researcher might have the requirements Glaser (1978) mentions, but there can also be benefits to being a novice researcher in the theoretical area of interest. Kelle (2010) discusses the tension between an experienced researcher who can conceptualise and make judgements in order to construct the theory, and a novice researcher who, without prior immersion in the field in question, would not be unduly influenced by other theories leaving the conceptual space to focus on the data. He says that a researcher with prior theoretical knowledge may "force inappropriate categories on the data when applying a specific sociological theory" (Kelle, 2010, p. 198). A researcher with fewer connections to existing theories would be better able to "hold various different theories in abeyance in order to use theoretical concepts only if they fit the data". Thus being able to bracket certain knowledge and suspend judgment about the fit of existing theories until after the data has been analysed using the processes of GTM as described above by Charmaz will help to ensure the developing theory truly fits the data of the particular situation in question.

My background position in this study came originally from a quantitative, scientific background (described further in section 3.2.1), so I felt that I had little theoretical understanding of educational philosophies, principles and concepts. During my post-doctoral research, however, I did develop some knowledge of theoretical frameworks and theories of learning. As this research was around how children learned mathematics and science through engineering, I became aware of theories such as Vygotsky's Zone of Proximal Development, and Kolb's Experiential Learning Cycle Model (Mann, 2016). What this meant was that during the study reported in this thesis, I was able to acknowledge that there were existing theories, take these into consideration during the data analysis, and this was beneficial for emerging theories (Kelle, 2010).

When it came to the need for constant comparison, however, my novice status may have been a drawback. This study, however, was part of a research higher degree, and hence I was able to draw on the theoretical expertise of my supervisors. As Pearson and Brew (2002) suggest, "the student learns through doing and through critical reflection on that experience in conversation with experts, who can draw on their extended repertoire of skills and strategies" (p. 140). Through frequent, lengthy discussions, I was able to debate the relationship between existing theories presented by my supervisors and the on-going analysis. My novice position meant that I did not have preconceptions about the proposed theories and therefore could question deeply and thoroughly investigate any potential connections. The supervisors in this case, had more knowledge of educational theories and therefore could help the researcher to flesh out the intricate details of any theory proposed for comparison, and hence no assumptions of the correlations were made. This is the essence of theoretical sensitivity as described by Glasser (2007) "to maintain analytic distance, tolerate confusion… [and] to enter the research setting with as few predetermined ideas as possible" (p. 57) and Charmaz (2014).

When considering existing theories, one of the questions I had to ask was whether any previous theory truly applied to the particular situation being studied. Existing theories may partially apply, or may need to be adapted, or may not be relevant at all. In any case, it was important to have a thorough understanding of the situation for the current study.

3.1.3 Situatedness

As is often the case in GTM, the theory that was developed surrounds a particular situation and will be recognisable as applying to that situation. Hence it is important, when interpreting the theory as developed through this research and presented in Chapter 5, that the conditions and the qualifiers of the situation be kept in mind (Noerager Stern, 2010). This 'Situatedness' is particularly applicable if the study involves some section, group or aspect of society which has elements in common, as the actions and interactions are inseparable from the context (Clarke & Friese, 2010). The conditions and qualifiers that appear in the theory are embedded in the situation. "The key concern that underlies negotiations, social worlds, and arenas is the *situatedness* of action and interaction" (Clarke & Friese, 2010, p. 364). Therefore the context, as described in this section, and backgrounds and attributes of the participants as described later in section 3.3.1, play an integral role in the setting of the theory, and hence the substantive theory itself. In a postmodern turn theories can be seen as temporal, partial and situated because the context is always dynamic.

Leading on from the context of the STEPS course as described in section 2.1.1, it is important to also understand the learning situation for the participants, in terms of the structure and timing of the mathematics units, class size and diversity, and teaching environment. At least one STEPS unit in mathematics is a prerequisite for many undergraduate programs to ensure a consistent entry level. Only six out of sixty-three undergraduate courses at CQUniversity do not require some STEPS mathematics study, although it is regularly recommended as an elective even in those cases. Other undergraduate courses require more advanced mathematics study. STEPS academics have therefore developed three consecutive mathematics units to meet the differing levels of mathematics required for different courses. As part of developing mathematic proficiency the structuring of the unit content and delivery also ensures that students learn the mathematics skills in an ordered and logical manner. This type of programming enables student to have flexibility in the level of proficiency required and they are at liberty to continue to develop proficiency beyond a prerequisite level stipulated for a specific course. This flexibility is also a safety-net for students if external factors, such as family or employment issues, interrupt study schedules and may therefore require a change to a different study plan.

The first level unit is Fundamental Mathematics for University (FMU) and is often the first time that many students have formally engaged with learning mathematics since school. This is the level required for courses in fields such as Accident Forensics, Agribusiness, Business, Exercise and Sports Science, Health Science, Hospitality, Information Technology, Nursing, Occupational Health and Safety, Oral Health, Occupational Therapy, Psychology, Social Work, Podiatry, and Speech Pathology. It begins at about a Primary Grade 4 level with addition, subtraction, multiplication and division, and works through to about a Secondary Grade 9 to 10 level (Australian Curriculum Assessment and Reporting Authority, 2015a) with algebraic equations and exponents.

The second level unit is Intermediate Mathematics for University (IMU). It aims to give students a sound mathematical knowledge up to about a senior Mathematics A level (Queensland Curriculum & Assessment Authority, 2015a), or general mathematics level (Australian Curriculum Assessment and Reporting Authority, 2015b), and covers more complex topics in algebra, geometry, trigonometry, and statistics. This is the level required or recommended for Associate Degrees of Building Design, Building Surveying, and Engineering, Bachelors in the fields of Aviation Technology, Chiropractic Science, Education, Environmental Science, Financial Planning, Medical Imaging, Medical Science, Paramedic Science, Property, Public Health, Science, Sonography, and Physiotherapy.

The third and highest level unit is Technical Mathematics for University (TMU). This unit covers advanced algebra, advanced geometry, vectors and introductory calculus and is considered for a CQUniversity context to be equivalent to senior Mathematics B (Queensland Curriculum & Assessment Authority, 2015b), or specialist mathematics level (Australian Curriculum Assessment and Reporting Authority, 2015c). This level is required for the Bachelor level Building Design, Building Surveying, Construction Management, Secondary Education (with mathematics or science major), Engineering and Physical Science disciplines.

The learning outcomes of the mathematics units have been developed to enable students to learn the knowledge and skills they need for undergraduate study and emphasise the process needed for students to replicate the solving of problems. The learning outcomes published in the unit profile for Fundamental Mathematics are:

1. Recall fundamental mathematical concepts and techniques such as operations, percentages, introductory algebra, simple equation solving, exponents, linear equations, introductory statistics and units and conversions.
2. Apply appropriate mathematical techniques.
3. Develop solutions to applied mathematical problems.
4. Reflect on formative assessment to improve mathematical comprehension.
5. Analyse information using mathematical techniques.
6. Communicate mathematical solutions.

For the later units, only the content topics in the first learning outcome changes. The other outcomes remain the same despite more complex content where contextualisation is more important (Madison, 2007). While learning outcome 4 does mention comprehension, the way this is interpreted is to improve the results in the summative assessment. At this stage it is clear that the focus of these units is to provide skill development.

Learning materials include a study guide or text book, online resources, videos, worked examples, and tutorial questions. While the content, textbook, example videos and assessment all remain the same within a unit, a point of variation is the way in which the lecturer teaches the unit. On campus classes are structured within a traditional timetable where only four to six of the nominal twelve hours per week spent in class.

The timing of when students undertake mathematics units is important to their level of confidence in negotiating the university environment and therefore their level of literacy of tertiary education while also developing mathematics literacy. Each term[5] in STEPS is twelve weeks and students undertake between one and four units each term. For study plans requiring mathematics units, the first mathematics unit, FMU, is often studied in a student's first or second term of the STEPS course. It is important to note that if this is done during a student's first term, they are still learning to negotiate the broader university context as described in section 2.3.1. Therefore students are dealing with multiple layers of new conditions and information. If students take FMU in their second term, or take a higher level mathematics unit IMU or TMU, they will still be dealing with new contexts, although they will have a higher level of literacy in the tertiary education context.

[5] CQUniversity uses the word 'term' for a period of enrolment, often called semester, session or study period.

The number and diversity of students in classes also affects the level and types of interactions that occur. In most instances, the philosophy of enabling courses is to maintain high teacher to student ratios to offer the most direct learning support feasible. Thus class sizes are typically around twenty-five to thirty students and one teacher. Within this size class, there is scope for much diversity in ages, backgrounds, and types of prior experience of the students. For example, some students are more mature, have children and have worked for many years, whereas others are recent school leavers who may never have been employed. As students are free to choose their own seating arrangements within the classroom, students seem to form associations with other students with similar backgrounds (Parkinson, Kleinbaum, & Wheatley, 2018), and, because of the relatively small class sizes, these tend to be small groups. This may affect the range of interactions and conversations that a student may experience within the classroom situation.

Interactions within the situation of the mathematics classroom are also somewhat controlled by the structure of the teaching environment and the style of teaching used by any particular teacher and this can range in the amount of interaction encouraged. Some teachers prefer a mostly instructional style with some limited opportunities for discussion such as “direct (explicit) teaching” (McInerney & McInerney, 2006, p. 6). Others use guided instruction approaches with more interaction “explaining and demonstrating… [and] asking students relevant questions” (McInerney & McInerney, 2006, p. 15). Further, some teachers employ discussion-based, problem solving activities where a lot of discussion and debate is encouraged through “active involvement… pondering over higher cognitive-level questions which… force them to apply, analyse, synthesise…” (McInerney & McInerney, 2006, p. 11). In all of these environments, however, if there are opportunities for students to engage in discussions around the content, an important context for the experiences of the STEPS students is established.

As well as the situation of the participants being important for the GTM used in this study, there is a separate aspect, but one that is also particularly related to the interpretivist approach taken by GTM. The background and experience of the researcher, and the relationships between the researcher and the participants must be acknowledged.

3.2 Researcher positioning

In this study, I as the researcher, was a mathematics lecturer within the STEPS course while doing the GTM project. This position is significant for three reasons. The first is that my extensive and high level knowledge of the subject of mathematics could have been either a help or hindrance in researching foundation level mathematics education. Secondly, my prior experiences with research were predominantly quantitative and this gave a unique perspective on this qualitative research study. Thirdly, within GTM I was an insider in the data gathering phase by conducting the interviews myself and hence also in the analysis of the data.

3.2.1 Discipline expert

I have a strong background in mathematics and science, and this led to benefits with in the research project, as long as any potential issues were recognised and accommodated.

I excelled at mathematics and science subjects at school. I then went on to a Bachelor of Science degree with majors in physics and mathematics, and gained Honours in Physics. I immediately went on to complete a PhD in Materials Engineering, again a discipline immersed in the physical sciences and mathematics. I have previously described myself as “deeply passionate about all things physics” (Mann, 2016, p. 17). After a year in the USA undertaking post-doctoral research in Engineering Education, I began working at CQUniversity and teaching in enabling courses. It was my discipline knowledge that led to a full time lecturing position in STEPS.

When it came to the GTM study around students’ experiences with mathematics, the discipline knowledge gave me a unique opportunity to interact with the students. This is because “background assumptions and disciplinary perspectives can alert [researchers] to certain possibilities and processes in their data” (Charmaz, 2014, p. 30). Being a mathematical discipline expert allowed me, in this study, to ask deeper questions. For example, when a participant was trying to explain knowledge around pluses and minuses, I could help the student clarify what mathematics they were trying to explain. It also meant that I knew if the participants had a correct understanding of the concepts, important when interpreting their level of understanding of the subject matter. A researcher without the subject knowledge may have found it difficult to glean what or how students understood the actual content of mathematics. For example, when students talked about algebra or higher level mathematics such as calculus, I could understand what they actually meant, and facets of that understanding. For the whole project, it was the mathematical content knowledge that was required to link it all together. Questioning in interviews conducted by someone who is not mathematically knowledgeable may not be as thorough and hence core issues may be missed.

A potential issue is that, either while interviewing or analysing, I might have made assumptions about what the participants were saying or their level of understanding. Even without being an insider in mathematics, any researcher could make this error (Halldén, Haglund, & Strömdahl, 2007). It is not inherently a result of a high level of discipline knowledge. Again, being aware of this, I was sure to recognise suppositions on my part, and hence fully clarify anything that may have been misconstrued or misrepresented. Indeed, this was beneficial in identifying subtle misconceptions in the mathematical understanding of the participants. I was more likely to be able to know what questions to ask to clarify ambiguous statements, or investigate more deeply if what they said was mathematically incorrect.

It was also beneficial to have a high level of discipline knowledge during the analysis phase of the research (Halldén et al., 2007). While the project was about learning and education, it was also about mathematics. The way people learn subjects is different for each subject (Ligozat & Leutenegger, 2015) and it is integral to the analysis that the researcher can identify the reasons students may make certain links. For example in this project, a participant said that she understood percentages through fractions, but could not say why that was despite further questioning. In the analyses of the data, I was able to use the discipline knowledge to make the connection that they were equivalent. I understood why participants made certain associations with the content and that helps position the project specifically about *mathematical* education, not a broad perspective on education (Potari, Sakonidis, Chatzigoula, & Manaridis, 2010).

3.2.2 Researcher prior experience

As already mentioned, I had completed a Bachelor of Science, an Honours thesis, a PhD thesis, and post-doctoral research and as such had a significant amount of research experience. This was all, however, in a highly quantitative realm and may seem to be counterproductive to undertaking a qualitative project except that I was cognisant of the differences and made an effort to incorporate previously learned research skills in the current project.

Extensive prior research experiences allowed transfer of research skills (Mann, 2016). Of particular note are my ability to critically review information and processes, and the importance of the selection of the methodology. Quantitative research, like qualitative research, required examining the literature, existing data and theories. This includes context, author background, reasons for research, evaluating conflicting viewpoints and interpreting variable dependent outcomes. Despite some notions that scientists who deal with quantitative data in a scientific world are positivist, there is still variation in outcomes, uncertainty, conjecture and interpretation, particularly in the area of atomic physics. This positions a researcher like myself well for critiquing and questioning in qualitative research.

3.2.3 Researcher as interviewer

In GTM, as an interpretive methodology, researchers are inherently not objective observers. As Charmaz argues that it is the aim of the researcher to “see this world as our research participants do

– from the inside" (Charmaz, 2014, p. 24). Therefore, she refers to the benefits of having the researcher conduct the interviews themselves (Charmaz, 2014). This had benefits for both the participants in helping them feel at ease, but the major benefit was for the analysis stage of the project as described here. Despite the benefits, there were some potential drawbacks because of the ethical considerations required, and these are detailed in Appendix B.

Charmaz (2014) notes in another study that the interviewer found "his background likely contributed to his interviewees' comfort and fostered their detailed responses" (p. 59). This can be a benefit of the researcher being known to the participants, and therefore, the participants may be more likely to tell more of their experiences. As previously mentioned, I was a lecturer within the STEPS course. This familiarity perhaps implies an assumption that participants in this study viewed me as more approachable.

My position also gave me the benefit of extensive situational knowledge. Charmaz (2014) argues that to "learn about the situation you will enter before you begin" (p. 59) the interviews, and this was not a problem for me. I had profound, established knowledge of every facet of the STEPS course, from the impetus of enabling courses, through the enrolment processes, and support offered, and the details of the mathematics units. This meant that myself as the interviewer was, as Charmaz (2014) describes, "fluent in pertinent procedural issues and technical questions [and this] helps them to engage the research participant and guide the conversation" (p. 59). I also knew key terms used throughout the university as well as the language of mathematics as described above, and this meant I was well positioned to "learn more by asking about special terms during the interview" (Charmaz, 2014, p. 60).

Of particular benefit for a GTM study was that as interviewer, I could tailor the interviews towards the emerging categories or theorisations. Firstly, I understood the need in GTM for the participants to tell their stories prior to extensive intervention. This means that they should be given time and space to talk about what they want, rather than the conversation being directed solely by a formal question protocol. As Charmaz (2014) explains, "during the interview, the participant talks; the interviewer encourages, listens, and learns" (p. 57). Once the participants had told their stories, the second important aspect of researcher as interviewer came into play. According to Charmaz, "interviewing permits interviewers to discover discourses and to pursue ideas and issues immediately that emerge during the interview" (p. 85). As the interviewer, I could be mindful of previous and on-going analysis and can use this during the interviews by "picking up and pursuing themes in interviews" (p. 86). This can be especially useful by "building additional carefully constructed and focused questions into later interviews" (p. 87) and as particularly prominent for

GTM, “explicit ‘what’ and ‘how’ questions… to begin to shape a subsequent theoretical analysis” (p. 93).

The notion of researcher as interviewer is therefore central to GTM and resulted in benefits both for the participants, and for the researcher. As a result, this benefitted the research throughout the analysis and the emerging theory development.

3.3 Data generation process

As Charmaz (2014) illustrated (Figure 3-1), in GTM, the data generation process is not necessarily completed in isolation prior to analysis. As will be described in this section, interviews with thirteen participants were conducted, recorded and transcribed. Between interviews, however, some of the initial data analysis of these interviews took place. This is described in section 3.4. Once several participants had been interviewed and the data initially analysed, there was still scope within GTM for further interviews if required during the process of theoretical analysis. Theoretical analysis is described in section 3.5 including the importance of theoretical saturation in determining the final number of participants and interviews. Therefore, in this thesis, the process is presented chronologically through data generation, data analysis and theoretical analysis, but recognising that in GTM the process is not limited to a step-wise process. Where this occurred in this study is clarified through the sections.

This study followed a common data generation process for GTM being individual interviews with participants, conducted by the researcher. This section describes the participant recruitment in 3.3.1 and introduces the participants, the interviews in 3.3.2 including the rationale of researcher as interviewer, and data management in 3.3.3.

3.3.1 Participant recruitment and selection, meet the participants

There are two aspects of GTM that influence participant recruitment and the selection of participants. First is determining the nature of the participants in relation to statistical demographics, and second is the number of participants.

GTM does not use a statistical sample and is not required to meet a certain demographic criteria (Morse, 2010). The students in the study should have the particular experience required for the study, that is, be involved in the research situation as described in section 3.1.3. In accord with GTM, recruitment was inherently non-random, did not necessarily reflect the general population, and did not require a large number of participants (Morse, 2010). Participants were students who were “willing to participate… have time to share… be reflective, willing, and able to speak articulately about the experience" (Morse, 2010, p. 231). Further, GTM recognises that any variation in experiences cannot solely be predicted by demographics. Morse (2010) encourages initially using "*convenience sampling* to locate persons who are available who have already gone through… the process" (p. 235). In addition, Charmaz's (2014) depiction of GTM in Figure 3-1 shows that the interviews and initial analysis go hand in hand as the researcher can "code and categorize data as [she collects] them" (p. 26). As such, further participants could be, and were, recruited via "*purposeful sampling* [where] participants [are] sought who are in or 'going through' the particular stage" (Morse, 2010, p. 237) as the study continued. The researcher determines selection of the participants.

As the context in this study was the STEPS mathematics units, initially a 'convenience sample' of students enrolled in FMU in and around my location, were invited to participate in interviews (See Appendix B for the permission to recruit, recruitment letter and information provided). Seven students accepted and were interviewed. They described their situations and experiences and I found they frequently discussed their teachers. Therefore, to extend the range of participant experiences, further participants were invited from a second campus. Six additional students were interviewed.

As interviews continued, and initial analysis began, there came a time when I began to hear similar comments and experiences repeated from interview to interview. In accordance with GTM, this is where I decided to pause the recruitment of new participants. After some time, I found avenues I wished to explore, and so recruited from a more 'purposeful sample' of FMU and IMU students from the second campus.

Further analysis could have seen additional 'purposeful sampling' later in the analysis, as in GTM, it is not necessarily the repetition of data, the "sameness or replication of instances" (Morse, 2010, p. 242), that concludes the interview stage. GTM allows for recruitment of additional participants up to and including the final analysis when the researcher is considering theoretical saturation (Morse, 2010). Theoretical saturation will be discussed in section 3.5.2. For this study, the thirteen participants were sufficient for this condition.

GTM explores the variations in the experiences of the participants, and therefore the initial determining factors in the recruitment of participants was to have a range of experiences in the classroom, as well as at work and in life. Within any set context, however, it is recognised that variation is often limited in certain aspects, and given that all of these students are involved in the STEPS course, it is expected that certain areas of their backgrounds may be similar, particularly in regard to prior education. With that caveat, participants were recruited until there was a mix of on campus and online students across different campuses and lecturers, and different ages and life experiences. At the beginning of the interview, participants were asked to provide their own pseudonym and from then on they were referred to by that name. The following descriptions use these pseudonyms and give basic descriptions of the participants to add to the understanding of their individual situations.

Stevie was a 19 year old female who was intending to study a Bachelor of Nursing. After withdrawing for medical reasons from on campus enrolment in STEPS, she was enrolled in FMU online. She was concurrently studying Preparation Skills and Computing online.

M[6] was a 21 year old male aiming for a Bachelor of Building Design. He was studying his second term of STEPS, and was enrolled in FMU on campus along with Essay Writing. He had previously completed Preparation Skills and Technical Writing both on campus.

Jane was a 38 year old female who wanted to progress to a Bachelor of Psychology and was studying her first term of STEPS. She was enrolled in FMU on campus and Preparation Skills online.

Kay was a 23 year old female who was aiming to study a Bachelor of Oral Health. She was enrolled in her second term of STEPS, in FMU and Essay Writing on campus, having completed Preparation Skills and Computing online.

Ro was a 29 year old female enrolled in her first term of STEPS, studying FMU, Preparation Skills and Computing all on campus. She was intending to progress to a Bachelor of Education (Primary).

Caroline was a 54 year old female who was not certain which degree she would ultimately undertake, but was aiming for a Bachelor of Accounting. Having attempted and not completed STEPS seventeen years earlier, she was in the first term of her renewed attempt. She was studying FMU, Preparation Skills and Computing all on campus.

Michelle was a 59 year old female in her first term of STEPS and was also enrolled in FMU, Preparation Skills and Computing all on campus. She was aiming for a Bachelor of Education (Secondary).

Kasey was a 30 year old female who had enrolled in STEPS online seven years prior but withdrew early. She was enrolled in the first term of the current attempt. Having done extremely well in

[6] This participant chose simply the letter M as his pseudonym.

STEPS diagnostic testing, Kasey was allowed to enrol in IMU in her first term. She was enrolled in IMU on campus and Preparation Skills online in that same term. She intended to study a Bachelor of Education (Secondary).

Candy was a 26 year old female. She had unsuccessfully attempted STEPS on campus eight years prior. She re-enrolled on campus six years after that, but did not actually commence classes. At the time of the interview, she was enrolled in FMU, Preparation Skills and Essay Writing all on campus and was aiming for a Bachelor of Engineering (Mechanical).

Cyndel was a 33 year old female intending to study a Bachelor of Information Technology. She was in her fourth term of STEPS opting to study one unit per term. She had completed Preparation Skills on campus, Computing online, and FMU on campus. She was enrolled in IMU on campus.

Thomas was a 20 year old male aiming to upskill to be successful at a Bachelor of Engineering, of which he had unsuccessfully attempted one term two years prior. He was in his second term of STEPS having completed FMU, Preparation Skills and Computing on campus, and was enrolled in IMU and Technical Writing also both on campus.

Charlie was a 33 year old male intending to study a Bachelor of Engineering. He was in his second term of STEPS, studying IMU and Technical Writing on campus and Science online. In the previous term, he completed FMU, Preparation Skills, Computing and Essay Writing all on campus.

Grace was a 52 year old female in her fourth term of STEPS. During her first three terms of STEPS, she had completed Preparation Skills and Essay Writing on campus, then FMU and Computing on campus, then Chemistry online. She was enrolled in IMU and Technical Writing on campus and Biology online. She was undecided about her subsequent course, but would like something in science.

3.3.2 Interviews and interviewing

A common method of interviewing in GTM is for researchers to conduct their own interviews.

Once participants had accepted the invitation, they were contacted to arrange a time and place, the necessary informed consent was collected, and the interviews were conducted.

The interviews were held in one of the campus libraries as this was deemed a neutral space for the participants (see section 3.6 for ethical considerations). A small meeting room was booked for the agreed time, and participants were informed to expect the interviews to be between thirty minutes and one hour in length. The participants were greeted in the library and offered a beverage and taken to the meeting room. The process of the interview was described using an information sheet. Participants were then asked to sign an informed consent form (see Appendix C for information sheet and template for informed consent). The final step prior to the questioning was the participant's choice of pseudonym.

In GTM it is acceptable for the researcher to either record the interviews or take notes. In this study all interviews were digitally recorded to allow the interview to flow without interruption and to allow me to revisit the data during the analysis stage. Recording the interviews allows for a high level of engagement with the participants, and it demonstrates valuing by showing full attention to the participant during the interview. Active listening was possible, including prompting, exploring, and being open to different avenues of conversation.

In line with GTM, an interview protocol that must be delivered in the same way to each participant was neither desired nor used. Instead, an interview guide that was flexible enough to deal with unexpected information, but still had open ended questions, facilitated the discussion (Charmaz, 2014) (see Appendix C for the initial interview guide). The questions were exploratory in nature with primary goal of elucidating information about the participants' experiences and to find details about the processes, actions, understandings, conceptualisations, and implications. The style of the interview was open and interactive, encouraging a conversation about the participants' experiences. At first, the participants were given time and space to tell their own stories.

The interviews focussed on the participants' experiences with mathematics. Questions began generally on how they were feeling about their current mathematics unit. This usually led to discussions around their classroom experiences, including individual and group activities, and interactions with the teaching. The questions also considered their past experiences in mathematics, especially through school, before moving on to explore how the participants used mathematics in their work, around the home, and in their daily lives outside of the classroom. Once the participants had told their stories, I asked about transitioning their mathematics knowledge from one situation to another. The interviews concluded when the participants indicated that they did not have anything further to say about their formal or informal encounters with mathematics.

3.3.3 Data management

After each interview the voice files were saved on a password protected computer under each participant's pseudonym, and subsequently transcribed by me. A template was used for transcription consisting of a table of six columns. The first and second columns contained the participant's pseudonym and a sequential reference number for that section of text. Every time the conversation changed from the interviewer to the participant or vice versa, a new row was made with the next number (turn taking). For ease of identifying who was talking, if it was the interviewer's comment, the pseudonym was accompanied by the letter G representing the name of the interviewer. Therefore, when quotes were taken for analysis, it was easy to identify where in the data the quote appeared and if it was the participant or the interviewer speaking. An example of this is shown in Figure 3-2.

Speaker ID	Turn taking	Interview Data	Code	Category	Notes
G Jane	001				
Jane	002				
G Jane	003				
Jane	004				

Figure 3-2 Example transcription table

The third column was for the transcribed text. The next two columns were for later use during analysis. The final column was to note elements such as time stamps, or if something significant but non-verbal happened during the interview, such as an interruption. This format made the text searchable, and clearly displayed for analysis.

To use quotes from the data, the pseudonym and the row number could be used as a reference, for example, "quote" (Jane 12). This will be seen predominantly in Chapter 4.

3.4 Data analysis

In GTM, the subject of what to do with the data has been much contested. There is a generally agreed upon initial data investigation process of open coding, memo-making, analytic categorisation, and making links or finding relationships between these broader categories (Dey, 2010). This is the process described in this section using the principles of GTM, prior to progressing to theoretical analysis.

3.4.1 Coding

A very first analysis of qualitative data can be open coding using line-by-line investigations (Holton, 2010). This can initially be simply a data management technique of grouping descriptive similarities. Coding is something, however, that cannot follow a prescriptive process. Glaser used "causes, context, contingencies, consequences, covariances, and conditions" (Bryant & Charmaz, 2010b, p. 8) which is very open and undefined, whereas Strauss used a process called 'axial coding' where intense work is done around one category at a time (Kelle, 2010). Care must be taken, however, as these sorts of techniques can be too prescriptive on the data and force it into preconceived codes and categories that might not emerge from any other method (Holton, 2010).

Charmaz uses a process of 'initial coding', and then 'focused coding'. This was useful in this study, but was adapted to expand on the initial coding development in more detail. This expansion was in line with the description of 'initial coding' from Saldaña (2016)[7]. Saldaña describes a vast many features of the notion of 'coding' and its many forms, but mentions that 'initial coding' is often the first stage of GTM studies. Saldaña defines 'initial coding' as a process that "breaks down qualitative data… examines them and compares them for similarities and differences" (295) and then the actual code "attributes interpreted meaning" (Saldaña, 2016, p. 4). This type of initial coding was done for this particular study using printed copies of the transcripts, and used the process of (i) tagging (breaking down), (ii) comparing (for similarities and differences), and (iii) defining a code (attributing meaning). An example for one code is given in Table 3-1.

Interestingly, Saldaña also highlights the interpretive nature of the process: "coding… is primarily an interpretive act" (Saldaña, 2016, p. 5) and that all researchers see the data through their own particular lens.

(i) Tagging: Each transcript was studied and sections of the text were identified with tags. Tags were words that the participant used and could be actions, emotions, people, mathematical terms or anything the researcher interpreted as possibly significant from their position as discipline expert or researcher as interviewer. Tags were both single words and phrases, and could represent a single statement, or up to a conversation of many lines. Where these were longer sections, they could have more than one tag. A tag was noted by highlighting, underlining or being written in a separate column on the transcript. Once a section of text with a tag was identified, those lines of the transcript were physically cut apart from the remaining script. Tags differ from codes in that they were transient and undefined. It was not until after the comparison process that a code was defined. The entire three step process was short, often moving on from a tag to a code within a matter of hours, hence why tags do not have the same standing as codes.

(ii) Comparing: The tags of several sections of text were constantly compared to each other. This was to ascertain if the tags were the same, synonyms, or had similar meaning. In these cases, the tagged sections of text on their pieces of paper were physically put together. This comparison also involved interpretation, but the researcher remained open to possibilities.

[7] Saldana notes that breaking down the process is useful for beginning qualitative researchers. Since the researcher in this study was a novice in the area of qualitative research, it was found helpful to have a more prescriptive process to follow.

(iii) Defining a code: If many pieces of text with specific tags were grouped, the researcher defined a code to both associate and differentiate the tags. Again, this was open to interpretation by the researcher, and so it was important to be explicit and detailed in the definition. This helped to maintain the meaning of what the participants said, while helping to move forward in the analysis. Each tag was allocated only to one code. Therefore, while larger sections of text may have had several tags, and therefore had several codes associated with them, it was specifically a certain tag that meant the allocation to, or exclusion from any particular code.

Table 3-1 Examples of tagging, comparing and coding

Tags	***Comparison notes***	***Code***
"visual" "diagrams" "visually see" "picture"	These are to do with seeing things on paper or as images in their heads.	Visualising
"lose it" "mixed up" "confusing" "not knowing your way through"	They lose their way and get confused so that they cannot do the problem at that time.	Confusion

The codes were written at the top of large sheets of paper and hung around my office as shown in Figure 3-3. This process helped in the tagging, comparison and coding of further transcripts as there could be several months between interviews. I was cognisant, however, not to be limited to existing codes, and not to force codes onto sections of text. Text sections with new tags were often put aside until the iterative tagging and comparison process meant that new codes could be defined. The definitions of all of the codes were refined over time.

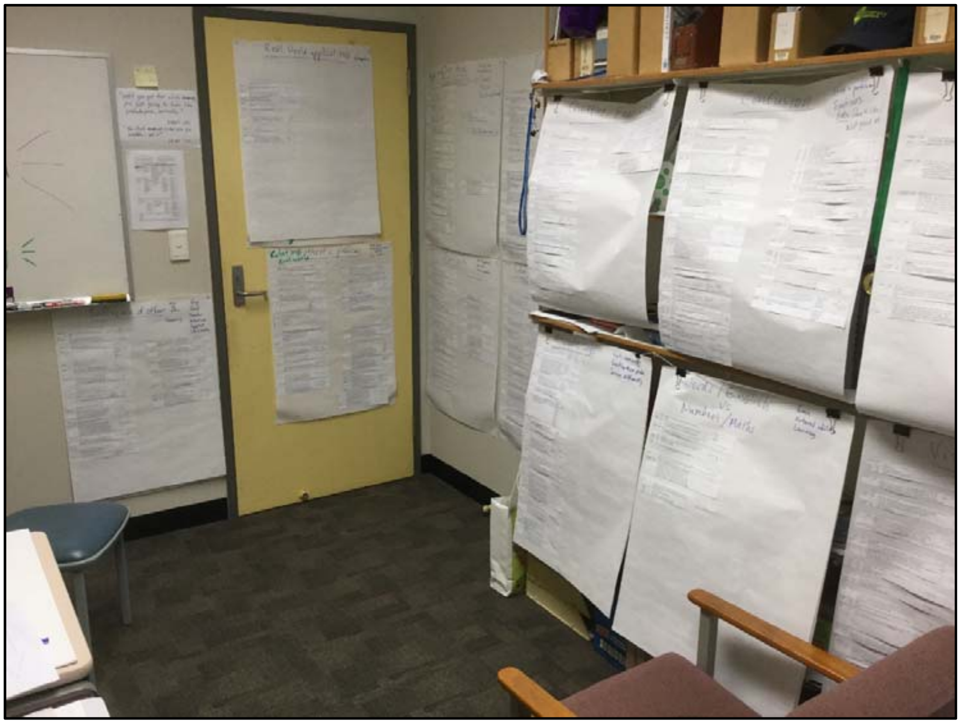

Figure 3-3 Coding of the data - visual representation

Once all of the transcripts had been analysed and coding of the data complete[8], the resulting codes and their definitions were finalised and are shown in Table 3-2.

Table 3-2 Codes and definitions used in this study

Code	***Definition***
Quitting, Fear, Self-doubt	Worry, anxiety. Students find it too difficult to do the subject, to continue with study, to attempt questions. Students have negative emotions overall related to mathematics or to study. Related to influence of others and prior experiences.
Confusion	Being a problem, bad. Struggle. This is portrayed by students struggling with the work and not wanting to do the wrong thing or go the wrong way. On the flip-side, students can't learn without being first confused and struggling through and frustration (borderlands discourse) otherwise they are not really learning anything new. Students often relate this to not having done or seen it before (familiarity).
Perseverance	Not giving up, persistence, repetition, building understanding. Students show that they are willing keep going for full understanding. They will often know that with practise and going over the work they will get there eventually.
Success	It builds confidence, counters bad thoughts, builds self-esteem. If students realise that they have had success, then they are more likely to try again. Students see doing well as a motivator.
Alternative ways	Work arounds, breaking down problems, seeing things differently. This could be from the student's point of view in that they know to look at different ways to do problems, or that they appreciate when teachers give them options and they can use the one they understand the most.
Words/English vs Numbers/ Mathematics	Brain, natural ability, way to learn. Interaction. Using words in mathematics. Some students think they are naturally mathematically minded, others have more affinity with words and writing. Coming into this is also the use of words in mathematics as 1) worded questions which students either struggle with or like, and 2) as annotations and explanations of their processes. Worded questions

[8] GTM in an ongoing process, and therefore "complete" is used to mean sufficient such that no further codes could be identified at that particular time. It did not necessarily close the process of coding off completely. In this study, however, even with additional interviews, no further codes were identified.

Code	Definition
	seem quite divisive but have been said that they are very good to show real world applications of the mathematics.
Visualising	Drawing, pictures, on paper, showing working. This is very much a way of learning, but has been pointed out in particular by students. It is more on the active side, either as the students do the work, or as the teacher teaches it. They prefer to be shown, use diagrams, relate things on paper, rather than listening or simply reading.
Ways of learning	Tools, strategies, preferences (apart from visualising). Many students talk about things that they prefer, such as a quiet space, or being shown rules. There are a wide range, but do all relate to learning preferences or strategies so were put together.
Real world applications	Examples of ways they use mathematics outside the classroom. When asked about whether students use mathematics outside of the classroom, they give a few standard answers such as budgets, cooking, work as a trade, other money, or practical hobbies involving making things. They may or may not relate these to the mathematics that they do in the classroom, or even realise they are doing mathematics.
Authentic problems	How book/problems in class relate to the real world. This is from the point of view of what they are learning in class. Students often comment that they want to see why they are doing the mathematics. This relates to worded questions. The trouble is that students have many different experiences/pathways that they do not always see the relevance. Related to looking to the future and their degrees.
Own pace	Taking time, no pressure. Mastery. Students often state that they need time to work it out, or do the questions, or go through the work. It relates to perseverance as students need time to practise and have sufficient repetition. They sometimes compare how quickly they understand in relation to others, or in relation to how fast the teacher is going.
Fun	Games, enjoyment, interest. If students have an interest in mathematics, they often enjoy it. This often relates to seeing the relevance or past experiences. It also relates to the teacher influence. However, for some students they just like mathematics.
Familiarity	Seen before, sort of remember, (not actually knowing already). Many think back to what they did at school and can see links or parts they remember.
Influence of others	Bad, good, teacher, relatives, classmates, support (seeking/using). Also ON others. Also comparing and competition. Many students commented on the good and bad influences of teachers. Some got in trouble for things they did 'wrong' and that influenced them liking/continuing mathematics. Many mentioned how the teachers in STEPS are enthusiastic/passionate or are good at explaining things. This relates to alternative ways and ways of learning. There is also some influence from family (spouse, parent, grandparent, children).
Patches	Talking about when they use calculators/computers automatically and do not understand the background mathematics to the processes.
Gaps	Knowledge and working. Some students mentioned the need to fill gaps in understanding or that they wanted to fully understand the mathematics and not just have a basic knowledge. Relates to perseverance in that they want to fill the gaps. Many students mentioned that when teachers leave gaps in their examples it makes them hard to follow. They also say when they skip steps in their working it can make it difficult to finish.

The next stage in the analysis was to look for associations between the codes and make connections through an interpretive process of memo making and thematic analysis.

3.4.2 Memo making

Memo-making is the step that begins to draw meaning from the codes. "Memo writing… is *the* fundamental process of researcher/data engagement that results in a 'grounded' theory" (Lempert, 2010, p. 245). Memo-making is, however, an extremely non-specific, often messy and physical process (Holton, 2010). It is a tool that allows the researcher flexibility to "formulate ideas, to play with them, to reconfigure them, to expand them, to explore them…" (Lempert, 2010, p. 247). This means that the codes and the data are explored in different ways. Connections are proposed but are open to being changed, being strengthened, or being discarded. The memos can be words, notes, thoughts, ideas, links, diagrams, or even a section of text that the researcher feels is meaningful at the time. The first round of memo making came after coding, when I was searching for connections and potential themes. Charmaz (2014) notes that memo making can occur anywhere "between data collection and writing drafts of papers" (p. 162) but it begins to be useful to "make discoveries about your data… become actively engaged in your materials and to develop your ideas, to fine-tune your subsequent data-gathering and to engage in critical reflexivity" (pp. 162-163).

Physically doing this memo-making is part of the process used by me to clarify ideas and write out the analytical process that is happening within my mind. It is a tool that makes the thoughts tangible by bringing these thoughts into being through the action of writing. This GTM is a visceral process, there are lots of actions and feelings that get transformed from the epistemological realm into the ontological aspect and subsequently demonstrated through the physicality of the process. In this case it was making notes on the papers around the office, writing and drawing on the whiteboard, then transformed again into the computer images and diagrams alongside text.

Ideas that occurred while processing the transcripts would be noted on the whiteboard. Being physically surrounded by the large sheets of paper and the visual aspect of the whiteboard meant I was truly immersed in the data and could readily draw on ideas from the data. This prompted other ideas and facilitated building relationships between the memos. From time to time, a photograph was taken of the whiteboard and it would be erased to make room for new ideas. This action was as much psychological cleansing of the mind as physical space making. This collection of photographs was then pinned to the noticeboard, so becoming the memos for building categories. One of these pictures has been included in Figure 3-4. As memos have a transient, context specific meaning, this is simply to show the process and is not designed to elucidate meaning. It can be seen, however, that codes are being grouped with arrows showing possible links. Words other than codes are used to expand and formulate ideas.

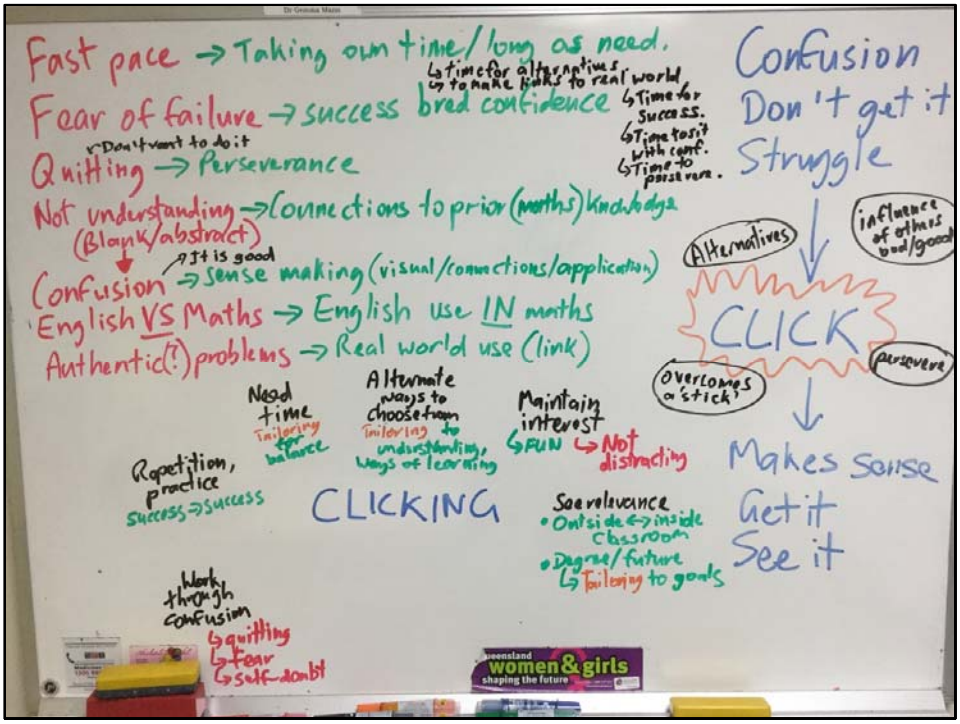

Figure 3-4 Memo making during thematic analysis

The memo-making process cannot be forced. It took time to think about relationships and links, and many iterations to bring themes together into analytic categories.

3.4.3 Analytic categories

Analytic categories form from the emerging relationships between codes. Charmaz (2014) calls this "focused coding [as] the second major phase" (p. 138). At this stage of the analysis, the researcher was open to any themes that could be drawn out as a result of the initial memo making process. Analytic categories formed through focussed coding could be descriptive, explanatory, conceptual, or a process, anything that "condenses, and sharpens what you have already done because it highlights what you find to be important in your emerging analysis [and it helps] to synthesize, analyze, and conceptualize larger segments of data" (Charmaz, 2014).

The analysis of the codes for this study led to ten categories. These categories had links, but did not yet represent an emerging theory. They were simply categories for later comparison and theory development. These ten categories were:

- Clicking
- Alternate ways to choose from
- Need time
- Repetition, practise

- Work through confusion
- Authentic problems make more sense/Real world uses
- Seen before
- See relevance
- Maintain interest
- Tailoring

These analytic categories were drawn on the whiteboard in an informal configuration as seen in Figure 3-5. Two aspects of note are that codes were combined within categories, and arrows were drawn showing potential links between categories. For example, it can be seen that the codes ‘visualising’ and ‘words/English’ were absorbed into the category of ‘authentic problems’. This category was then linked to the category ‘see relevance’ with the memo about seeing relevance to a degree or the future. The categories of ‘clicking’ and ‘tailoring’ had links to many other categories, shown by the strong lines or positioning of the words.

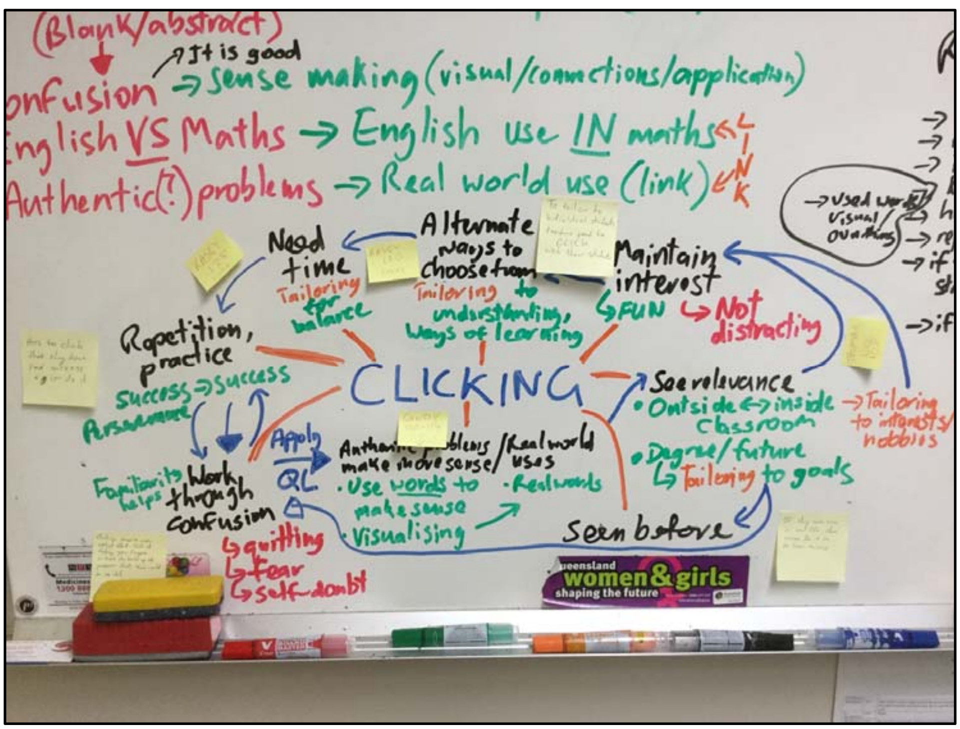

Figure 3-5 Initial development of analytic categories

At this stage of the development of the categories, the system did not have any particular order nor the links any properties. As described by Kelle (2010) “the whole structure or system of categories should not be exclusively developed in a top-down manner by deriving subcategories from major categories. Instead, researchers are encouraged to find major categories by carefully comparing the initially found categories (which may later become subcategories) and by integrating them into a larger structure.” (p. 194). In this particular study, all possible links were fully investigated. As each link between analytic categories was explored, memos were made and the emerging relationships were compared back to the data and original codes. Some explorations led to dead-ends, and others to new pathways. Eventually there was a transition from analytic categories to more theoretical categories, and for those categories to have emerging properties. This transition was neither a distinct point in time, nor a linear process, but I progressed and regressed, explored and reiterated, reworked categories and at some stage the analysis moved from predominantly *data* analysis to a more *theoretical* analysis.

3.5 Theoretical analysis

While useful, open coding and thematic categorisation, however, are not sufficient in building a theory. A subsequent and necessary stage of the GTM analysis must be *theoretical* categorisation (Dey, 2010). The stages in this process of this study are explained in this section. As mentioned the transition from data analysis to theoretical analysis was non-linear, involved much memo making and comparison back to the data. This is discussed in section 3.5.1. It is at this stage, however, that prior theories were considered and compared to the emerging analysis to maintain theoretical sensitivity.

Section 3.5.2 explains the process of ensuring theoretical saturation, as required by GMT.

Finally, through theoretical analysis, theoretical categories emerge and the relationships between them are made robust so that the result can be considered a theory. This process of development is described in section 3.5.3.

3.5.1 Return to memo making, constant comparison, and theoretical sensitivity

Charmaz (2014) explains that “writing successive memos throughout the research process… helps you to increase the level of abstraction of your ideas. Certain codes stand out and take form as theoretical categories as you write successive memos.” (p. 162). Thus memo making is once again the process of exploration, consideration of ideas, links and prior theories, and acceptance or rejection of any or all of these. This can be a lengthy process as all possibilities are explored. One example for this study is given here as an illustration of the processes of making memos, using constant comparison, and being sensitive to existing theories.

One of the analytic categories was ‘repetition, practise’. Figure 3-6 shows one of the whiteboard memos for this category. ‘Practicing [sic]’ was placed roughly in the centre and then lists of related words written alongside. Connections were drawn with arrows between ideas. This whiteboard also shows another category being included in the relationships by the word ‘time’. I had also written some of the original codes ‘gaps’ and ‘quitting’ as a comparison back to the data. In this way, the “categories [that] emerge from a close engagement with the data… can achieve a higher level of abstraction through a process of ‘constant comparison’” (Dey, 2010).

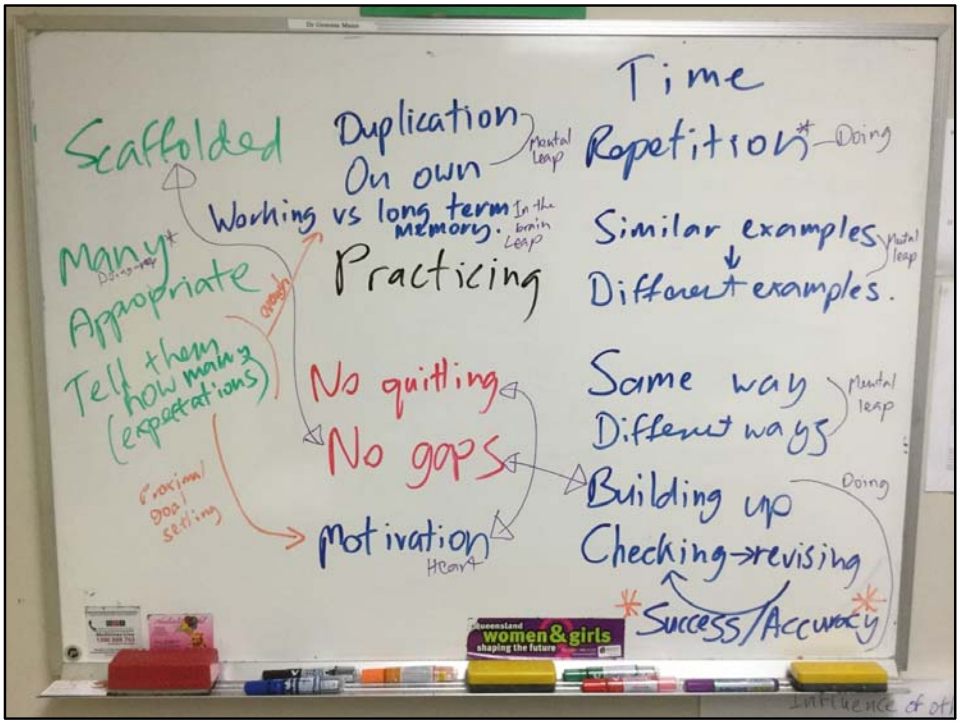

Figure 3-6 Memo of analytic categories, comparison and theoretical links

Memos are also the first place for the researcher to use theoretical sensitivity (Lempert, 2010). In the above example, I was aware from experience and the literature that there was an established theory around ‘proximal goal setting’ (Bandura & Schunk, 1981) and so the memo has incorporated this as a note. While this link has been identified, I had not necessarily drawn any conclusion about how, or even if, this will contribute to the final theory.

As another aspect of theoretical sensitivity, I was also aware of my own potential biases because of nature of my personal background and situatedness within the context of higher education (see Section 3.2). It would be impossible not to have certain theoretical insights into theories involving learning and mathematics. Through recognition and balance, however, I was able to utilise the knowledge to make sense of the data and emerging theory, but without undue influence.

3.5.2 Theoretical saturation and additional interviews

As analytical categories developed into theoretical categories, part of GTM is to consider theoretical saturation and whether these categories are as complete. This means that "categories are robust because you have found no new properties of these categories and your established properties account for patterns in you data… you have defined, checked, and explained relationships and the range of variation within and between your categories" (Charmaz, 2014, p. 213). If this is not the case, then further data collection may be warranted, either by reinterviewing previous participants, or recruiting additional participants.

Theoretical saturation can only occur well into the analysis process. This is because "theoretical saturation is not the same as witnessing repetition of the same events or stories" (Charmaz, 2014, p. 213). Therefore, it is only after potential theoretical categories have been identified and compared with the data where some properties of that category may not have sufficient data to be fully described. According to Dey (2010) saturation is when "the theory needs no more elaboration or refinement" (p. 185). Dey does, however, acknowledge that additional data may change the emerging theory and thus it is the researcher who must interpret the data at this point. The researcher plays "the 'authoritative' role" and that "saturation is a function… of the interpretation we make of it" (Dey, 2010, p. 186).

This study had progressed well into the theoretical analysis when several of the analytic categories were indicating a potential theoretical category of 'succeeding'. When compared with both the codes and the interview transcripts, I found little data on this concept. I decided to reinterview two of the prior thirteen participants and ask about their perceptions of succeeding, and as previously, this was within the context of learning mathematics in the STEPS course. I was able to focus on this one concept, because in GTM, "participants may also be asked targeted questions… or be asked to supplement information about linkages between two categories, hence contributing to the emerging theory" (Morse, 2010, p. 240). The interviews were once again transcribed as in section 3.3.3.

Once these additional interviews had taken place, theorisation continued and by the end of the study, no further interviews or participants were deemed necessary.

3.5.3 Theoretical categories and gerunds

As described in sections 3.5.1 and 3.5.2, coding and memo-making in GTM, led to identifying relationships and developing theoretical categories including properties of these categories. This is where the model moves from descriptive to conceptual and is based on theoretical judgement (Dey, 2010). Charmaz (2014) points out that "coding for themes rather than analyzing actions contributes to remaining descriptive" (p. 246). Instead, the researcher might "pursue theoretical possibilities… make connections between our theoretical categories and ideas concerning the core of human experience" (p. 246). In the discussion around the final theory produced by GTM, Reichertz (2010) argues that as a theory rather than a description, it should in some way be able to be used to "make predictions about the future on the basis of a past that is hypothetically understood" (p. 222).

Charmaz (2014) provides the way to transition to theoretical analysis rather than descriptive analysis. She "argue[s] that the bottom-up approach gives grounded theory its strength, *when the researcher asks analytic questions of the data*. The researcher's subjectivity provides a *way* of viewing, engaging and interrogating the data." (p. 247). Charmaz also "suggest[s]… emphasis on actions and on processes, rather than on viewing individuals as discrete units of analysis" (p. 245) and that steps within or properties of these processes may have causal links (Bryant & Charmaz, 2010a).

Since the theoretical categories should emphasise process, Charmaz (2014) stresses the importance of "using gerunds [as it] fosters theoretical sensitivity because these words nudge us out of the static topics into enacted processes" (p. 245).

In line with these suggestions, I spent much time asking questions of the data, looking for gerunds to name theoretical categories and investigating possible processes within categories. This mostly revolved around seeking the connections, determining the properties and the flow of what theoretical categories might look like. These potential theoretical categories were all noted using memos, the more complex of which were made with the aid of computer diagrams. To return to the example of 'repetition, practise', Figure 3-7 shows how this could be interpreted as theoretical category called 'practising' with defined, sequential links between its properties.

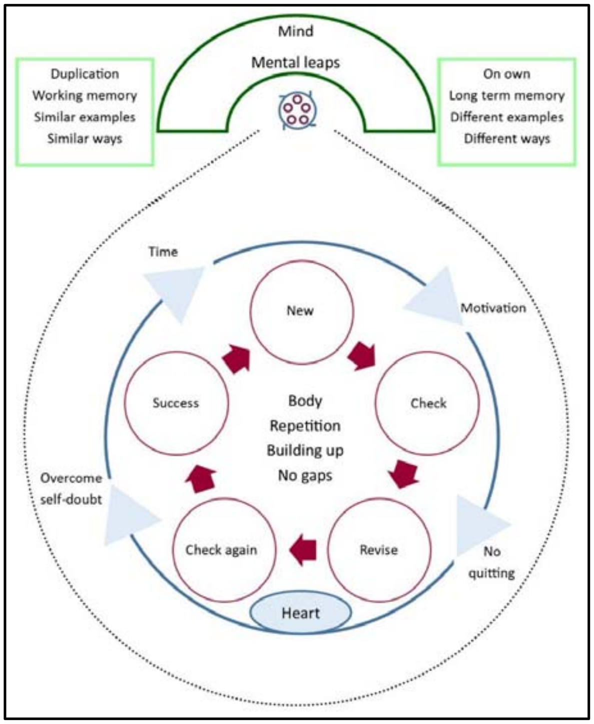

Figure 3-7 Investigation of the potential theoretical category of 'practising'

Again, there are connections to initial codes such as 'gaps' and 'quitting', other analytic categories such as 'time', but now there is more context and more detail in the direction of the interrelationships. There were also some new words appearing because of theoretical sensitivity, such as 'motivation' (Fielding-Wells, Brien, & Makar, 2017) and 'overcome self-doubt' (Krause, Bochner, Duchesne, & McMaugh, 2010).

All of the analytic categories were explored and analysed in the transition to theoretical categories, all while having theoretical sensitivity. As the analysis progressed, one theory in particular became a recurring theme. This was literacy theory and specifically, multiliteracies and quantitative literacy as described in Chapter 2. Thus the theoretical analysis ended with defining the categories and their properties within a literacy framework. The categories and their interrelationships are detailed in Chapter 4 and the overall theorisation is presented in Chapter 5. The last section in this chapter will detail the ethical considerations and scope and limitations of the study so as to include any constraints around the overall methodology, and how this may or may not have impacted the analysis.

3.6 Limitations

The scope of the study was determined by the investigation, the research questions, and the methodology. There were also limitations to study including timeframe, location, and funding.

The study aimed to research a certain phenomenon within a certain context and situation as outlined in section 3.1.3. This was with participants in the STEPS Course at CQUniversity who were taking mathematics units at the time of interview. This did not extend to students at in other courses at CQUniversity as it was investigating enabling education. It also did not extend to students at other institutions because of variations in courses and time constraints. The scope was limited to students in the STEPS course, and not teaching or other staff, as it was aimed at hearing the student experience in particular. Only current STEPS students were recruited to ensure their recounts of their experiences were recent and therefore as clear as possible. The methodology also helped determine the scope in as far as the number of participants, number of interviews, and data that was collected, as detailed in Chapter 3.

The timeframe was limited due to this being a 'Masters by Research' project and hence it had to be ensured in the nature of the study that it was suitable for completion within the time allocation. With guidance from the supervisory team, this project was able to be completed within the four years part time.

There was also a limitation on where the participants were located. STEPS students can study on campus or online so could have lived anywhere. This study was limited to students who could travel to a limited number of locations. As such, invitations were initially sent to participants in the Rockhampton region and subsequently in the Mackay region and interviews held on campuses in these cities. This resulted in sufficient participants as previously detailed, and so no further locations were used. This was a Research Training Scheme place using candidate support funds for a Masters by Research project and hence there was a limitation on expenses. This was guided by university policy.

3.7 Ethical considerations

The study was conducted in a university setting with university students. While it was not focussing on any minority groups, or people under the age of 18, there were ethical issues involved that meant a full National Ethics Application Form was required (The National Health and Medical Research Council, The Australian Research Council, & The Australian Vice-Chancellors' Committee, 2015). These are detailed here.

Masters research higher degree: This study was undertaken as a requirement for the Master of Education, and hence the Principal Researcher for the HREC application was necessarily the candidate's principal supervisor.

Conflict of interest: I currently hold a lecturing position in the STEPS program and this had two implications. The first risk was that I could have been in a position of power and therefore use this influence to cajole the students into participating (Ehrich, Cranston, Kimber, & Starr, 2012). A third party was engaged to deliver the recruitment message to the students and to take their initial expressions of interest. I had permission from the Associate Dean, School of Access Education for this third party to access student email addresses, to disseminate the invitation and pass on the details of interested participants to me.

The second implication was that often I taught FMU, IMU, and TMU classes. Since participants know that I am a lecturer in the subject that could mean that they felt intimidated or nervous about sharing personal stories (Isman, Altinay Aksal, & Altinay Gazi, 2009). To mitigate this, it was ensured that no participants were included where I was directly teaching a student, was Unit Coordinator for a student or in any way had direct or indirect influence over the teaching, marking, or grading of a student. This was at the time of the interview or if it was known that would be the case in a subsequent term. If a student is recruited and interviewed prior to any knowledge of there being a subsequent student/teacher situation, that was deemed suitable for inclusion in the study, but then no further interviews would be conducted with that student once the situation was known. The person receiving the expressions of interest had my class lists and knowledge of the student enrolments.

Risk to participants: There was negligible risk for harm or discomfort for participants. There was a risk of inconvenience, mitigated by participants self-nominating for participation with full knowledge about the time commitments and types of questions prior to interview. The time for the interview was negotiated with the participant, and the location was a campus library.

Risk to researcher: There was a possible risk that I might experience discomfort from the interview discussions. The pre-arrangement was to debrief with my supervisors. If the situation arose where I experienced significant discomfort I would inform the participant and suspend the interview. There was also the risk of travel between collection sites, mitigated by using a vehicle that was regularly serviced, and had appropriate insurance and registration.

Benefits of the research: In any research project, there is a risk-benefit analysis. In this study there was benefit to the participants as they were able to discuss their experiences in units, may have felt that they were contributing, and may feel that their feedback is important. The academic community and myself will benefit from the knowledge gained through this study and associated publications. Society and the community could also benefit from increased QL.

Research funding and source: This project was supported by the Research Training Scheme. There was no external funding, and I did receive any payment for this research.

Remuneration for participants: There was no monetary remuneration for participants. Interviews were conducted on the usual days for participants to be visiting the campus and so no extra financial burden was placed on the students by extra travel. To ensure participant comfort, I offered to purchase a beverage for the participant at the beginning of the interview.

Information and Consent: The participants were handed an Information Sheet at the commencement of the interview and this was specifically discussed to ensure understanding. Then the participant and was requested to sign an Informed Consent document prior to any questioning taking place.

Confidentiality: Each participant was invited to provide a pseudonym for the duration of the study accessible only to me and supervisory team. Names of the participants were not disseminated or published. Recordings only contained the pseudonym and were only accessible by myself and supervisory team.

Data storage: The list of participants, digital audio files and electronic transcripts were password protected and saved to the secure AARNET Cloudstor account. Once the project was complete, the data will be stored in this secure location until such time as it is deemed necessary, but for a minimum of 5 years after last publication according to CQUniversity policy. At such a time, digital files will be permanently deleted.

Dissemination of results: The research was and will be published in the form of a thesis, conference papers, journal articles, book publications, and internal reports.

With these ethical considerations accounted for, the study was granted ethics approval from the Human Research Ethics Committee of CQUniversity.

Chapter 4 What students said assisted them to learn mathematics

Two of the main concepts students spoke about were what they did themselves to assist their own mathematics learning, and what others did to assist their learning. The students described many different experiences with learning mathematics and, from those experiences, the researcher was able to develop theoretical categories that explain how these students believed they were able to learn mathematics effectively. These categories described deep learning processes, with outcomes that involved understanding and potential application, rather than a process such as memorisation. This chapter will outline the seven categories. I created a structure using these categories, with six of the categories forming a cycle and the seventh category in the centre as shown in Figure 4-1.

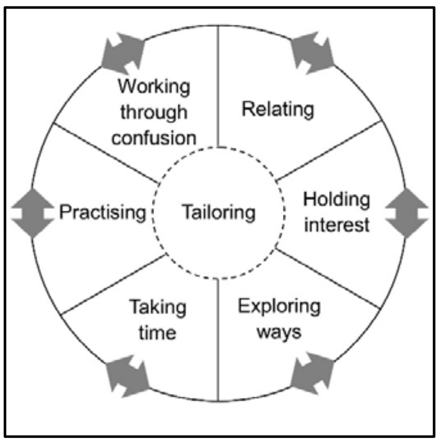

Figure 4-1 Student learning cycle

Although there is no beginning or end to the cycle, the six outer categories have been presented individually for the purposes of this discussion in sections 4.1 through 4.6, and subsequently the seventh, central category in section 4.7.

4.1 Relating

The students explained a desire to make connections between the mathematics they are learning and other experiences of their world, and they did this by relating aspects of each. This relating category was constructed predominantly from the codes ‘real world applications’, ‘authentic problems’, ‘familiarity’, and ‘future thinking and goal setting’ as all of these included students’ relating their learning and understanding to other aspects of their lives. Students were relating the mathematics concepts to previous learning, prior work or life experiences, current work and leisure activities, and to their future needs. Therefore, three properties of the relating category were: relating to the past (4.1.1), to the present (4.1.2), and to the future (4.1.3).

4.1.1 Past

All students were asked about their experiences of mathematics at school and therefore, all talked about what they did or did not remember from school. "I remembered it from school was the one we did last week, I think it was geometry" (Cyndel 138). If they could relate the current mathematics to what they did at school, it made it easier for them to learn new concepts in their current class. "I'd been out of school longer than I was in it. And it was just a matter of then going back and oh yeh, that's fine. Worked it out from there" (Charlie 54). "Some of the stuff is stuff that I did in junior and I remember having a really good experience throughout the trigonometry we've been doing this week" (Grace 4). "I found that having come back and doing it now, through the STEPS Program, through Fundamental Maths[9], you haven't done any maths up until I've come back as such, as a structured maths class and yeh, the negatives and positives… I just flowed into it. Like naturally" (Grace 16). Being familiar with the work from previous experiences, whether they could completely remember it or not, made the learning easier. "And the first part of it was like, graphs and finding the mean and modian (sic) and mode and whatever and like I did those in grade eight or like grade seven and I was like oh, I remember this. I don't know how to do it but I remember it" (Stevie 36). "Because I've done it all before it's like coming back to a familiar thing" (Thomas 52).

On the other hand, if students could not recall mathematics from school, it did make it harder for them to learn the new work and connect (students used the term "click") with the concepts. Kay admitted to not having learnt certain content at school: "algebra just did my head in, so to speak, I just didn't know… understand it because I didn't do it at school" (Kay 4). Stevie did remember doing the work at school, but when asked if she thought that would help her learn maths in the current unit, replied: "Probably not because… I don't really remember that much from primary school… I remember concepts and stuff, but not… fully enough to be comfortable enough to be able to do it" (Stevie 264).

The past was not especially useful to Stevie as an aid to learning maths because, even though she remembered some parts, she did not "really remember that much from primary school", especially not enough to make her "comfortable enough to be able to do it" then or later in STEPS. However, some students such as Charlie, Grace, and Thomas found that explicitly relating their current learning to previous learning, and making the connection to mathematics they have seen in the past consolidated their knowledge and helped them transfer that knowledge to the present.

[9] 'Maths' is an abbreviation of the word 'mathematics' as used commonly in speech. Therefore, it occurs throughout the quotes both from students and the researcher.

4.1.2 Present

The line of questioning about students' current hobbies and work prompted varied responses from the students. It was clear that some answers did demonstrate an ability to relate the knowledge required in these activities to an understanding of mathematics. Some of the students, however, were not able to relate their work and hobbies to mathematics at all, let alone to the unit content.

The sorts of hobbies that students talked about were

- constructing such as sewing or with timber (M, Caroline, Michelle, Candy, Thomas),
- cooking and baking related activities (Stevie, M, Jane, Kay, Ro, Michelle, Candy),
- budgeting (Stevie, Jane, Kay, Ro, Kasey, Candy, Grace),
- video games (M),
- photography (Kasey),
- sport (Stevie, Cyndel),

Students could see the mathematics involved in their hobbies where they actually made an artefact, for example: "So you use a lot of calculation in sewing, particularly if you're going to make a bed spread" (Caroline 114). Michelle also related her hobby of sewing to mathematics: "I use… material and that you use point three, or you use twenty-five percent or something of that, thirty percent of that" (Michelle 110). Both Caroline and Michelle found they were relating to what they knew as a way to help them understand the concepts of measurements, decimals and percentages.

When talking about cooking Jane could see the relevance of the mathematics in the classroom: "Probably if you'd have asked me before I started, no, not so much but you do become more aware of things. It's… like your brain waking up a little bit and all of a sudden you do realise, oh that rule actually relates back to what I was talking about today, or what I learnt today" (Jane 270). This, she then agreed, helped her in class: "So, the fact that you've used decimals, you can use your decimals in measurements, use your decimals in grams, use your decimals in a maths problem that you're doing in class?" (G Jane 279), "Yep. Yep" (Jane 280). Kay also related her mathematics to cooking: "at the start of the term I related maths to cooking measurements" (Kay 80); "because I do a lot of cooking so that's the only thing, like one fourths, one over four, like that's the one thing I had to relate the fractions to was cooking, that the only way I could understand fractions" (Kay 82).

Students realised that there was mathematics involved in budgeting: "I need to calculate how much all my groceries are coming up to before I get to the checkout… adding… and division as well. So if you're trying to spend like over a month so try and divide it into my weekly amount. And subtraction… decimals definitely" (Ro 142, 170, 172); "I'll do a weekly budget… write the costs... Add that up, make sure it adds up to what I get paid" (Candy 36, 38). Relating the mathematics skills required for this budgeting then helped them in the classroom.

For the other hobbies, the students related more to numbers than mathematical calculations or processes. M (72) related numbers explicitly to video games: "for this item I need this much of this, this much of that this much of that… and you end up building like a little graph"; and Kasey (92) related numbers to photography: "in photography you need numbers to do with ISOs and apertures and shutter speeds and different lights". For sports, students still related to numbers but the relationship was a little less prominent due to the simple nature of the maths perceived in these activities: "[adding scores] I did that a lot in my head because I don't like losing… That's just simple maths though" (Stevie 96, 100); "things like fitball, boxing, sprints, cardio sessions… the heart rate, we work it out… we count in the seconds that the instructor tells us" (Cyndel 240, 248, 250). Even simple numbers, however, can help students like M, Kasey, Stevie and Cyndel to feel that they can relate to mathematics, as, at the beginning of FMU, types of numbers are discussed.

Nearly all of the students mentioned that they used mathematics in their work, either with money or technical factors. Within the vast array of examples students gave, they were actually clear about the relationship between the mathematics they do at work and in the classroom. Two examples are from Cyndel and Charlie.

When asked what sorts of mathematics she does at work, Cyndel replied: "Only like the basic stuff, the percentage [when] they might split an amount of an invoice between a few departments" (220, 222). She said she does not do the calculations in her head, instead: "I'm using the calculator… Just a little one" (226, 228). Even prior to commencing FMU she said she "understood what was happening" (232) and when asked: "So did that really help when you got to the module?" (G Cyndel 235), she agreed saying: "Yeh. Yes. Yep" (Cyndel 236).

Charlie knew that: "There's a lot of maths involved in my trade" and specifically "proportions and… ratios… need to be correct in order to make enough paint" (Charlie 106) and he said it specifically helped in the module: "in fractions and that sort of stuff" (Charlie 108).

In contrast, when they could not relate the maths from their hobbies or work, it was evident this did not help them in the maths class. When Stevie was asked if she was able "to relate it back to things in your life that it might be easier?" (G Stevie 55), she said: "I find it hard to form connections to things like that" (Stevie 56) because the relationship was not explicit: "that's not the same with algebra… you've got plusses and minuses and then they turn into other minuses or positive numbers" and therefore found it: "Terrible, I can't wait for it to finish" (Stevie 66).

When Cyndel, Charlie and Stevie mention points such as "make connections" this is clearly relating the maths to their real world. If they can relate the maths to their current activities outside of the classroom, they are more likely to be able to understand the maths through practical applications.

4.1.3 Future

One of the strongest relationships the students made was between the *need* for the maths they were learning for their future studies and chosen careers, although relating to the *actual* maths was not always clear. An example was Kay, who was aiming for a Bachelor of Oral Health, when asked: "You're a dental assistant, so can you see any relevance at all from what you're doing, or the skills you're learning?" (G Kay 129) she responded: "Not yet but I'm thinking… giving needles and stuff and the right cartridges to the weight of someone or how much we can give local anaesthetic is going to be definitely…" (Kay 130). Candy, when asked a similar question in terms of relevance to a Mechanical Engineering degree, gave a similar response: "No, I can… well I know a little bit of mechanics now, so I can sort of see the relevance" (106). Also Charlie when talking about his intended Paramedics degree initially could not see a defined relationship: "I understand where it will relate to, but the actual uses of it, I'm not a hundred percent sure on yet" (Charlie 112). In the next statement, however, he could relate a few concepts: "percentages… fractions and ratios and that sort of stuff as to administering certain things when you're doing the job. But as far as the rest of it goes, no I'm not a hundred percent sure" (114). Therefore, Kay, Candy and Charlie all could relate the mathematics to their degree to some extent, and so knew they needed to learn the content.

One reason they may not be able to distinctly relate the mathematics to the degree is because the degree was too far removed from their current reality: "I'd say it is a bit far away" (M 128). This is also the case with Stevie (206), who intends to study a Nursing degree. She had trouble relating the mathematics to future work: "Although sometimes like algebra, I'm like, really? I'm not going to be 'a' plussing (sic) 'b' and whatever else. I'll be like, sorry I can't give you this tablet before I do some algebra, like that's why I can't… see." It is interesting, however, that when asked the subsequent question of: "What about if you needed to work out milligrams per body weight?" (G Stevie 207) she could see greater relevance: "Yeh see, I'd… I'd probably have to do it then." (Stevie 208). Therefore, it is evident that students like M and Stevie feel it is important to know the links to their future degrees in a way that makes the mathematics more relatable to their current learning. This would help mathematics become a resource, (using numbers and making calculations), and make the content more relevant for learning subsequent mathematical concepts.

This was further evident when M was discussing one of his hobbies. M (92) mentioned: "one of the things I love to create is floor plans" as a hobby and happily talked about units of measurement (98) "I try to work in millimetres", and scale (102) "can I split that into a scale where I can have nine metres along one edge and three metres along another edge and then so that's how I've got my scale". These are both covered in the maths unit, but he did not talk about that aspect. Despite not seeing the mathematical connections, he could still relate his hobby to his "end game so far for the uni is to do a (sic) AD[10] Building Design" (M 94). It was extremely important for M to build his quantitative literacy, and explicitly connect the maths to his chosen degree and career path.

From a different angle, if students could relate the maths to their future career, they were motivated to learn the maths. Jane, for her Psychology degree, noted: "I need to do algebra, probably not in the literal sense but probably it will apply to things I don't realise" (Jane 114); also "I'm sure there'll be statistical analysis and stuff like that that will definitely be used in its raw form too." (Jane 116). Jane was therefore able to relate to the mathematics as a resource for future learning.

Less often mentioned, but still evident, was students' desires to understand how each module would relate to the next module within the unit or from one unit to the next within the STEPS course. M was aware of more complex variation of current work around long division in subsequent units and stated: "I'm actually probably looking forward to it in a way" (M 62). Grace (170) was keen to look ahead in the unit: "I think it helps having… some of the clips[11], if you have a little bit of a pre-look at what's coming up, and that's what I did through Fundamentals, I would actually work through the week before, through the module, just go, oh, yeh, ok" (Grace 170). Stevie also wanted to see what was ahead: "Like I fast forwarded to the test B, the one that you sit. I just wanted to see what it was like" (Stevie 34). Looking ahead and between modules seemed to serve two purposes. First, it helped Grace and Stevie overcome the fear of the unknown, of what is coming next. Second, with M making these mathematical associations between his current and future modules promoted the development of a thorough understanding and would help give him a reason to pursue his current learning.

[10] AD is and Associate Degree (AQF level 6). While STEPS is designed to allow entry into Bachelor degrees, students occasionally opt for the lower level of AD.

[11] "clips" refers to the videos available on the unit site as described in section 3.1.3.

Although students may not always be able to see the relationships, it is clear that experiences with making connections to prior learning, current pursuits, and future endeavours influences their mathematical understanding and helped them learn concepts.

"It was actually finding that there is the real world, you know, aspect to it, but not just that, it's that you can you know, there is a reason to do it and that is probably the best thing" (Kasey 50).

4.2 Holding interest

In order to learn, it can be beneficial for students to be able to maintain their attention on the work and this therefore, this 'hold interest' in what they were doing became a category. When coding the transcripts, an initial code appeared and was labelled 'fun' and this included aspects such as enjoyment and being interested in the subject and in learning. As the category developed, however, there was more to this category than simply fun. Students were also cognisant of their need to maintain a commitment to the work and to stay interested despite it not being what they might call fun. This 'interest' was predominantly so that they could progress towards their degrees and career aspirations. As such, this category came to be linked with the previous category where relating the learning to goals became the motivation to hold their interest. Therefore, there were two properties of the category of 'holding interest' and these were 'enjoyment' and 'serious interest'.

4.2.1 Enjoyment

Students talked about enjoying university, their study, and mathematics, and also participating in fun activities such as games, and 'enjoyment' became one of the properties of 'holding interest'.

Beginning with the bigger picture around university study, Michelle mentioned that it was important to enjoy the overall course experience. After Michelle mentioned that school "was just really difficult time" (Michelle 306), in regard to university she stated: "I'm enjoying it now… being out here… I'm enjoying learning" (Michelle 308, 310, 312). Also in general, M and Thomas related enjoyment to learning: "I think that is just a fact of life. If you are interested in something, you're paying attention so then you remember it" (M 118); "it's easier for me to understand maths when I'm interested in it" (Thomas 110).

For the mathematics content, there were three particular instances of students talking about the work being enjoyable or fun. Stevie and Kasey mentioned topics in FMU and IMU respectively: "I'm looking forward to graphs and linears (sic) and stuff like that. I think that will be fun" (Stevie 304); "you've got to find the length and the height of the actual object… I'm like hey this is really cool!... That's awesome" (Kasey 48). Candy related mathematics to a game: "I like adding numbers and fiddling with numbers and… it's like a puzzle" (Candy 32). This provides some evidence that Stevie, Kasey and Candy have an intrinsic interest in maths.

One reason that students were to remain interested in the learning may have been the sense of enjoyment that came with recognising when they had done well and had achieved a sense of clicking. This was true for M, Kay and Grace: "I think there's also a bit of a reward thing going on you know, like wow, this all clicks into place, I understand this and there's just a bit of a reward" (M 122); "I think conquering some of the equations in algebras some, kind of enjoyable" (Kay 120); "I think it was because I had such a good experience with it, that I didn't have that blockage to overcome" (Grace 34). This was an intrinsic reward that made doing the mathematics enjoyable and hence it held their interest.

Finding maths enjoyable motivated M to think about mathematics even outside of the classroom: "It's just kind of fascinating seeing how it all works and how it all goes together. Sometimes I find myself just doing little problems in my head, like how much time is this, or planning out my day even just this will take this much time, this will take this much time, so that will add up to this much time… or even just counting out things" (M 66).

On a different note, Ro and M both mentioned that actual games can make maths more enjoyable. Ro remembers from school: "I think primary school… like that it was fun, in my head so we did a lot of games and stuff which were linked to maths which kept it fun in my head" (Ro 64). M discusses video games: "I play the game Minecraft… and do a lot of building, constructing… this many blocks wide and this blocks that way… each pillar will take up one block with a three block gap I'll need to plan so I don't have an awkward gap at the end" (M 82). This helped Ro and M associate mathematics with enjoyment.

One benefit of games in the classroom was that it promoted learning, helping Ro understand the content. When asked about using games in STEPS mathematics, explicitly: "In the maths now, when you did the card games and stuff early on, was that a bit more fun? (G Ro 73), Ro said: "yep I was able to grasp it" (Ro 74). A later question asked about incorporating more games into the STEPS classroom, and Ro replied: "it's interaction and I don't like doing stuff solo. So it'd be interaction, it'd be fun, and a group of people so that would benefit for me" (Ro 82). Ro then explicitly linked the games to holding her interest: "You're sort of learning as well as fun and that would keep my attention" (Ro 84).

It is clear that enjoyment is a facet of holding interest for M, Kay, Grace and Ro in doing the mathematics so they can achieve learning outcomes. Not all students, however found maths inherently enjoyable, nor did they appreciate games for the sake of making learning fun. This led to the more serious aspect of them maintaining interest.

4.2.2 Serious interest

For some students, the primary motivation for engagement with maths was that they knew they would need the mathematics that they were learning in the future. This meant that they were serious about learning and hence remained engaged.

M reinforced that he generally had a more serious interest in the university classroom than at school:

> one of the biggest differences, and this is not just maths, this is the whole of STEPS class compared to secondary school… secondary school is compulsory, a tertiary education is voluntary. So everyone who's in STEPS wants to be here, wants to learn, sits down, pays attention, because otherwise they're wasting their time and everyone else's time. In high school, not all the people wanted to be there. So they mucked up, played up, so the teacher spent some time instead of teaching trying to get the class under control so then there was that element as well. The distraction and just getting off topic and probably the other issues that would have made it difficult (M 138).

M was motivated by this to maintain his interest in the STEPS mathematics class, even when the learning was not necessarily fun.

Students who were not intrinsically interested in the content found other ways to stay focussed on the work. Ro knew that she needed to understand the concepts for when she completed STEPS and so was more willing to engage whether she liked it or not. Ro said of her FMU modules: "I just wanted to finish" (Ro 50). When asked if she "just did the maths to get through?" (G Ro 51), she replied: "Yep" (Ro 52). Again, Ro was able to remain interested enough to complete the work.

Measures appearing in the interviews where students have improved their attention were extrinsic rewards, eliminating distraction, and scheduling time.

Rewards had helped two students stay on track with their work in previous experiences at school: "I actually got a school award… so that was sort of nice to know well I'm actually improving" (Kay 108); "they sent me up to the principal for a sticker, she was happy with the work" (Cyndel 346). These rewards helped Kay and Cyndel remain interested in continuing with the subject.

Thomas spoke about attending class as a means to remove distraction and also make time:

> I don't tend to do much work outside of class beyond what's needed, but in class I'm more willing to work ahead and do extra problems. I'd say it's because… you're there, so you might as well do something. It's sort of that mentality, but if I'm at the library, it's like, well I could do this other assignment. I'm not in a hurry while I've these ten thousand other things I need to do but, in class, yeh I can be a lot more focussed (Thomas 126).

Since Thomas knew it was important to hold his interest in the class, he found a way that suited him and which served to maintain his interest.

Jane, however, indicated that she knew she needed to schedule time, but that it was difficult: "I don't really know quite how to schedule it and handle it, um but I'm getting there" (Jane 314). Time emerged as such a strong theme that it will be discussed later as a separate category. The overlap, however, is clear. These students often needed to make time when there was a lack of intrinsic interest in the subject, but making time did, in turn, encourage them to maintain their interest in learning.

4.2.3 Holding interest and relating

There is an overlap of this category of 'holding interest' with the previous category of 'relating'. Part of the serious nature of holding their interest is because of the relevance to the future, as mentioned above, to their degree or career. It took mature, adult thinking to be able to maintain interest in something for such delayed benefit as Thomas explained: "I wasn't nearly as mature when I was in high school… and… I probably have a deeper appreciation for its role in the world, now than I did" (Thomas 40). For Stevie and Jane, one of the strongest motivators for them to keep going with the work despite it not being 'fun' was the relevance to future career aspirations: "to get to where I want to be, which is Nursing, I need to do it and that's just, you know, it's like a recipe, you can't skip the butter or it's going to taste gross" (Stevie 186); "it's wanting to take this seriously because I want to take the next bit very seriously" (Jane 14).

Interest in pursuing the subject, whether because it is 'fun' and inherently enjoyable, or due to 'serious' reasons has given the students discussed here, more opportunities for learning.

4.3 Exploring ways

The data showed that students were prepared to explore different ways of learning and this is developed in this category. The category evolved from three different but related codes. Firstly, I had identified that many of the students were shown different ways of doing problems, or 'alternative ways' of understanding a process. As part of this they also mentioned different things they would do, like highlighting or annotating certain aspects, or drawing diagrams. This then intersected with the second code, involving learning styles or 'ways of learning', in I noted both physical and cognitive aspects. It also encompassed the third code of 'visualising' which I had originally coded separately because of the large number of students who mentioned that particular style. However, it became increasingly clear to me that these three codes were all about exploring ways of learning, including the detailed ways of writing out explanations, preferences for time and space for learning, and visual, aural, or kinetic learning styles.

The following examination of the overall category is organised in three parts, representing the three ways that students explore different ways of learning, including ways of understanding concepts, including interpreting different explanations (4.3.1), learning preferences in terms of the physical environment, time and space (4.3.2), and different cognitive learning styles and the way this affects learning (4.3.3). The data highlight the diverse range of preferences even within this group and that students themselves are also aware of learning diversity within their classes. Finally the interplay with the previous category of 'holding interest' is examined in 4.3.4.

4.3.1 Understanding concepts

Michelle and Kasey were aware that there were different ways of understanding mathematical processes. Michelle mentioned listening to the teacher: "he gives a few methods I suppose… I just got to click with something." (Michelle 122). Kasey noted: "it was that diversity. Being able to you know, if you don't get it that way, actually understanding that there's not just one way to do things. You know, your brain, everyone's brains works differently" (Kasey 32). Both students were therefore aware of differences in the way a concept could be explained.

Three students were generally in favour of being shown different ways and said that it helped them learn. Kasey was in favour of different explanations: "being able to see… being able to break them down all in different ways until something goes click, because that's all it comes down to is that, you know because everybody learns things different" (Kasey 130). Candy also reported that the teacher gave multiple explanations: "she'd write it on the board in two or three different ways, and say if you don't understand this way, then, maybe you'll understand this way" (Candy 186). Charlie mentioned that his teacher could change the way she approached problems: “she’s just very good at explaining things from different perspectives… which is really quite handy. I’m not sure about the other students in the class, but I found that really good.” (Charlie 66). Thus Kasey, Candy and Charlie all agreed that exploring different ways of understanding, whether they did it themselves, or were helped by the teacher, helped them in their learning.

Stevie then described how she used this knowledge of different ways to find a meaning that she understood: “I have realised, like with fractions I had no idea that the top number was divided by the bottom number. That makes it a lot easier, especially like on my calculator. Because I was trying to figure out how to do like, six over eight, but I couldn’t find the line and I was like, it’s literally just six divided by eight” (Stevie 82). This highlights that she found it important to be able to understand, in her own way, what the maths on the page actually means.

At least four of the students also noted that they were better off just choosing one method that suited them the best. M said that the teacher told him to do so: “one of the first things my lecturer said was that you can use any method you like, the method you use will be the right method as long as it still gets you to the answer” (M 6). Kay chose the method herself without any trouble: “so when you’re seeing the different methods, you're not really thinking too hard about all of the methods, you’re just picking… the one that fits right” (Kay 169, 170). Ro also chose the methods she used. When asked: “so when you take the notes off the board, do you really just write down the one process? Just one, and then follow that?” (G Ro 21, 23), she twice affirmed: “yep” (Ro 22, 24). Caroline found the method in the book confusing, and was shown a different method. When she talked to the teacher about it, he encouraged her to use the method that suited her: “for some reason, my brain didn’t like it… I’m sorry but I look at maths left to right and I just can’t look up and down. But no, he said I can do it like that.” (Caroline 216). M, Kay, Ro and Caroline all benefitted from being shown different ways as part of the exploration of their preferences, and were able to then choose the one that suited them best.

Since exploring alternative ways was already spoken about as beneficial, I wanted to confirm by asking if being shown different ways was confusing. There was a mixed response, and this serves to further illustrate the diversity of learners. As above, Kay had already mentioned that choosing one method of several was beneficial and so in answer to the question: “and you don’t find it confusing to see different methods?” (G Kay 49), she replied: “no, I actually find it better because fractions I do it one way and then decimals I do it another way” (Kay 50). Stevie, on the other hand did not like being shown alternative ways: “Grandma will try and show me like, show me some stuff, but, she all did hers in like the olden days, and so she does hers really differently. I was like just stop showing me, you're confusing me, like if she tries to show me her way" (Stevie 126). Whether it would have been different coming from a teacher, clearly Stevie was one student who found exploring alternative explanations not so conducive to learning, despite the fact that at least M, Kay, Ro and Caroline appreciated exploring different ways.

Although the four above mentioned students only used one way of understanding, this was not the case for Candy. Candy sometimes used more than one: "sometimes I could use two, sometimes I could do it all three ways, just depends on what you're doing" (Candy 188). Candy was, therefore, certainly appreciative of having the opportunity to explore alternative ways.

To maximise the benefit from being shown different methods, Charlie realised that he should seek out alternative perspectives from peers as well as teachers: "when you're in a class, you've got more than one perspective… fair enough I'm going to learn from you, but then there might be something I've missed, and then somebody else is going to go, oh, hang on, what about that. And then that might jog your memory. For instance, I could explain it this way. And then from that perspective you've all of a sudden got a whole different avenue that you can look at that you might be able to pick up a problem better." (Charlie 188, 190). Therefore, Charlie found exploring different ways helpful.

Overall, exploring ways to actually understand the concepts helped students in their learning. Whether this was to "break them down in different ways" in order to find "the one that fits right", these students were able to "pick up a problem better" and thus it helped them to learn mathematics concepts.

4.3.2 Physical preferences

Another way students explored ways of learning was by exploring preferences for their physical study environment including where, with whom, and when to study.

Michelle had a preference for where she studied to learn best: "that's why I go and sit up there, you know where the chairs and table are… I sit there a lot… I find it better than being at home trying to do it" (Michelle 46, 50, 52).

Jane indicated a preference for learning individually, and exploring different understandings in her own way: "I probably get more… if there's things that I'm not too sure of, I probably get more out of coming home and watching the [teacher's] clips which are fantastic… than I do out of sitting in a classroom" (Jane 88, 90).

Candy considered what suited her best in terms of what time of the day to study: "I find if I do it, in the afternoons or before I go to bed, and then I sleep on it, it plays in my head all night and sometimes that helps" (Candy 82).

Michelle, Jane and Candy all highlight that it was important to them to explore their own preferences as to physically where, with whom and when was most conducive to their learning requirements.

4.3.3 Learning styles

Lastly, students often mentioned the need to explore their own learning styles. Five students in particular referred to the fact that they were visual learners. Stevie said in general: "yeh, I'm visual" (Stevie 134). Jane and Thomas mentioned the visual learning aspect of pictures: "big on diagrams" (Jane 142); and "I always start with a sketch" (Thomas 64). Even writing solutions out was said to be visual: "I need to show every single working out I do" (Kay 12). Ro, however, also included mental visualisation: "I actually have to visually see the five dollars sixty-five over the two dollars forty-five… and then I just visualise it so I just go five and five, zero, add the one" (Ro 188). Both Kay and Jane described their use of colour as a visual tool: "I circle them in different colours" (Kay 178); and "all my handwritten notes are a little bit colour-coded and I find that really good" (Jane 200). Exploring their visual learning preferences really helped these students.

Exploring this aspect also helped Caroline (194) determine that she found pictures distracting: "for me personally, if you have the picture there it can be distracting. It's great in English, but if you put a picture up there, the only thing you're going to remember at the end of the day is that picture" (Caroline 194). She was therefore able to customise her notes to this style.

There were other descriptions of how students had explored their learning styles. Jane and Thomas found hearing explanations beneficial: "the videos where they're speaking it and writing it at the same time, that's incredible for me. That's probably my biggest learning tool" (Jane 96); "for the more complicated things, it has to get explained in person" (Thomas 74).

Another learning preference, as described by Charlie and Candy, was for active learning: "I'm probably more kinetic. I learn from doing" (Charlie 170); "I'm a hands on learner, so I struggle a lot more if it's on a book. I've actually got to do it and go oh, that's how it's done" (Candy 122). There were also variations within this active learning. Charlie said he liked to learn rules and follow processes: "it's just what it is. It's just remembering the rules that go along with it. And then just applying them" (Charlie 12). M said logic was more important: "needing to write them down and set them out in a clear and logical manner" (M 32). Grace was also in favour of a logical sequence:

“mathematics seems to follow a sequence… once you’re shown, you go, right, I’ll follow that path” (Grace 30). It is these students’ preference for being ‘hands on’ that helps them in their learning.

On a different note, Kay and Kasey’s preferences were for seeing the big picture before any detailed sequence: “it’s good because it gives you a whole picture” (Kay 46); “I think it’s better to have the understanding… to get the whole picture” (Kasey 78).

One of the main differences in learning style related to whether students considered themselves to prefer numbers to words, that is they have an “affinity with maths” (M 148) or if they “see words better than… numbers” (Stevie 10). There seemed to be a divide between those who were “more drawn to maths” (Candy 222) and have trouble with worded questions: “those sort of word questions, I stumble over them sometimes” (M 152); versus those who like words better: “like words if I can read things I can relate that perfectly to things that may have happened or I may have seen, but numbers just because, I just don’t know… my brain does not get them” (Stevie 58). Students certainly seemed aware of their preference for one over the other: “I’ve read about what is described more as right-brain thinking, sort of building something and then building on top of that” (M 88). Ultimately, exploring the relationships between words and numbers have helped M, Stevie and Candy to know what suits their learning styles the most.

All of these points highlight that these students can be quite different from each other. They are able, however, to describe many aspects of exploring their own ways of understanding and learning. They have said that this aspect of being in tune with their own learning helps them to ultimately be able to maximise their experience.

4.3.4 Exploring ways and holding interest

The findings suggest strongly that there is an overlap between exploring ways of learning and holding an interest in learning. One clear reason is because for students to have the tenacity to explore the different possible ways of learning, they need to be interested in undertaking such a process of discovery.

Similarly, in reverse, exploring ways and constructing their own interpretations of the content can also help students to understand more and therefore remain interested. “I think it’s understanding it fully… I think potentially I have more of an interest in paying attention now that I would have when I was… at school.” (Jane 12). This shows that for Jane, enthusiasm for learning was enhanced.

4.4 Taking time

This category is about how students understand the time required to maximise their learning. It shows key aspects of how students view time. Some felt the pressure from time and were time-poor (4.4.1), whereas others understood the need to be judicious with their time (4.4.2). This category also overlaps with exploring ways, as it takes time to explore for understanding and preferences (4.4.3).

Comments from Kay and M highlighted that they like to take their own time and work at their own pace to consolidate their understanding: “there’s people that understand it instantly and then there’s us that don’t understand it, so it takes a little bit of time” (Kay 168). M was one of the students who found: “it’s something that’s really intuitive to me… so it’s something I don’t have to work too hard at... to understand a concept I don’t have to go and spend ages just trying to get my head around it. Often times I just have to look at it a little bit and it’ll just click” (M 46).

4.4.1 Time pressure

Other students said they did not have enough time during the modules and units. The lack of time resulted in confusion for Stevie: “in a classroom I was like, it was going a bit too fast then like I couldn’t process anything, he’d be onto the next subject and I just got really confused. And in the class too, I kind of felt a bit like, maybe dumb, because everyone was like, getting it” (Stevie, 28). Ro was not quite able to keep up: “there’s half of us that are only sort of up to speed with what she’s teaching” (Ro 256). Candy and Cyndel would have liked more time: “maybe we needed a little bit more time on each topic because it seemed to be very rushed” (Candy 42); “there’s not enough time… in the week” (Cyndel 34). For these students, the lack of time resulted in them not being able to learn the content as completely as they desired.

On the other hand, Kasey reported an anecdote from the teacher and this made it apparent that allowing more time or reducing the work in the unit would be unfeasible: “obviously you have to push for time and you’ve got so many things that you have to learn per week” (Kasey 128).

4.4.2 Making time

Caroline, Michelle and Grace specifically ensured they had enough time by actually setting aside time, and they found this helpful. Caroline made time for the videos: “I watch every one, and sometimes twice… some of them are a minute, some of them three minutes long, some of them are fifteen minutes long, but you know, I’ll set aside an hour to sit there and just watch the videos” (Caroline 20). Michelle used different times of the day: “that’s why I come in here a couple of hours early every day to do it here. I do a bit at night" (Michelle 94). Grace made time for assessments: "I know that I like to take my time with the assessments. To put them in and go away and come back. Come back fresh and then go back through and about every single assessment I've come up with a couple of… at least two where I've spotted an error and gone, oh how did you miss seeing that" (Grace 48). When they dedicated time to activities, this helped them learn. Putting in the time also helped Grace not be so far behind: "I actually went back as I found time… the next week or two… I did a catch up" (Grace 54). Each of these students understood how important it was to not only take the time, but to make time for their learning.

4.4.3 Taking time and exploring ways

Kasey mentioned that she tries to take the time to explore different ways: "see it in a hundred different ways… but being able to allocate extra time even if it's not in that week" (Kasey 128). Conversely, Charlie also had a desire to explore different ways but found he did not require much time for this. "I'll play with it myself and work out the best way for me… sometimes I could do the entire thing differently… but I don't need to spend a lot of time on my maths." (Charlie 152, 156, 166).

This shows that students do require time to explore different ways, although how much time will depend on the student as Kasey and Charlie demonstrate. Similarly, the amount of time will depend on how much pressure they feel to complete the work as with Candy and Cyndel versus looking for different outcomes as for Grace with her assessment.

4.5 Practising

Students raised aspects such as going over work, moving from watching to doing, and repetition, hence practising in that regard. Practising, however, involves both physically doing repetitive activities (4.5.1) and the mindset of persevering (4.5.2). They talked about how both of these properties of practising improved their understanding and learning. Also, practising takes time and as such there is an overlap with the previous category described in 4.5.3.

4.5.1 Repetition

Repetition was found to be an important part of practising, as Michelle said: "I think it's just repetition till you click" (Michelle 212). Cyndel said that repetition helped her learn: "Like I retain most of it, but sometimes then I forget it, and then the only way I learn it is by repetition" (Cyndel 300). For M and Charlie, they only had to spend a small amount of time practising through repetition: "a lot of the times the answer would just click and write down the answer… and it's like, well how did you get the answer, and it's like just… it's obvious! Isn't it obvious to you?" (M 20); "It was a breeze" (Charlie 52).

Practising is described by Charlie as the leap from seeing to doing, from the familiar to the unfamiliar, and from short term memory to long term memory. Practising helped him go from watching someone else demonstrate the work to actually being able to do it himself: "it's great to be able to look up there and copy what somebody's done. But that's not going to actually teach you. That doesn't actually teach me how to do something. I need to then implicate (sic) it myself and then have practise and then… to be able to duplicate it in my own head" (Charlie 26). Jane also described the problem of: "monkey see, monkey do where there was a lot of copying but maybe not as much comprehension on my behalf" (Jane 50) where she "just copied down what was on the board" (G Jane 51). This resulted in her only being able to do problems on her own "if it looked similar" (Jane 54). Whereas "if it was a little bit more advanced… I'm not sure" (Jane 56). Both Charlie and Jane wanted to be able to move on to understanding so that they could do further problems.

Jane mentioned that practising by looking back at previous work helped: "I have to sit and just re-read it and just, I feel like my short term memory… it's not retaining. Obviously once I refresh and reread a little bit, I go, oh yeh, that's right, I get it and I have no problem" (Jane 300). Michelle said that looking at the answers for some questions helped her when she was repeating exercises: "well I try… to work it in my head first, and do a couple and then I look up the answers and see if I'm on the track or not on track. If I'm on track that's fine I'll do the rest and then go back and look at them. If I've got it wrong, well I've got to look to see what I've done wrong" (Michelle 62). So for Jane and Michelle, this sort of repetition by looking things up helped them learn.

Thomas talked about repetition to commit the learning to long term memory: "I actually want to remember what I learn and not just forget it straight after the test" (Thomas 42). He wanted to practise to improve understanding and retention.

There was diversity in the activities students repeated in order to practise the mathematics, including using videos, the textbook, and their own notes. Candy, Jane and Caroline watched the online videos. Candy emphasised the repetition: "watching the Moodle[12] videos over and over again" (Candy 62) and Jane talked about repeating targeted sections: "I can rewind it if I don't get it and go, OK, we'll just keep doing this until I get it" (Jane 98). Caroline links the repetition to

[12] Moodle is the online learning management system used by CQUniversity.

practising: “actual videos on Moodle, it becomes a visual aid and it just really cements it in there. It’s so amazing. I really like those visual aids because I can sit there and practise with them at home” (Caroline 16). The videos, therefore, were a flexible tool that these students could use to practise.

Stevie, Caroline and Cyndel all used the textbook to repeat the sorts of questions many times. Stevie used the exercises with answers: “I’ll even do all the review exercises and then turn to the back of the page and see how they’ve done the review exercises” (Stevie 178). Caroline repeated the questions until she understood them: “Just by sitting there continually practising all the exercises that are given, continually reading. I have to… I tend to go over and over things, until it sinks into my brain” (Caroline 14). Cyndel also practised for learning: “there was a lot of exercises we could practise, which I found was really good for repetitiveness say… you do learn… grasp it and learn it” (Cyndel 12). For these three, the textbook was an essential tool to help them repeat the question and practise the work.

Another practising method used by Ro, Cyndel and Caroline was very practical, especially in terms of writing. Ro made the connection between writing and understanding: “I have to do a lot on paper… just keep writing stuff down until… it just clicks in my head” (Ro116, 118). Cyndel made the connection more between writing and retention: “I’m more hands on, like writing it for me to retain it” (Cyndel 300). Caroline specifically mentioned writing helped her learn: “Well basically when it comes to mathematics, it’s repetition and writing it down constantly. You know, that’s the way I learn the best. Is just continually doing exercises” (Caroline 192). Repeating in this way moved the information towards understanding and the learning from the short term to long term memory so it could be retained.

Caroline even stated that a combination of practising methods was best for her learning: “I use every… resource available… I actually need to use visual, auditorial (sic) practise, mechanical. They all have to be used at once” (Caroline 16, 192). Therefore a lot of practising and repetition was beneficial.

No matter whether it was using the videos, the textbook or any of the resources, these students found that repetition helped them to retain the information and learn at a deeper level.

4.5.2 Perseverance

There was the need to put a lot of effort into practising and this was “perseverance” (Michelle 30). Williams (Williams, 2014) investigated perseverance as a concept different from repetitive practicing. The overall finding was that perseverance requires strategic direction in thinking to adjust the actions taken in a search for a more positive outcome. As such, it requires a metacognitive approach to know how to vary the practicing as opposed to repeating tasks that are not beneficial, or abandoning the problem all together.

Charlie and Ro commented on this perseverance as an important aspect of practising. Charlie persevered until: "eventually, it's just the way my head works, eventually it will click" (Charlie 36). Ro knew that she had to "just keep going and keep going until something goes 'ding'. That's what I need to do" (Ro 120). The determination helped Charlie and Ro move to a place where they understood the content.

Jane, Michelle and Thomas describe the mental requirement involved in practising. Jane said: "eventually things make sense and that's the ridiculous thing is that if you sit there for long enough you are going to figure it out" (Jane 330). Michelle found practising very difficult: "I'll just um, keep flogging myself to try and get it" (Michelle 274). Thomas described the mental effort as force: "if I force myself to do it certain ways. I feel like… if I spend more effort on it, just subconsciously, I'll force myself to remember it better" (Thomas 88). By putting in the effort, practising paid off for Jane, Michelle and Thomas.

Overall, some students found repetition easy and some found it a struggle. For such students, it resulted in greater retention, deeper understanding, and increased learning.

4.5.3 Practising and taking time

There is an overlap with the previous category of 'taking time', as it is evident that practising will involve taking time to repeat activities as described above. Kay specifically notes this: "time to sit down and practise" (Kay 40). Cyndel particularly stated that to practise and persevere through the repetitive activities, required time for her to learn: "like trying to get through all the tutorial questions and actually first learning each chapter, and actually meeting all the deadlines. And learn… actually learning it within that time" (Cyndel 6). Jane also knew she would need to spend time: "I know that that's something that I'm going to really have to do… over time… when it comes to practise" (Jane 188). Therefore, it is important to take the time needed to practise.

Time is not the only factor for practising, as simply writing out the content many times may not necessarily help students construct a deep understanding. Also, students may burn out doing long activities for little reward. As mentioned, it is the type of repetitive activity along with the perseverance that will maximise the benefit from any time spent on practising. Therefore there are also links to the next category when students were considering how they would spend their time practising.

4.6 Working through confusion

I connected the code of 'confusion' with the code of 'quitting, fear, self-doubt' as this was one of the outcomes of students being frustrated by the confusion. I could, however, see a link with the code of success. One of the properties that I found linked the two was content, students even being happy in a state of 'not knowing'. To cover this linkage, the discussion will flow from confusion leading to quitting, fear or self-doubt (4.6.1) to learning to accept and be comfortable with the unknown (4.6.2). Again, this category will be related to the previous category of 'practising' (4.6.3).

4.6.1 Confusion leading to quitting, fear or self-doubt

Candy related the newness of mathematics to confusion: "probably confusing because it's new" (Candy 14). Stevie also talked about newness and linked it to distinct fear: "it's a fear of maths. Probably just because it's new" (Stevie 12). Jane also had strong feelings: "I remember, yeh, feeling quite overwhelmed and underprepared for all this whole new realm of stuff" (Jane 30), even to the point of "terror, dread" (Jane 294). These strong negative feelings that Stevie, Candy and Jane had about new content, made it difficult for them to learn.

Michelle and Cyndel expressed the view that they should know how to do the mathematics because, if they did not, they were worried they were going to fail. Michelle said thinking like that made her emotional: "all that stuff, I've never heard of. And I think I panic… I'm not going to get it right and I don't understand it. I have a few tearful little times" (Michelle 24, 26), and Cyndel felt afraid: "I'm scared I'm going to fail big time with that area" (Cyndel 120). Michelle alludes to the fact that this may be a product of age or maturity: "The younger ones don't know their times tables" (Michelle 168) whereas, as an older student, she felt she had been expected to know them. Not only did this fear of failure make it difficult for students like Michelle to learn mathematics, but it also meant that they might not even try: "I just feel like an absolute dork… I get really upset. I can't catch up" (Michelle 126, 130).

Grace noted that while she was not so worried about it, other students were afraid to go too far into the unknown in case they go down the wrong track. Grace said of those students: "because [of] the anxiety, I think they're afraid to take a step in case it's going to be in the wrong direction" (Grace 154). When asked if that would "be so bad… taking a step in the wrong direction" (G Grace 155), she explained that "[w]ell… you're going to be completely off track… you're going to be way over here and that's going to be a waste of effort going all the way down there" (Grace 156). She went on to say that a student in her class felt that one of the problems "seems so big." When they tried to "picture it like a full package" they found it too difficult. When "it's not broken down… they go…

that's too big. No I can't. Nah, hands up, no, I'll wait until we actually work through it" (Grace 166). Grace said that, in her experience, students such as this quit trying to work through the confusion for themselves and instead wait for further, direct instruction.

4.6.2 Being content with the unknown

Despite the fear and the pull to quitting, Jane, however, recognised the need to overcome these sorts of barriers before she could approach the work and move forwards in understanding: "I know I got to do this and I want to start it, but I can't start it yet… I did tend to stress about it" (Jane 338). Grace also knew she had to move forward to potentially confusing work: "you know you get so used to just doing the same process over and you can practise it over and over and over, but then you have to apply it to something new" (Grace 233). The strategy M used for going forward into the unknown was: "breaking it down into chunks and going with it that way" (M 176). Using that tactic, M was able to approach a problem without the fear of going too far out of his comfort zone, or down the wrong path.

Kay talked about the need to develop a level of comfort and confidence even if she did happen to go down the wrong path. Kay recognised that reaching into the unknown is particularly key for working through confusion: "I still struggle because I'm like but what number is x? And I needed to know a value… but now my thought is, ok, it's just a number that I won't be able to find out unless the equation asks me to find it out" (Kay 20). When asked if she was "getting more comfortable with the unknown" (G Kay 21), she replied: "yeh, definitely more comfortable" (Kay 22).

Charlie was also comfortable in heading down unknown pathways: "because I've always just looked for a different way to solve a problem… Because it just gives myself a different perspective on what they've said… I'll play with it myself and work out the best way for me" (Charlie 146, 152).

Grace found she was content with the unknown: "there's nothing wrong with actually not knowing your way through" (Grace 176) although she did say that part of her comfort stemmed from looking ahead: "if you have a little bit of a pre-look at what's coming up…, through the module, just go, oh, yeh, ok" (Grace 170). So while Grace was not able to necessarily do the new work, she was still not worried by the fact that it was still confusing at that point in time.

Jane found that in her class she became more comfortable with the unknown through discussion: "I'm with a table of people that will bounce ideas back and forth" (Jane 88). For Ro, it was important to distinguish what she did know from what she did not know: "so we just circle everything that is important that we do know and put it on one side" (Ro 122). Caroline and M lessened the impact of the confusion by writing it in a different way: "I'd actually write it in English first" (Caroline 58); "the first drawing I do is usually just rough on a piece of blank paper just some sort of rough sketch" (M 106). Kasey also did this for algebra: "so change it to a letter and it'll help get in your head" (Kasey 116).

In becoming comfortable with the unknown and with the fact that sometimes there would be confusion, these students gave themselves the scope and the opportunity to construct their own understanding. By finding ways to overcome the fear, they were in a better position to maximise their learning, certainly better than if they had succumbed to the urge to quit.

4.6.3 Working through confusion, practising and perseverance

One main feature of lessening anxiety was to practise, and hence there is overlap with the category of 'practising': "I just struggle with maths. I think I've got a mindset I don't like it. And that's what I'm trying to… In class, like, when we're doing it, the same thing over and over, I get it." (Michelle 4). It is through practising that concepts gradually go from the realm of the unknown to the realm of the known. Practising can also help a student realise that the unknown is not something to be afraid of, and that with repetition and perseverance, it will lose the element of scariness: "there will be more want to learn it instead of being afraid" (Kasey 64).

4.7 Tailoring

The previous six categories discussed aspects of the learning experience that were integral to the student. They were actions that the student controlled or chose to do. Encouraging students to take direction over their own learning is the aim of any mathematics class or unit in the STEPS course[13]. During the interviews, however, the students also talked about the immense influence that others had on their learning. More specifically, they described how other people helped them learn. From the code 'influence of others', I developed a seventh category, labelled "tailoring", to indicate the nature of the influence of others insofar as the influence was 'suited' to fit the needs of the student.

Most predominantly was the teacher, whether it was from the STEPS units or school teachers or private tutors[14] in years gone by (4.7.1). Others mentioned that peers and relatives also had

[13] This was discussed in section 2.3.2 with reference to the Preparation Skills for University unit and overall aim of the STEPS course.

[14] In this document, a 'tutor' is used to describe a person who helps students outside of the classroom, as opposed to a 'teacher' who is the person teaching within a classroom.

influence on their maths learning (4.7.2). Finally, some students explained how others such as friends and family had benefitted them (4.73).

The categories are once again shown in Figure 4-2 for reference, this time highlighting the position of 'tailoring' in the centre. This category of 'tailoring' sits apart from the loop of the previous categories, but is directly linked to each of the other categories, hence its position in the hub.

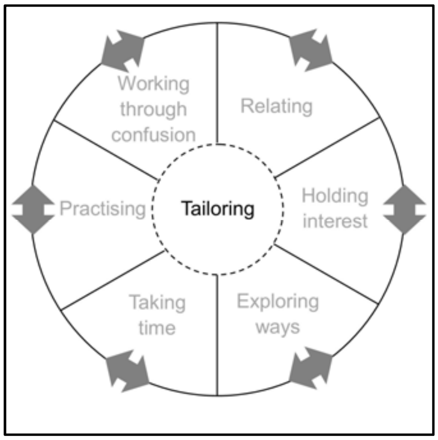

Figure 4-2 Tailoring

The dotted line between 'tailoring' and the other categories indicates that tailoring has importance for each of the other categories. These relationships are discussed in section 4.7.4.

4.7.1 STEPS teachers

STEPS teachers were mentioned often because one line of questioning in the interviews focussed on the students' experiences in the STEPS mathematics units. Comments concerned mainly the ways in which teachers met (or tailored their teaching to) students' self-identified needs (as discussed above) in terms of learning maths. Therefore, I was able to relate teachers' influence in to any or all of the previous six categories (4.7.4).

Charlie commented that STEPS teachers helped him relate the content to the real world as he often struggled with that: "like I did a question today and I looked at [teacher], where am I going to use that in the real world? Like help me here" (Charlie 114).

Jane and Thomas suggested ways in which teachers could show them more relevance which would benefit their learning. Jane said about real life situations: "if you give that problem to me in words, in more a real life situation then I can figure it out" (Jane 68). Thomas talked about more realistic problems:

> I feel like, maybe using more specific examples, especially with the application problems. Like, right now, doing trigonometry, it's like some standing at a cliff looking down, well, I feel like there would be some real world application that you could write… they're at the airport and something to do with the radar and it's looking up at a plane… it's a bit monotonous, somebody standing on a cliff looking down at a boat. Why is he looking at the boat? (Thomas 104).

Jane indicated that the problems do not have to directly relate to something they actually do, such as work or a hobby, so long as it is close enough and real world enough for her to see that the maths does have relevance beyond the classroom: "The examples will give you a real life scenario and you go, oh yeh… It may not exactly apply to you, but something similar you know, you can make it fit." (Jane 292). Stevie also highlighted that mathematics problems involving "drug calculations, obviously all that stuff" (Stevie 202) would be relevant to a number of health related courses such as Nursing and Paramedic Science. When asked: "Does it help when [STEPS teachers] link maths to real world concepts?" (G M 147), M agreed that it might help people who struggle with maths: "for me personally, I don't think it would make too much of a difference, just because of my own affinity with maths. For others I think it would really provide a benefit" (M 148). These students benefitted from the teacher tailoring the mathematics to reflect the real world, and that a wide variety of examples that match the students' past experiences, current endeavours and future pathways are useful in assisting them to learn maths.

One of the key ways teachers impacted the engagement level for Jane and Candy was through their teaching approaches. Jane liked that the "[teacher] is a complete professional and she… the way she teaches, and the way she approaches people I think is really well rounded" (Jane 350). Candy appreciated the teacher's enthusiasm: "I found Fundamental maths really easy to follow… it was full on, but it seemed to be enjoyable. I don't know whether it was the teacher maybe that made it more interesting… she was just bubbly and made it sound exciting… because she got excited about it" (Candy 178, 180). Jane and Candy found that the way the teachers tailored their interactions for each student helped them feel more comfortable in the class and therefore more receptive to learning.

A benefit of an enthusiastic teacher that was noted was that they were more willing to tailor the learning activities to the diverse needs of the students. M, Kasey, Cyndel, and Jane appreciated teachers demonstrating and explaining a variety of examples and being understanding of their diverse needs. They valued it when teachers catered to the individual learning styles and preferences of students, had the knowledge and ability to explain concepts in alternative ways, committed the time and had the patience to explain a number of ways, and encouraged them to try different ways themselves to construct their own understanding. M particularly mentioned his teacher encouraging this exploration: “my [teacher] will write down as many methods as she can think of and then if another student has another method she’ll go and write it up on the board so whatever method works and she’s really, really encouraging of that” (M 16). Kasey commented that she appreciated it when the teacher understood her learning styles as well as background and prior learning history: “you know, having that different thought process… he understood how my brain ticked and was able to teach me along that line and I’ve been able to click everything since… he was able to actually manipulate, or not manipulate, you know it’s understanding the way that you think and being able to teach to that that way” (Kasey 30, 32). Cyndel also appreciated the teacher knowing her learning style: “I find she explains it a lot more. Maybe she knows the way I take it in” (Cyndel 304). Jane found her teacher to be very flexible with catering to diversity: “she has been excellent with people who are obviously really advanced with their maths skills and she will be able to talk to them… at that advanced maths level, but in the same breath she’s answering a question over here which is at really, really basic level and there’s no difference in her and I think that makes a really big impact for me” (Jane 354). Tailoring by the teacher in the classroom was what helped these four students understand and “take it in” so that their learning was most effective.

Apart from ways of explaining, Thomas and Kasey commented that it was beneficial for the teacher to have the ability and to take adequate time to teach. Thomas commented on the individual time shown to him: “I’ve got to have somebody show me how to do a problem in person and talk me through it step by step the first time and the second and the third time maybe sometimes… In class, on the white board... I can’t read through notes in silence and understand complicated problems” (Thomas 70, 72). Kasey said that extra time given by the teacher helped her and her classmates with concepts they struggled with:

> I think it’s actually quite good… he does take time. If you don’t understand it… he’ll set times away and he’ll help you see it in a hundred different ways… And being able to have somebody that takes the time, you know, it’s not just rushing everything through… It’s getting everybody to understand on the same level, then, well, you know, obviously you have to push for time and you’ve got so many things that you have to learn per week, but being able to allocate extra time and even if it’s not in that week, if it’s, you know, weeks after, and you’re still struggling with that (Kasey 124, 128).

Thomas also regarded highly the interaction and conversation that a teacher provided during this time: “It’s the back and forth that you can have with a teacher… You can ask the questions and you can almost criticise their way of doing it, and it makes you think about better ways to do it… and you feel more involved” (Thomas 74, 76). Therefore, for the teacher to take the time, tailored in the way to meet their individual needs, was important for Thomas and Kasey for them to be able to overcome struggles, and learn the content.

An important aspect of what the teachers did to tailor the learning for these students was to be able to judge when to give, or when to hold back instruction. Kay mentioned the teacher encouraged her to try the problems on her own: “[teacher] just told me it was ok to be flustered and frustrated” (Kay 44). The transition from direct instruction to independent work allowed Jane to become an independent learner and find her own ways to overcome issues: “Little frustrations yeh, but nothing that I haven’t been able to work out at home… by going over everything again” (Jane 104). When Cyndel became stuck, however, she appreciated tailored facilitation and prompting from the teacher: “There was one… that I did over the last couple of days, I just asked [the teacher] after today’s lecture. And yeh, he showed me how it was done. I could work out some, but that one line… I couldn’t get it” (Cyndel 82). She again mentioned later in the conversation that tailoring helped her through a struggle: “[the teacher has] done really well, like I’ve been happy with the way he’s been teaching and he saw that I got stuck with logarithms and functions and he like gave me that little bit of extra tutoring that I needed to get through it” (Cyndel 288). Kay also appreciated that the teacher would tailor the explanation if needed: “and then I just took a couple of deep breaths and she explained it a bit more or I asked her questions” (Kay 44).

These examples demonstrate that students found tailoring from the teachers in the STEPS classroom to be integral and essential to their learning mathematics. Their ability to engage with the tailored approach seemed to be appreciated regardless of previous experiences in the classroom.

4.7.2 School and other teachers

Both positive and negative influences of primary and secondary school teachers and tutors were raised during the interviews. Positive experiences concerned the use of games in the classroom to engage the students, and teachers taking the time to explain and understand individual needs, similar to the STEPS teachers.

Ro discussed how the teachers used games: “[In primary school] we did a lot of games and stuff which were linked to maths which kept it fun in my head… I remember one game, we did that one like all the time, every week" (Ro 64, 66, 72). This fun was then a positive influence on her learning mathematics.

Kay gave an example of the positive influences from a school teacher: "year 6 I had a really good teacher that I was reading at a year 4/5 level and she brought me back up to the level I was meant to and my maths and everything, so I think having a teacher that's dedicated to the way that other people learn definitely helped me because if I didn't have that teacher who knows what I would've been able to do" (Kay 98). Also taking the time to explain multiple ways was appreciated by Kasey: "he had a very good rate of how many kids passed his class because he was that kind of teacher and he did take time" (Kasey 32).

Outside of the school classroom, Cyndel also had a good experience with a tutor. She mentioned the benefits of tailoring: "she teaches it a different way… we actually go through the examples together. And then sometimes she'll let me do it… when people just talk in front of the… I retain most of it, but sometimes then I forget it. But I find she explains it a lot more. Maybe she knows the way I take it in. I don't know. And she probably sees my downside where… she helps me to improve in that area." (Cyndel 298, 300, 304, 308).

There are also clear examples that Michelle, Stevie and M gave of how school teachers were not able to tailor to their needs, and hence had a negative effect on their emotional journey through mathematics. One such example was Michelle who found the treatment inequitable and not tailored at all: "Like when I was at high school, there was twenty-four boys and four girls and we were put over there and the boys were dealt with… We weren't dealt with. Never even come near us half the time. So we could have been reading a book, who cares. So I just switched off" (Michelle 12, 14). This led her to conclude: "probably because I never had a teacher that was interested in teaching us. That's probably why it's never clicked" (Michelle 280). Stevie also described how the teacher had a negative effect on her emotionally by not tailoring to her needs: "I had a really terrible grade 4 teacher, like he was really mean to me especially with maths too, so I'm thinking… well that following year that's every time I had maths I cried" (Stevie 270, 272). While M had a slightly better experience, he still found the teacher unapproachable and he was not able to ask for tailored help: "I was only a shy little high schooler, not really wanting to question the teacher least I get in trouble" (M 14). The experiences of these three students highlights the impact their prior school education had on their skills, knowledge and confidence in doing mathematics. It also indicates that they may initially have difficulty accepting the responsiveness and tailoring that the STEPS teachers use in their approaches.

Stevie also had a poor experience where the tutor was unable to tailor the teaching to her needs: “I had a tutor for the first week and she made me cry and basically called me dumb.” Stevie’s tutor was not able to see a different way of doing multiplication: “She’s like, ‘you need to learn your times tables’. I do know my times tables, but… for my nine times I use my fingers still, just cause it’s easier. She’s like ‘you can't use your fingers’” (Stevie 118). Instead of seeing the benefit of process in Stevie’s method, she focussed on memorisation: “She’s like ‘you need to memorise them all’. And she was really mean…” (Stevie 122). This had a lasting emotional impact on Stevie: “It makes me want to cry a little bit… especially because I told her I wasn’t the best at maths… she was horrible” (Stevie 124). This negative experience by the tutor compounded the issues Stevie had from the teacher and highlights that she had multiple bad experiences that she brought with her to the STEPS classroom.

M also commented on the negative experiences he had with the more practical aspects of classroom teaching. He described the influence of his school teacher’s lack of ability to tailor to his learning needs. First, around the teacher’s inability to see different ways of doing a problem: “something I used to get in trouble all the time for… not using the teacher’s method in high school or even primary school” (M 6). His second comment was that his teachers had to rely heavily on text books instead of having an in-depth knowledge themselves: “the other issues that would have made it difficult [in high school] would have been the fact that we did really rely on a text book, we were working through a text book… so I think that’s one of the biggest differences is that in class we probably didn’t go through the methods in as greater depth and we definitely didn’t [see any] other methods” (M 138, 140). Here it was evident that there was little M’s teacher did to differentiate between students in M’s classroom and so M, for one, fell behind. He felt: “I have all these holes in my knowledge where the high school maths has failed me” (M 128, 130). Because there was little exploration by the teacher of ways of doing the subject at school, M could not benefit from tailored discussions and demonstrations.

The influence the teachers and tutors had on these students, particularly in whether the learning was tailored to individuals, was clearly still having an impact on them up to and during STEPS. This was how Kasey felt: “And that kind of made my decision on, you know, how much impact there is in those early years, and then wanting to be able to [help] when they actually start to get a choice... Because I had a brilliant maths teacher, he was my foundation for everything. I would not be here without him” (Kasey 16). Students cannot simply forget their past experiences, and this adds to the complexity of the individuals as learners in the STEPS mathematics units.

4.7.3 Other people

The influence of others came from a variety of sources for the participants in this study, and some of these examples were not people with a teaching role. This section will explore the influence of classroom peers, partners, grandparents, and friends.

Michelle and Ro mentioned that help from peers could be beneficial in facilitating their learning. The one-on-one conversations were good for Michelle when she needed help, because other students who were more confident with the content, could tailor assistance just to where she needed it: "Because [friend], she just understands it… she just loves it… she's helped me a bit. And another young boy who helps me" (Michelle 46).

In Ro's experience in class with her peers, she mentioned that some students do not require help: "[they] know every single thing that is being taught" (Ro 258). She found that both "unnerving… I'm like why are you so smart…" (258) but also she appreciated when they could give her help: "it's good because they'll come help you if you need help" (260). She does clarify, however, that she wants this help to be: "from people that I know understand it" (268). At other times: "I've had a few people at my table try and help me and I would prefer them not to" (268) and she felt that these people did not understand and: "I don't want you to teach me a way that is wrong" (270). When the help is from the: "two people [who] help me" (272) they could tailor the approach just for her, and she said: "they just kept going until I understood it… And then when I thought I understood it, they would give me an example… then I would do it and if I got it right, they were like, ok cool, you've got it" (Ro 272, 274). This led her to conclude that: "we've got some pretty good peer support" (276) especially when there is: "two or three of them that'll actually get up and come around and help… it's good" (278).

Ro found this support from her peers beneficial to help her understand the content, because, as with Michelle, the peers were focussed specifically on tailoring their assistance for her in the one-on-one discussion. The interaction could continue, and she could ask specific questions, until she understood.

As with Ro, Kay also mentioned that one of the difficulties with peer discussions is that sometimes peers do not fully understand the content, and therefore are more of a hindrance than a help. Kay said this had set her back, so it was more beneficial to stop seeking peers support at that point: "Like there's one guy... He was trying to explain something to me the other day. I go I know you're trying to help but it's confusing me even more. I said I've understood one process" (Kay 162).

Michelle, Ro and Kay indicated that peers can be both beneficial and problematic in tailoring the help they provide. For Michelle and Ro it was helpful to their learning when their peers were able to understand and actually tailor the explanations, but as Ro and Kay point out, it is not always the case, such as when the process offered differs from the process they already understand.

Outside of formal learning environments, a few students mentioned how their relatives tried to help them learn maths. If the relative was able to tailor explanations so that the students understood, again, this was beneficial for their learning.

In terms of partners, Kasey and Jane both mentioned their husbands. Kasey found she knew that she was beginning to understand concepts when comparing to her husband's work: "probably the best thing is also having a husband who's an engineer… Starting to understand what he teaches… Because he teaches as well" (Kasey 50, 52). She also found he could then offer her appropriate help: "I had hubby tell me, it goes if you put a letter in there instead of the word log, you'd see it a lot better… so change it to a letter and it'll help get in your head" (Kasey 114, 116). The most important aspect that Kasey mentioned was that he could tailor the help: "because he obviously knows a number of ways to do different things". Interestingly, she associates this ability to tailor by relating it to his prior and current work experiences: "because being a mechanical engineer you kind of have to" (118). Completely opposite to Kasey, Jane found that her husband did not help when it came to explaining a mathematical concept: "I distinctly remember not being able to calculate stability… which ironically I remember that because my husband learnt how to do that as a ship's master" (Jane 40, 42). Therefore, a partner could be both a help, as for Kasey with exploring different ways, or a hindrance, as for Jane whose husband could not pass on the knowledge.

Stevie in particular had a great deal of influence from her grandmother. While her grandmother tried to tailor some help for Stevie at one particular time around map reading: "she'll be like, 'look at this map'" (Stevie 130), Stevie was reluctant to accept the help: "I'm like, 'no, no, just no, I don't want to look' (130). This was a recurring theme with Stevie in that she would rely on her grandmother for support rather than trust her own abilities. In cooking, Stevie said: "if we don't have the measurement cups, I have to ask my grandma" (Stevie 112) showing that she would ask about the mathematics component. With percentages, she first said: "I have never ever used percentages" (Stevie 74), and would simply rely on her grandmother to work it out: "I'll go shopping with my grandma, and it'll be twenty percent off whatever it was, and I'll be like, 'grandma, what is this? What will it come to?'" (74). In the very next sentence, however, Stevie said: "I can do fifty percent off because that's just half" (74) indicating that she had, and could use some percentages and perhaps the over-reliance on her grandmother was for reasons other than she could not do the mathematical calculations. This is important considering comments above about Stevie's prior experiences in learning mathematics.

Apart from her grandmother, Stevie also mentioned that she found that the response from a friend was a positive influence on her learning: "I messaged [my friend] my test results and she's like I'm so proud of you… it's nice to hear that. She's like, 'I believe in you', and that's really helpful" (Stevie 192, 196). Stevie highlights the difference that hearing a friend say that can have over the same sentiments from a close relative: "My grandma says that but it's different…" (196). Therefore she found her friend a greater, positive influence. Although her friend did not necessarily tailor any mathematical explanations or content for Stevie, in framing her response to the results in a positive light, she did tailor her words specifically for Stevie as she knew Stevie, and understood her reactions and motivators.

Whether it was peers for Michelle, Ro and Kay, or relatives for Kasey, Jane and Stevie, these were people who did not have a teaching role, but were able to tailor interactions around some aspect of mathematics. It was most beneficial when the person explaining also had a thorough understanding of the content, but also was able to explain it in ways with which these students were able to resonate. In some of the situations described here, it was the tailoring of the actual mathematics, "logs" or "stability", and others it was the tailoring of the emotional support, "believe in you", but for these six students these interpersonal interactions had a great impact on their learning.

4.7.4 Tailoring and other categories

One important attribute of 'tailoring' is that it works in harmony with the other six categories. Depending on who the tailoring comes from and what area it relates to, the category of 'tailoring' is not static. The dotted line indicates that it can change in both shape and size. Another way 'tailoring' works in harmony with all six other categories is to form links between them.

The central position of 'tailoring' means it can overlap into some categories more than others. Students have said that they were weak in some areas and stronger in other areas, therefore they would like the teacher to help them with those weaknesses. The location of the tailoring category shows how teachers or others tailor explanations or other learning activities to individual students' strengths and weaknesses. For example, when Kay was not particularly willing to work through confusion, the teacher tailored her facilitation to help the Kay overcome the frustration. For Charlie, however, where perseverance was not an issue, he had trouble relating the concepts to the real world, the teacher tailored explanations to include real world examples. In this way, the central category may not be circular, but may skewed towards certain categories such as 'working through confusion' for Kay, or 'relating' for Charlie.

Students also indicated that more or less tailoring was desired depending on what was happening and who was giving the tailored explanation, hence there could be a great deal of overlap, or little overlap. For example, Kasey was not very confident and utilised a lot of tailoring from her tutor. On the other hand, M felt very intuitive at mathematics, and did not need as much input. The central category of 'tailoring' would be very large for Kasey when interacting with her tutor, but much smaller for M within the STEPS classroom. Even though the category of 'tailoring' may change shape or size, it is important that tailoring remains as a category[15].

The position of 'tailoring' amongst the other categories also serves to link all of the categories. 'Tailoring' can form a bridge even between non-adjacent categories so that the teacher can help students to see links. While each of sections 4.1 to 4.6 described the connection between adjoining categories, there are also interplays between non-adjacent categories as well, and the teacher can draw on these to assist students.

One particular connection that M, Michelle and Steve made were the overlaps of other categories with the category 'working through confusion'. M needed time to overcome confusion and relate the maths to the real world: "I probably only half understood… got through my head. I think with time though, I will see the practicality of it" (M 52). Michelle also made the connection between her confusion and the real world: "the boxes are just confusing me, something shocking… You see to me, it's just a number. I don't know what a prime factor really is" (Michelle 68, 70). Stevie connected both 'taking time' and 'practising' to overcoming her confusion: "It takes a while to sink in and if I don't get it the first few times, I get really cranky at myself… and then I'm like, just kept trying to do it" (Stevie 48). M also linked his time commitment with holding his interest. He said that he did not have "to spend as much time invested in it" as he was not interested in "trying to really get into it" (M 120).

For M, Michelle and Stevie, they were unable to make the associations themselves, and that is where tailoring could be useful. It also implies that although not particularly mentioned by these participants, there could be potential gaps in understanding the links between any or all of the other

[15] Chapter 5 will explore in more detail the questions of what might be considered "self-teaching" for adults, particularly as it rarely occurs without some help-seeking behaviours and receipt of assistance.

categories. The arrangement of the categories with 'tailoring' touching each of them makes tailoring a key linkage pathway to help students with all aspects of their learning.

The seven categories described in this chapter were constructed from the data and the detailed analysis from coding to theoretical categorisation. The process by which the categories that have been established in Chapter 4 were developed in a theoretical framework is explained in Chapter 5. The theory that resulted proposes to facilitate the development of a quantitative literacy for learning mathematics.

Chapter 5 Constructing the theory

From the previous chapter, relationships among the categories within the model of mathematics learning were identified. This chapter explores these relationships to construct a theory explaining how quantitative literacy can be developed in adult and further education. The chapter also explores how this theory links to and is underpinned by an existing literacy theory. This existing theory is then extended and contextualised for developing the quantitative literacy of students in a university enabling course.

Section 5.1 presents the core category by bringing the previous seven categories together. Section 5.2 places this core category in the context of literacy theory, in particular the '4 Resource Model' (5.2.1) as related to mathematics (5.2.2) and as related to all of the categories (5.2.3). Section 5.3 shows that these literacy theories traditionally used in early childhood and primary school, the foundational education areas, are able to be used in adult education by considering how adults form their state of mind in regard to learning (5.3.1), how they plan (5.3.2), how they engage in learning (5.3.3) and how they reflectively evaluate their learning (5.3.4). Application of the theory to mathematics learning in the enabling education learning environment is proposed in 5.4.

5.1 Core category

All seven categories described in Chapter 4 may be explained through a core conceptual category that I chose to label 'clicking', which is an *in vivo* term from the transcripts. Students stated that the reason for everything they were doing in their study was to understand the content. The way they described the gaining of this understanding for any particular concept, however, was more of a sudden occurrence, a singular point in time, rather than a developing process of building meaning over time.

The moment when it all made sense was described as:

- a "click"

(M 20, 120, 122, 170, Ro 118, Michelle 104, 122, 162, 182 (x2), 192 (x2), 212, 214, 278, 280, Kasey 30, 130 (x2), 132, 134, Candy 132, Thomas 94, Charlie 30, 36);

or understanding that would

- "sink in" (Stevie 48, Ro 28, Caroline 14, Kasey 120, Cyndel 322);

and they would

- “get it” (Stevie 48, 296, Jane 98, 294, 300, Ro 240, Michelle 4, 22, 274, Kasey 32, Cyndel 82, Charlie 38).

‘Clicking’, ‘sinking in’, or ‘getting it’ appear to be point-in-time processes where there is a distinct transition from not understanding the concepts to understanding them. The students were not necessarily able to fully comprehend what happens during the ‘click’, “I guess it’s just um… just ‘connects’ you know. I can’t really describe it.” (M 46), but they did realise when it happened. While understanding, *per se*, is seen as a process, it would appear in the particular case of learning mathematics for quantitative literacy in enabling mathematics for university study, there is an actual moment in time that is vital: “the click moment is when you go, oooohhh, I got it” (Kasey 132). Thus, I chose the core category for the set of categories as ‘clicking’, and this core subsumes all other categories as shown in Figure 5-1.

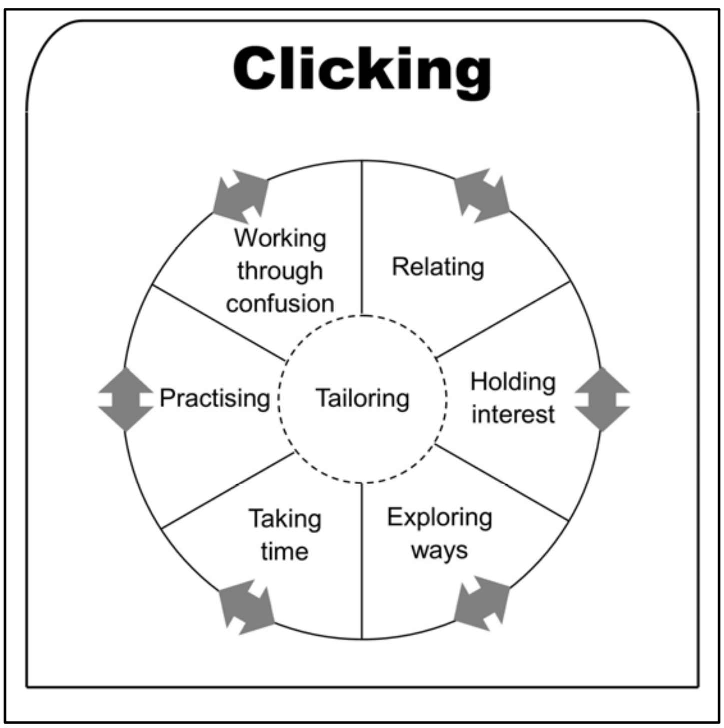

Figure 5-1 ‘Clicking’ as the core category incorporating all other categories

This action of understanding, the ‘clicking’, the ‘aha moment’ or when the students ‘get it’ was also familiar to me having been a maths student and also as a maths teacher. It is a level of understanding when everything falls into place, and, in its outward manifestation, appears to be quite sudden. Teachers or tutors may see this with their students when there is a sudden look of ‘knowing’ coming from the student. It is important here to note that while ‘clicking’ can be recognised by teachers, the processes of 'clicking' are essentially a student-centred, student-owned process. Findings reported in the previous chapter illustrate that the build-up to clicking varies widely from student to student. Further, while clicking may be the 'light bulb', 'aha' moment, there have been processes of relating, being interested, exploring ways, taking time, practising, working through confusion and tailoring which have all contributed to 'clicking'.

There are different levels at which 'clicking' can impact. It can happen for individual concepts such as adding fractions, or it can happen at a larger scale such as understanding the meaning of calculus. The six categories of 'relating', 'holding interest', 'exploring ways', 'taking time', 'practising', and 'working through confusion', are what the students said they did to achieve 'clicking'. When the seventh category of 'tailoring' occurs within the processes of the other six categories, students reported that 'clicking' is facilitated.

5.2 'Clicking' as quantitative literacy for learning maths

Using the GTM philosophy of theoretical sensitivity, many theoretical perspectives were considered throughout the analysis. Many of these, however, described only parts of the learning process, or described QL without involving the actual development of quantitative literacy. As the categories were developed in this study, it was clear that students were explaining processes that helped them learn mathematics. Once the core category of 'clicking' emerged, its relationship to the concept of QL for learning mathematics was formed and this will be discussed in this subsection. There were also emerging links that suggested QL could be a subset of more general literacy, hence could be developed via the exploration of literacy theories. In this regard, the four-resource model (4RM) appeared to be particularly useful and adaptable to explain the development of 'clicking' as a theory of the learning process in maths for students in enabling courses, and potentially also a teaching process for achieving quantitative literacy in maths learning in such courses.

5.2.1 The 4RM

Freebody and Luke (1990) discuss a framework for literacy in a sociocultural context that involves 'four roles'. These educationists are credited with developing the roles into the notion of "resources [as] necessary components of literacy" (p. 7). This development became known as the '4 Resource Model' (4RM).

As their work developed, Luke contributed this notion to the discussions of the New London Group around multiliteracies. As a result, the 4RM that was originally concerned with literacy from written text, was introduced to, and accepted by, the framework of multiliteracies (Anstey & Bull, 2003).

The concept of multiliteracies also incorporates pedagogical theories from Durrant and Green's (2000) 3D Model of Literacy Learning (for integrating information communication technologies), together with Cope and Kalantzis' (2009) four components of pedagogy (situated practice, overt instruction, critical framing, transformed practice). Luke and Freebody developed this further, as referenced by Anstey and Bull (2003) "as a framework to help teachers interpret the social critical theories of literacy… specifically for the teaching of reading" (p. 92). Anstey and Bull proposed that it would be useful across several practices including history, science and mathematics. Because of the nature of STEPS as an enabling course centred around learning literacy skills to move students forward in their education and career prospects, the 4RM provides a theoretical framework to explain processes "that teach students to analyse tasks, problem-solve, identify resources and self-monitor" (Anstey & Bull, 2003, p. 91).

The 4RM consists of four interwoven and interrelated resources for learning (Anstey & Bull, 2003; Freebody & Luke, 1990). They are:

Code breaker: "make sense of the 'marks on the page'…to understand how these parts work individually and in combination" (Anstey & Bull, 2003, pp. 92-93).

Meaning maker: "make literal and inferential meanings of text… Understanding the genres of the texts used in particular disciplines" (Anstey & Bull, 2003, pp. 94-95).

Text user: "use of text in real-life reading situations… in different contexts and on different platforms [and] variation in its structure or layout" (Anstey & Bull, 2003, pp. 95-96) with the emphasis given on creating text for a reader.

Text analyst: "involve readers in the critical analysis of texts in order to understand how texts construct and reconstruct our world, how we live in it and the power we exercise over it. By engaging in text-analyst practices the readers, rather than the text, hold the power as the readers make informed decisions about how they will use the text and what authority they will accord it" (Anstey & Bull, 2003, p. 97).

These are non-hierarchical and often used inseparably, as presented in the model from Serafini (2012) shown in Figure 5-2.

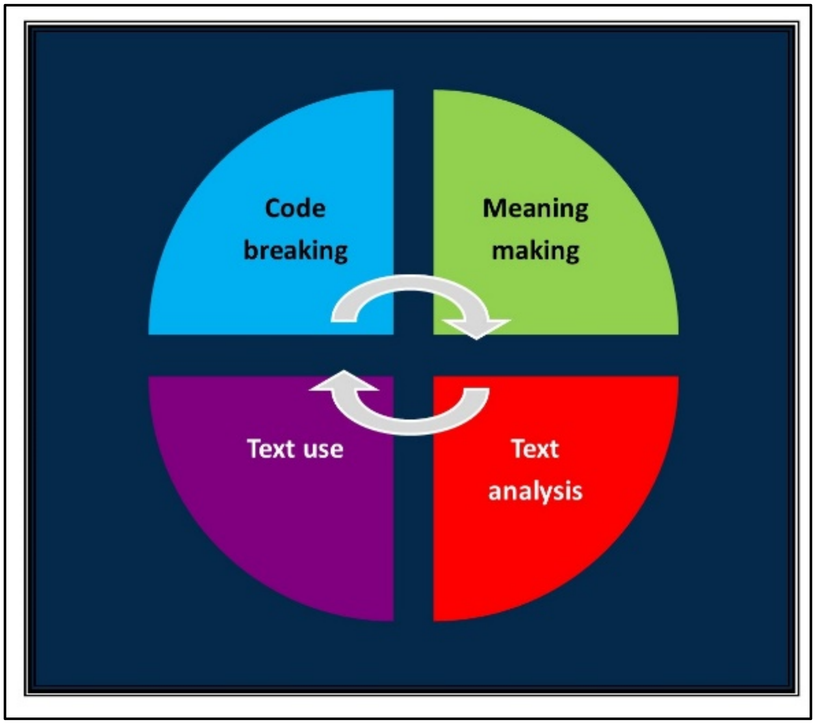

Figure 5-2 The 4RM for literacy [Adapted from (Serafini, 2012)]

The concept of multiliteracies encapsulates the 4RM and allows the expansion beyond the realm of text-based, reading comprehension. By referring to aspects of language use, the 4RM expands to discipline specific 'languages' such as, in context of this study, the 'language of mathematics'. The 4RM by the way of multiliteracies, as described in 2.2 also allows for the domain-specific context of enabling mathematics units and other languages around enabling education such as the 'language (literacy) of higher education'. Therefore, the 4RM provides an interface with multi-faceted learning of 21st century adults in further education in their patterns of meaning making.

5.2.2 4RM and mathematics

The 4RM has been adapted for use in mathematics literacy, and two examples of such adaptation of are discussed here. The first serves to demonstrate how the model can be used explicitly for a mathematical context, and the second to show how the 4RM can be used to help students in learning mathematics and developing the resources to do so.

Quinnell (2016) presented a representation of the 4RM in her doctoral thesis. Some of the key points specifically in terms of the mathematical symbols, terminology, meaning and analysis are presented in Figure 5-3.

Code breaking	Meaning making/Text participating
Mathematical symbols (e.g. π, ¼, ≥) and abbreviations (e.g. mm, NE, h) Words and sentences (sounds, spelling, formatting, page layout, directionality) Mathematical graphs, tables and visual images Relationships between different semiotic systems such as written text and visuals	Word meanings (instructional, lexical, technical, everyday, prefixes, roots, origins, synonyms, conjunctions, obsolete words, words for abstract concepts, modified meanings) Meanings of mathematical symbols and abbreviations, visual images and tables Understanding and composing text with input from others Interpreting and generating linear, non-linear, non-interactive, interactive text Locating key ideas, filling in the gaps, using story maps, reading and retelling, considering the audience, making meaning from a combination of textual information such as graphic information, diagrams, and symbols
Text using	**Critically analysing**
Understanding of content, context, purpose, audience, significance, implications of text with mathematical content- not just a set of stated skills Recognising and using varying structures and features in text with mathematical content Interpreting problems in problem solving Using and composing different text-types such as tables, graphs, maps; including everyday text such as timetables, accounts, maps and text from different cultures Presenting and understanding text with various structures and features; including text containing multi-semiotic systems	Understanding that texts (with mathematical content) are written for set purposes and may influence readers in various ways Establishing whether a text (with mathematical content) is true, fair, biased, misleading, or whether anything is omitted Understanding of the use of particular words or diagrams to convey specific messages Establishing the facts/opinions, views, author's background, reason for writing, other views Understanding of different ways of presenting the same set of information

Figure 5-3 Application of the 4RM for mathematical contexts [Adapted from (Quinnell, 2016)]

In Figure 5-3, Quinnell draws attention to aspects of mathematical text that may not be found in written text. For example, in code-breaking, 'directionality' is not necessarily a consideration in conversational language, but in mathematics, it is the order of operations, not the order of appearance that determines the meaning. Mathematics also has terminology that has specific mathematical implications, and is described in Figure 5-3, by the term 'modified meanings'. Several times in her version, Quinnell mentions visual representations including 'graphs' and 'tables' and these require the 'understanding' that they 'convey specific messages'. Therefore, this figure gives a mathematically significant contextualisation of the 4RM.

A second study (Stack, Watson, Hindley, Samson, & Devlin, 2010) related the 4RM more specifically to learning mathematics. These authors describe a model of the 4RM that they developed. It related the four areas for school teachers to help their students develop deeper thinking around mathematical terminology and concepts. A version of their model (slightly adapted by the researcher) is shown in Figure 5-4. This model is centred on questioning in order to help students in ‘de-coding’, ‘meaning-making’, ‘analysing’ and ‘using’ mathematical concepts. Stack et al. (2010) aimed to make “the different thinking processes visible to students via such a model” so that students would “eventually… bring discernment to their own reading of texts” (p. 11). They suggest that this develops the literacy of the students and they may become more self-sufficient in their learning, relying less on direct instruction from the teacher.

De-coding What are the different ways numbers are used and represented? What is the terminology being used and what does it mean? What are the key mathematical concepts that are being used? What are the key mathematical processes and procedures?	**Meaning-making** What is this text about? How does it relate to what I already know? How can I use what I already know? How do the mathematical concepts make sense in this context? How do the mathematical concepts help me understand the context? What is confusing or misleading? Are there other possible meanings?
Using In what ways are the numbers or mathematical concepts in this context significant or useful? What is the purpose of the text and how does it connect into a bigger picture? How might this text be used to promote particular viewpoints? What are possible applications and likely impacts? How would I use this text and what decisions would I make based on it? In what ways am I now thinking about the issues and the mathematical concepts differently?	**Analysing** Is it true? – Are the mathematical concepts used appropriately in this text? What is the evidence? Does it have reasonable assumptions? Is it logical and consistent? Is it researched appropriately? Does it have a reputable source? What do I need to know more about to be convinced that it is plausible? Is it fair? – Does it include different views, values, perspectives or types of research? What is missing? Who might be silenced? Where would I look for alternatives? How does it position me? – What do I think the author’s values and intentions are? What do they want me to believe? How do they use the mathematical concepts or terminology to position me? Do I believe it?

Figure 5-4 A version of the 4RM specifically focussed on questions to build mathematical meaning [Adapted from (Stack et al., 2010)]

Stack et al. (2010) found that the teachers were able to successfully use this mathematical version of the 4RM such that students’ “skills can be developed, gradually building on students’ increasing familiarity with the contexts and the mathematical concepts” (p. 15).

These two models demonstrate that the 4RM can be used in a mathematics context to answer the question of how students develop quantitative literacy in learning mathematics.

5.2.3 4RM and 'Clicking'

Even though the models in section 5.2.2 contextualised the 4RM for mathematics, they were based on the primary school classroom. The 'clicking' theorisaton proposed in this thesis relates the 4RM to learning mathematics in enabling units in the higher education environment, and as described by the participants in this study in Chapter 4. The categories within 'clicking' are what the students need to do to learn mathematics. The 4RM serves to situate 'clicking' as a literacy such that students can become quantitatively literate in learning mathematics. All of the categories encompassed in the 'clicking' theory are the strategies that students use to build their proficiency with the four resources. That is, by pursuing the six elements of 'clicking', along with help from others, students can learn how to break the code, make meaning, analyse text, and use text all from a mathematical perspective, as shown in Figure 5-5. It is only when students have achieved all aspects of 'clicking', facilitated by tailoring, that they will have all of the resources or tools required to be quantitatively literate for learning mathematics.

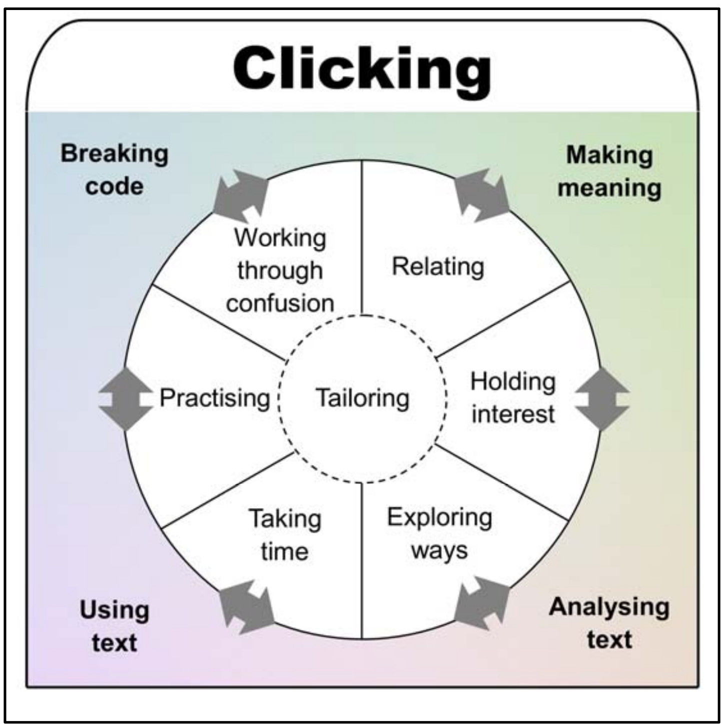

Figure 5-5 'Clicking' as a process to develop the four resources of literacy for learning mathematics

The 4RM highlights the impacts of learning and the learning process involved for students learning mathematics within the STEPS course at CQUniversity. The 4RM also helps students to develop quantitative literacy when learning mathematics. For students, it means understanding at a core level that which they need to achieve in four steps. How they can achieve them is outlined in the categories. For teachers, it theorises and breaks down the cognitive steps of clicking so that the tailoring, and hence teaching, can have the most impact. If teachers tailor the curriculum or the learning activities to achieve the distinct steps of code breaking, meaning making, text analysis and text use, it is much easier for students to achieve 'clicking' and have the resources to become quantitatively literate.

One of the areas of potential significance for adapting the 4RM to enabling education is that it allows the distinct backgrounds of students to be taken into account. Typically, as discussed in section 2.3.1, students in enabling courses have had disruptions and challenges in previous education experiences, especially in formal classrooms. Because of this, there may have also been disruption to their processes of 'learning how to learn' (Winch, 2008) and hence their preparedness for further study. This may also have impacted on their confidence, anxiety, fear and ultimately success. In an enabling course such as STEPS, teachers are in a position to help students learn how to learn. The 4RM is a framework on which to base this learning how to learn, and the categories of 'clicking' provide the details on how students might seek to develop the four resources.

The prior learning experiences of students in enabling courses, means they might very well be unfamiliar with learning how to learn. Issues then arising in the tertiary context may be compounded by the backgrounds of the teachers specifically in mathematics. Teachers who come from a practitioner-based background, such as research or industry are not necessarily trained as educators. The lack of proficiency in pedagogy and curriculum development or lack of awareness of specific educational and literacy theories may mean that they are not well-versed or well-practised in being able to implement suitable strategies to encourage literacy within the students.

There may also be a mismatch between tertiary mathematics teachers who have a wide and deep knowledge of mathematics (Hapsari, Putri, & Raharjo, 2017), and enabling students who may not yet be proficient. It may be assumed that people who excel at maths have had prior learning experiences that matched their learning styles so that they possess the resources they need to be quantitatively literate in learning mathematics and can be so adept at using them that they may never have been cognisant that they are using four interrelated resources when approaching a mathematical problem. This subsequently puts them in a very different mindset from the students in the enabling learning environment as described and explained in this thesis. 'Clicking' is able to explicate the 4RM not only for students, but also for teachers, and may help lessen the impact of the gap, and may allow all involved in mathematics education in enabling courses to share a common language in regard to learning mathematics.

As students move through mathematics units, they develop ability in the four resources, and confidence to use these resources for themselves. In the enabling environment in particular, this shifts the power balance from 'unknowing' students and the 'knowing' teacher, to literate students who are able to use the resources for themselves, while the teacher acts as guide who can tailor practices depending on student need. That need may be direct instruction to help students break the code, facilitating meaning making through examples that relate to the student's situation, or encouraging text use by normalising the act of working through confusion. Students and teachers are able to then use all of the facets of 'clicking' to achieve students who are quantitatively literate in learning mathematics.

5.3 The case of adult learners

According to Anstey and Bull (2003), the 4RM was developed for use in early childhood and primary classrooms where students initially are just learning how to read. Multiliteracies theories, however, have been shown to have power and application beyond the school classroom into adult literacy. In particular, Cope and Kalantzis (2009) used the multiliteracies framework "in the field of adult education and to offer a focal point in the struggle against social exclusion by promoting lifelong learning to general population" (p. 190). This setting is remarkably similar to that of enabling education discussed in section 2.3.1. Therefore, I maintain that it is reasonable to extend the 4RM to the STEPS course, and that it is prudent to do so.

From the interviews conducted in this study, it was clear that students understood their own knowledge levels and learning practices. For one, they could identify their own strengths and weaknesses. Michelle and Cyndel knew they already had strengths: "Percentages I thought I'd be good and I was good at that" (Michelle 106); "sin, cos and tan, I remembered as well… I was really good at it" (Cyndel 146). Caroline identified that she developed a strength through the unit: "I actually got that good at doing it" (Caroline 126). On the other hand, Jane knew she had a couple of areas of weakness: "I was never strong at it at school" (Jane 8); "I'm particularly bad at still… positives and negatives" (Jane 58, 60). A second area students were able to identify were the factors that assisted them in their learning. M knew that: "comprehension basically, has helped in maths" (M 155) and Kay understood that: "having a teacher that's dedicated to the way that other people learn definitely helped me" (Kay 98). Kay also found that "colour… helped a lot" (Kay 176). This demonstrates that these STEPS students knew their own competencies, and what helped them to learn. In this sense, they were adult learners who were knowledgeable and active participants in their own learning.

This is well supported by the theory of andragogy, or adult learning. Within andragogy, as originally introduced, Malcolm Knowles (Knowles, 1981; Knowles, Holton, & Swanson, 2005) distinguishes adult[16] learning from the learning done by children (pedagogy) through recognition by the learner that they are situated within the learning. Therefore, they are able to be involved in their learning pathway and, in particular, use previous experiences to influence the direction of this pathway. This is described by Philip Candy (1991) as 'self-directed learning'. Andragogy, and the self-determination that adults are able to undertake, are important to the use of the 4RM in the adult learning environments. Knowles' theory of andragogy exhibits key features of this student-directed learning that are relevant to the adult learners in the STEPS classroom, and are related to the 4RM. Knowles et al. (2005) described eight elements (p. 116) that fall into four general areas of state of mind, planning, doing, and evaluating. These four areas will be explored in the following sections to show the power of the 4RM and 'clicking' in adult education.

5.3.1 State of mind

The students' state of mind and openness to learning is critical in order for them to be able to use the four resources. Firstly, they must be prepared to learn. This is related to other aspects of life, but is an area where the teachers can help the students be ready for what they are going to encounter inside the mathematics learning environment. Being prepared to learn is also being open to asking questions, an important aspect of the 4RM discussed in section 5.2.2.

Secondly, they must feel relaxed and trusting, in what is described by Knowles and his colleague Tough (Tough & Knowles, 1985, p. 708) as the "psychological climate" of the learning environment. This recognises that adult learners are able to be aware of their mindset and use available information to change that mindset; to be open and willing to learn, and even to find pleasure in learning. If students understand and are comfortable with a mindset that is open to using the four resources, plus put their mind to achieving these aspects, then they can be willing and active participants in the process. Again, this gives them power over their own learning. So once they understand what they are trying to achieve, they are able to accept and be motivated to undertake what they need to do as part of the activities described in the clicking categories.

Candy (1991) highlighted that motivation is key to learning content that may not interest them at that particular point in time with the "method of instruction as distinct from the content of instruction" (p. 66). This will allow the student to see why those activities are important for their

[16] Candy (1991, pp. 42-46) has a detailed discussion of what is an 'adult' and according to this, students attending university would fit the category.

learning, and how those activities relate to them being able to understand mathematics, not just at the current moment, but as a literacy to take into the future.

One major barrier for student mindset is anxiety, in particular, mathematics anxiety, and this has been the subject of several studies. The anxiety has been attributed to a variety of causes such as lack of student uptake of mathematics subjects in high schools (Frith, 2011; McNeilage, 2014; Stephens, 2013), a lack of high school teachers with sufficient knowledge and confidence in mathematics (Mather, 2014) or how to teach for understanding (Heng & Sudarshan, 2013), and a perpetuated issue of mathematics-related anxiety being passed on from teachers to students (Hughes-Warrington, 2013).

'Mathematics anxiety' is a problematic state of mind right from early primary school and it can affect how children perform and how much mathematics they actually learn; and this anxiety can continue from year to year (Vukovic, Kieffer, Bailey, & Harari, 2013). Once students reach high school, mathematics anxiety again influences how well students perform (Yaratan & Kasapoğlu, 2012). If students are able to go on to university, mathematics anxiety has strong links to grades in the subject (Kargar, Tarmizi, & Bayat, 2010; Núñez-Peña, Suárez-Pellicioni, & Bono, 2013). Mathematics anxiety is strongly linked to previous poor performance, although poor performance due to high levels of anxiety is not necessarily a reflection of actual ability (Hoffman, 2010; Jansen et al., 2013). Andragogy is significant here, as adults can learn to change their mindset. Through developing their four resources, and with appropriate tailoring, students can work towards that moment of clicking with more confidence.

5.3.2 Planning

Once students understand their ability to control their own mindset, they can be more involved in planning their learning, in collaboration with the teacher and other advisors appropriate along the journey. It is quite understandable that students have exhibited self-direction in deciding to undertake STEPS and a university degree, but according to Candy (1991), it is important to still give them the power to plan their study within any learning environment. When learning mathematics, this means that they will need to be able to understand what it is that they need to do regarding the four resources and then plan to use the elements of 'clicking' to help them achieve those four aspects. According to Knowles et al. (2005), planning has to involve diagnosing their learning needs, formulating learning objectives around those needs, and creating plans to meet those needs. With the guidance of the 4RM as that which they need to achieve, students may be informed about what they need to do in order to learn, and why that is the case. They can then determine which aspects of clicking they will need to use, in collaboration with the teachers who can help by tailoring learning activities to these needs. Indeed they can also mindfully access other people to help with their learning needs in a fashion that is best suited to them. Students can use the 4RM as an objective to aim towards in their planning and have some control over their learning. By using 'mutual planning' and 'mutual negotiation', the students then have an active role and vested interest in their learning activities. This is quite different from other pedagogical techniques where it is the teacher who is responsible for planning, and the teacher who "decides in advance what knowledge or skill needs to be transmitted" (Knowles et al., 2005, p. 115). If students know what the end goal is, and how they will learn to use the four resources, it gives them reason for doing what may be otherwise seemingly meaningless tasks. This could be the motivation to undertake repetitious practising, or the encouragement for them to work through confusion. They will know that they will achieve more than doing that particular exercise, as it will increase their literacy for doing similar and even more advanced problems in the future.

5.3.3 Doing

The next stage after planning is doing and in this stage it is the students who are 'doing'. As Knowles et al. (2005) explain it, there are: "principles of action that are likely to achieve desired changes in the learner" (p. 129), and so, in order to achieve a change, students must take an active role in their learning. 'Clicking' clearly sets out a scaffold for what constitutes 'doing' through the outer six categories. Students can use these actions to help them develop the four resources.

There is a key point in andragogy concerning the definition of the learner 'doing'. It is important to point out the difference between self-directed learning, and self-teaching (Miflin, 2004). While Knowles et al. (2005) say that adult students must themselves be ready to learn, there is still a need for teachers to help students carry out their learning plans by contributing learning activities. This must be a joint effort, and is represented by the role of tailoring in 'clicking'.

As pointed out by Tough (1967) who also researched adult, self-directed learning, it was uncommon for adults to be able to solely self-teach. In his work, even when the decision to undertake was entirely the students' own, they sought and "obtained a very large amount of assistance" (Tough, 1967, p. 47). The type of assistance included a large amount of help with "deciding [which] activities" (p. 48) would be helpful and "dealing with difficult parts" (p. 48) and thus indicating informative, direct instruction on what to do and how to do it. The important point that Tough makes, however, is that adult learners need to desire help for the help to be effective. Learners need the motivation themselves to pursue the aspects of the 4RM, and then decide when to access help. In the adult learning environment, this ranges from deciding when to attend classes or online workshops, what they will pay attention to, and in which activities they will participate.

Tough (1979) again refers to decision-making when he emphasises the importance of who is in control of the learning in adult learning situations. He shows that if students maintain control, but receive instruction, including direct teaching, students are more likely to request help, ask for activities, decide from options offered by the teacher, and determine what they will do when. This is heavily influenced by their mindset, and how much control they have had over their learning plan. If, however, the teacher is in control, it is up to the student whether to accept the dependent position. This is often seen in classroom situations where the teacher is the 'expert' and the student is the 'novice', a "teacher-directed education, wherein the learner has only the submissive role of following a teacher's instructions" (Knowles et al., 2005, p. 62). This is contradictory to the mindset of learning required to utilise the four resources because in this model, the students have to be willing to develop control of their own mindset and cognitive activities. Indeed, Tough argues that when teachers want to provide too much help, that is, "more help than desired ... [it] is often the sign of a helper who tried to control and dominate the learner's decisions and arrangements" and that this made the "learner feel that he had to resist the helper's attempts to influence his strategy and subject matter" (Tough, 1979, p. 192).

Particularly in enabling mathematics units, the students' resolve is often low due to ineffective previous learning and classroom experiences. This puts increasing pressure on the teachers to provide a tailored experience. As Tough found, if the teaching was "congruent with the amount of help that the learner wanted or welcomed" (Tough, 1979, p. 192), it meant that students were not put in situations that induced anxiety. By creating an environment where students maintain control of their own learning, anxiety can be decreased. When the students acknowledge that they are responsible for engaging with the four resources, and they themselves can determine which activities will help them achieve 'clicking', then they are more willing to be open to assistance, even to the point of receiving direct instruction.

5.3.4 Evaluating

Knowles et al. (2005) also emphasise that adult learners should be involved learners in evaluating their own learning. The 4RM includes, as a critical aspect of learning, the ability to learn the cycle of four resources and be able to see how the cycle applies to different situations. Knowles et al. (2005) encourages students to reflect on their ability and to continually work on increasing their proficiency and, in the 4RM, this would be in respect to each resource. This is how students gain literacy and are able to learn in any situation in the future. Adult learners are not only able to reflect on their learning of mathematics subject matter, but evaluate their own abilities to learn. Again, Knowles et al. (2005) state that this is a collaborative effort between learner and teacher and hence reinforces the inseparable nature of all categories that contribute to ‘clicking’, and the opportunity for teachers to explicitly inform students about the 4RM.

In summary, Knowles’ (Knowles, 1981; Knowles et al., 2005) elements of andragogy promote the success of the 4RM in the adult education environment, and in particular, in enabling education. Students can be self-directed in their motivation to study, but may also ask for help. Teachers would then be able to tailor an environment suitable for the negotiation of learning plans and learning activities within the ‘clicking’ framework that would be most beneficial for each student to develop the four resources and in so doing, develop quantitative literacy.

5.4 Chapter summary

‘Clicking’ is a theory of developing QL for learning maths because ‘clicking’ enables students to engage the four resources in the 4RM. This can also be facilitated by any other people involved in the student’s learning journey by using the aspects of ‘clicking’ to break down the concepts of state of mind, planning, doing and reflecting thus helping the students to understand explicitly the concept of literacy, and what QL is for learning maths. The positioning of ‘tailoring’ within clicking helps any facilitator of learning to direct students into specific aspects of ‘clicking’, and in the amount necessary, as required by each individual student. The proposal is that the concept is highly responsive to a diverse range of learning needs.

In adult education, this concept is really important. STEPS was founded on the philosophies of andragogy (Seary & Willans, 2004). Adult students are able to have metacognition, helping them be open to the questioning required to develop the four resources through ‘clicking’. They are able to be actively involved in determining their own pathways, study plans and learning activities and so they can maximise the benefit of all aspects of ‘clicking’. As such, they are also able to take responsibility for their actions while ‘doing’ the learning. Ultimately, adult students are able to reflect and evaluate how their ‘clicking’ is going and the level of competence they feel in developing the four resources in a more autonomous manner, reducing the need for tailoring, and empowering the students in their own learning.

Chapter 6 Conclusion

This chapter brings my research and thesis to a conclusion. Consistent with the Constructivist Grounded Theory Methodology in the research design (Chapter 3), the evidentiary chapter (Chapter 4), and the extensive discussion chapter (Chapter 5) of the key elements of "clicking" for developing quantitative literacy for learning mathematics in an enabling course in tertiary education were six interrelated student centred categories: relating, holding interest, exploring ways, taking time, practising, and working through confusion. This was complemented with the seventh category of tailoring ways of learning mathematics provided through teachers and others such as peers, family, friends.

The impetus for this study was to help students who were so motivated for a second chance at learning through tertiary education not be disillusioned by the challenges, particularly in the subject area of mathematics. While the STEPS enabling course aims to ease the transition to the university environment for students who had previously had poor, or disrupted learning, there seemed to be a continual struggle in mathematics units. When students encountered mathematics concepts that they felt they had not learnt before, it appeared to bring back anxieties from prior formal learning experiences that may have been negative. The focus then became how students could remain engaged with this 'second chance' opportunity and have a positive learning experience in mathematics. Not only could it counter the anxiety, they could also take this new found 'learning how to learn' mathematics on to their undergraduate courses as a quantitative literacy for learning mathematics.

This research made prominent the student voice through a GTM study such that participants were able to explore their past, present, and future mathematical learning under guidance from the researcher. Throughout the questioning, I focussed on asking about the sorts of things that helped them learn mathematics, but also what hindered their learning. I discussed different situations with the students, from formal learning to at work and with hobbies, and across time, and particularly explored the STEPS learning environment. Thus during the analysis, I interpreted what they said, and answered my first question as to the processes involved for them to learn mathematics in the STEPS units:

- What learning processes are involved for students learning mathematics within the STEPS course at CQUniversity?

Through analytic and theoretical analysis, I demonstrated the learning process involved with students learning mathematics and was able to construct categories and relationships between those categories in a way consistent with GTM. In the context of adult, enabling students, I compared the emerging categories with the existing theory of andragogy, already used in developing the philosophical underpinnings of STEPS as to how adults develop learning tools and techniques. I also investigated literacy theories from other contexts and along with andragogy, this helped me in constructing an overall theory to answer my second research question:

- How do students develop a quantitative literacy for learning mathematics?

The theory of quantitative literacy for learning mathematics that I constructed from this research was ‘clicking’.

This theory of ‘clicking’ is the transitionary link for students to use the seven elements so as to develop quantitative literacy resources for mathematics learning. This theory can offer a basic practical guide as a starting point for teachers in enabling courses to use with their students so that the students can develop their own 4RM literacy resources, being breaking code, making meaning, analysing text, and using text in a way that helps them become confident learners of mathematics. For students, being quantitatively literate in ‘learning how to learn mathematics’ through clicking has implications for overcoming anxiety, embracing new concepts, and their overall success in learning mathematics for their chosen professional studies at university referred to in Chapter 5.

Implications

There are two implications emerging from this research. The first implication concerns replication of the research design. This design could be used in other enabling courses or other disciplines to determine student understandings of learning. By developing their understanding of learning, they will become literate in that discipline.

The second implication concerns testing the model developed in this thesis in other situations where students are learning mathematics. The resultant concept of ‘clicking’ may be useful in examining mathematics in other transitional tertiary education environments, where students need to progress from a state of ‘not knowing’ to ‘knowing partially’, to a state of ‘knowing’, which describes all learning, might also benefit from the 4RM model and the theory of clicking constructed through this thesis. Indeed, any situation where adults need to learn, critically where there is power imbued through education through the increase of literacy, the theory of ‘clicking’ may have a place.

In the wise words of a quantitatively literate student in the STEPS Program at CQUniversity, having completed her maths units:

"I've been able to click everything since" (Kasey 30).

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Appendix A

(a) Outlines of units in the STEPS course

Outlines of units in the STEPS course:

SKIL40025 Preparation Skills for University (Preparation Skills or PSU)

This unit is designed to help students become self-directed, active and confident learners. It introduces them to a range of theories and concepts to facilitate the development of practical skills and positive attitudes necessary for success in university. There will be opportunities for critical self-reflection on key aspects of student life, including: individual learning preferences and study habits; time management and goalsetting; individual study and career paths; note-taking and assessment strategies. Students will practise critical thinking, and apply information literacy skills to their research. They will learn to negotiate the procedures and systems used at CQUniversity, and practise communication skills in a range of contexts.

COIT40206 Computing Skills for University (Computing)

On completion of this unit, students should be able to use a word processor to format the layout of an academic essay and a report. The students should be able to use a spreadsheet to complete a workbook, create simple formula, apply simple functions as well as create and format charts. The students should be able to use the Internet, negotiate a Learning Management System and communicate using email at an academic level. Students should also be able to create a basic Power Point presentation appropriate for university units.

LNGE40049 Essay Writing for University (Essay Writing)

On completion of this unit students should be able to apply the reading, thinking and writing skills necessary for academic purposes utilising appropriate grammar and writing patterns. Students are familiarised with the stages of the writing process and assisted to apply a range of associated learning strategies. In addition, students develop strategies to plan and write paragraphs, using academic language and conventions. They are introduced to research, note-taking and referencing skills for this purpose. They are also encouraged to examine their own worldviews, and those of others, and to develop critical thinking skills. Students have the opportunity to participate in online discussion forums to support their learning. The unit culminates with students planning and writing an academic essay, using independent research skills acquired throughout the unit. Reflective practice is integral to the unit and this enables students to consider the connection between their personal learning journey and the unit outcomes.

LNGE40064 Technical Writing for University (Technical Writing)

This unit introduces students to the writing skills they will need to succeed in university science and technology units. Students will develop skills in writing clearly and concisely, organising and presenting information in a logical way, and applying relevant conventions of style and grammar. Through intensive reading and writing, they will learn to critically analyse, paraphrase and summarise a range of scientific and technical texts. Students will consolidate their learning by researching and writing a report.

MATH40237 Fundamental Mathematics for University (FMU)

Fundamental Mathematics for University is designed to provide students with foundation concepts, rules and methods of elementary mathematics. The main aim of this unit is to provide the fundamentals of mathematics, which are necessary to develop a unified body of knowledge. Topics covered in the unit include operations, percentages, introductory algebra, simple equation solving, exponents, linear equations, introductory statistics, and units and conversions.

MATH40228 Intermediate Mathematics for University (IMU)

Intermediate Mathematics for University is designed to follow on from a study of introductory mathematical concepts, such as Fundamental Mathematics for University, and prepare students for Technical Mathematics for University and/or undergraduate courses requiring an intermediate level of mathematics. Students will complete core and elective modules, chosen according to their future study plans, including simultaneous equations; inequalities and absolute values; quadratic equations; logarithms; functions; geometry; trigonometry; variation, ratio, and proportion; sequences and series; statistics and standard deviation; probability; financial mathematics; and annuities.

MATH40252 Technical Mathematics for University (TMU)

Technical Mathematics for University is designed to follow on from Intermediate Mathematics for University. The completion of both Intermediate Mathematics for University and Technical Mathematics for University prepares students for first year tertiary mathematics in applied science and engineering. The unit has been developed to provide knowledge of various mathematical topics including algebra techniques; trigonometric functions, ratios, and graphs; plane and analytical geometry; introductory vectors and introductory calculus.

BIOL40108 Introductory Biology (Biology)

This unit prepares students for university study in the environmental, biomedical or life sciences. Students will gain an introductory understanding of the main concepts in modern biology, particularly as they relate to humans. This unit covers a range of topics including cell theory, organ systems, genetics, taxonomy, ecology and environmental science.

CHEM40079 Introductory Chemistry (Chemistry)

Introductory Chemistry prepares students for university study in the chemical sciences. This unit introduces a range of topics such as matter, molecules, bonding, chemical reactions, measurements, acids and bases, pH, and organic chemistry. Students will gain an introductory understanding of chemical concepts and learn to perform chemical calculations.

PHYS40110 Introductory Physics (Physics)

This unit will prepare students for university study in engineering or the physical sciences. Students will gain an introductory understanding of the basic concepts in physics and learn to apply the principles of physics to solve problems of a physical nature in everyday life. Topics covered in this unit include measurement, motion, forces and mechanics, atomic and nuclear physics, properties of matter, heat and thermodynamics, electricity, magnetism and electromagnetism, waves, and optics. This unit assumes an intermediate level of mathematical knowledge.

SCIE40018 Foundation Science (Science)

This unit will enable students with no recent formal education in science to gain the necessary understanding of the basic principles of the major branches of science that will serve as a foundation for entry into relevant courses, such as nursing/health, and related areas. Students will develop study skills in selecting and evaluating scientific information. They will also enhance their knowledge and understanding of the fundamentals of biology, chemistry, physics and related mathematical concepts, and their applications in real-world contexts.

SKIL40016 Positive Learning for University (Positive Learning)

Positive Learning for University introduces students to a variety of concepts through the framework of Positive Psychology. Techniques will be taught to: enhance clarity and identify personal meaning and values; increase optimism through changes in thinking; consider how gratitude and mindfulness improve personal well-being; identify personal strengths; provide opportunities to develop positive relationships; improve communication skills; and integrate healthy living to ensure a healthy environment for study. Through a mixture of theory, practical activities and reflection, students will demonstrate how personal attitudes and ways of thinking affect their learning, and they will consider solutions to the challenges that may be encountered in higher education. Additionally, in order to navigate an online world, students will be introduced to a number of technology platforms that will further support their learning and assist them to demonstrate understanding of concepts using technology.

Appendix B

(a) HREC approval

Secretary, Human Research Ethics Committee
Ph: 07 4923 2603
Fax: 07 4923 2600
Email: ethics@cqu.edu.au

Dr Teresa Moore and
Dr Gemma Mann
School of Education and the Arts
Building 33

1 September 2015

Dear Dr Moore and Dr Mann

HUMAN RESEARCH ETHICS COMMITTEE OUTCOME PROJECT: H15/08-174, *DEVELOPING QUANTITATIVE LITERACY IN STEPS STUDENTS*

The Human Research Ethics Committee is an approved institutional ethics committee constituted in accord with guidelines formulated by the National Health and Medical Research Council (NHMRC) and governed by policies and procedures consistent with principles as contained in publications such as the joint Universities Australia and NHMRC *Australian Code for the Responsible Conduct of Research.* This is available at http://www.nhmrc.gov.au/publications/synopses/_files/r39.pdf.

On 25 August 2015, the committee considered your application. The project was assessed as being greater than low risk, as defined in the National Statement. On 1 September 2015, the committee acknowledged compliance with the conditions imposed on your research project *Developing Quantitative Literacy in STEPS students* (Project Number H15/08-174) and it is now **APPROVED**.

The period of ethics approval will be from 1 September 2015 to 30 August 2018. The approval number is H15/08-174; please quote this number in all dealings with the Committee. HREC wishes you well with the undertaking of the project and looks forward to receiving the final report and statement of findings.

The standard conditions of approval for this research project are that:

(a) you conduct the research project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee;

(b) you advise the Human Research Ethics Committee (email ethics@cqu.edu.au) immediately if any complaints are made, or expressions of concern are raised, or any other issue in relation to the project which may warrant review of ethics approval of the project. *(A written report detailing the adverse occurrence or unforeseen event must be submitted to the Committee Chair within one working day after the event.)*

(c) you make submission to the Human Research Ethics Committee for approval of any proposed variations or modifications to the approved project before making any such changes;

(d) you provide the Human Research Ethics Committee with a written "Annual Report" on each anniversary date of approval (for projects of greater than 12 months) and "Final Report" by no later than one (1) month after the approval expiry date; *(A copy of the reporting pro formas may be obtained from the Human Research Ethics Committee Secretary, Sue Evans please contact at the telephone or email given on the first page.)*

(e) you accept that the Human Research Ethics Committee reserves the right to conduct scheduled or random inspections to confirm that the project is being conducted in accordance to its approval. Inspections may include asking questions of the research team, inspecting all consent documents and records and being guided through any physical experiments associated with the project

(f) if the research project is discontinued, you advise the Committee in writing within five (5) working days of the discontinuation;

(g) A copy of the Statement of Findings is provided to the Human Research Ethics Committee when it is forwarded to participants.

Please note that failure to comply with the conditions of approval and the *National Statement on Ethical Conduct in Human Research* may result in withdrawal of approval for the project.

The Human Research Ethics Committee is committed to supporting researchers in achieving positive research outcomes through sound ethical research projects. If you have issues where the Human Research Ethics Committee may be of assistance or have any queries in relation to this approval please do not hesitate to contact the Ethics Officer or myself.

Yours sincerely,

Signature Redacted

A/Prof Tania Signal
Chair, Human Research Ethics Committee

Cc: A/Prof Bobby Harreveld (co-supervisor) Project file

APPROVED

Appendix C

(a) Approval to recruit from Associate Dean Academic Learning Services Unit

(b) Recruitment Letter

(c) Information Sheet

(d) Informed Consent

(a) Approval to recruit from Associate Dean Academic Learning Services Unit

Karen Seary

Fri 3/07/2015 12:58 PM
To:
Gemma Mann;

Hi Gemma
It is with pleasure that I offer my approval to allow you to conduct your Masters research with your STEPS students. I am also supportive of Joy Spence providing approximately three hours of working time across the next eighteen months to assist you with the recruitment of students. I understand Joy will need to access STEPS students' email addresses and then use them to send the invitation email.
All the very best with this very valuable research, Gemma. You will do us proud.
Cheers
Karen

Karen Seary
Associate Dean (Academic Learning Services Unit), Industry, Vocational Training and Access Education Division
CQUniversity Bundaberg, Building 1, University Drive, Bundaberg QLD 4670
P +61 7 4150 7067 (x57067) **M** +61 417309854 **E** k.seary@cqu.edu.au

(b) Recruitment letter

<<insert logo or print on letterhead>>

I would like to invite you to participate in my study into the experiences of STEPS students in learning and using maths as part of my Masters of Education study.

Why am I doing this study?

In this study I am exploring how people learn about maths and how they then use maths. Therefore I want to find out how you have experienced maths in your life. I would like to explore with you how you have previously used maths, perhaps in work or in your daily life. Also I would like to discuss how you learnt maths whether at school, in another formal setting, or in the work. I am also interested in how you are learning maths in your STEPS course.

What will I ask you to do?

My data collection involves discussing with you, your experiences of maths. Initially that involves about one hour of your time. Depending on what we talk about I may also ask for the opportunity to talk to you again to explore more about your previous responses, to discuss my model so far, and to see if you had anything else to offer, or to clarify. These interviews would be much shorter, maybe around thirty minutes. I will record the interviews so I am able to analyse the data at a later time. These recordings are confidential and will only accessibly by me and my academic supervisors. When I use the information you and all the other participants will be anonymous. To make sure that interview data is anonymous I will ask you to select a pseudonym that you would like to be known as.

Will this help you?

This process might benefit you to explore your own experiences in learning and using maths, and it will give you an opportunity to reflect on these.

How will you help future students?

The information in your interview will be used to help us to understand how students learn about maths, what is useful and what doesn't work, plus the kinds of knowledge that our students bring to the Steps courses. This will help me in my teaching of future STEPS students by creating a model about learning maths. You will be contributing to the improvement of STEPS courses and this will help students in future STEPS courses.

Will anyone know you are doing this?

You and all participants will be anonymous. Your name will not be used in any way in publications. All information will remain confidential. Participation or non-participation in this study will not influence your academic standing or any other engagements with CQUniversity. You are also free to withdraw from the study at any stage without penalty or needing to give me a reason.

Could this cause you any problems?

There may be times you might feel uncomfortable with what you are talking about, or that the interview might inconvenience you for your time. I am happy to work with you to schedule suitable times and will arrange the interviews to be done in the library. I will be doing my utmost to also ensure that I will not be directly teaching you, or having any say over your grades as that would not be in either of our best interests. If you feel uncomfortable or have any concerns, you will have the contact details of people who can help.

What if you want to stop participating?

At any time, if you do not feel like continuing with the study, you can withdraw including during an interview. Once I transcribe your interview, however, I will be using the data for publications and so you will not be able to withdraw any past interview information once that has happened.

What will happen with the results?

I will be publishing work in the form of a thesis, conference papers, journal articles, book publications, and internal reports. All of these will be anonymous and you will not be able to be identified from the work. You will be able to ask me for any feedback or for the results of this study from my contact details below.

Who is doing this study?

My name is Dr Gemma Mann and I am a student in the Masters of Education. I will be doing the majority of the project including your interviews.

Please contact me by email (preferred) g.mann@cqu.edu.au or phone 07 4930 9294.

As a student I have two supervisors. My Principal supervisor is Dr Teresa Moore who can be emailed on t.moore@cqu.edu.au and my Associate supervisor is Professor Bobby Harreveld who can be emailed on b.harreveld@cqu.edu.au

Concerns / Complaints

Please contact CQUniversity's Office of Research (Tel: 07 4923 2603; E-mail: ethics@cqu.edu.au; Mailing address: Building 32, CQUniversity, Rockhampton QLD 4702) should there be any concerns about the nature and/or conduct of this research project.

This project has been approved by the CQUniversity Human Research Ethics Committee, approval number (*this will be the number shown on your approval letter*).

(c) Information Sheet

<<insert logo or print on letterhead>>

A study into the experiences of STEPS students in learning and using maths

INFORMATION SHEET

Project Overview

What I would like to do in this study is to find out how you have experienced maths in your life. I would like to explore with you how you have previously used maths, perhaps in work or in your daily life. Also I would like to discuss how you learnt maths whether that be at school, in another formal setting, in the work. Along with this is how you are finding learning maths in STEPS. The information in your interview will be used to help us teach future STEPS students by creating a model about learning maths. This will form the basis of my Masters of Education study.

Participation Procedure

I would like to spend approximately an hour with you in an informal interview setting for the first stage. I will ask questions around certain areas related to your experiences in both learning and using maths. I will record the interview, but this will be kept confidential and only accessibly by myself and my two Masters degree supervisors. When I use the information in any publications, presentations, reports, or in my thesis, you and all the other participants will be kept anonymous. Later in the study, I would most probably like to talk to you again for about half an hour to explore more about your previous responses and discuss how your experiences contribute to my analysis at that point. Again, this interview will be in an informal setting, and will be recorded. I might like to talk to you briefly a third time as my model develops to see if you had anything else to offer, or to clarify.

Benefits and Risks

This might benefit you to explore your own experiences in learning and using maths, and it will give you an opportunity to reflect on these. It will also allow you to contribute to the improvement of STEPS courses and help students in future STEPS courses.

There may be times you might feel uncomfortable with what you are talking about, or that the interview might inconvenience you for your time. I am happy to work with you to schedule suitable times and will arrange the interviews to be done in the library. I will be doing my utmost to also ensure that I will not be directly teaching you, or having any say over your grades as that would not be in either of our best interests. If you feel uncomfortable or have any concerns, please make contact with one of the people listed below.

Confidentiality / Anonymity

I will be keeping you and all participants anonymous, and as such I will invite you to choose a made up name, or pseudonym, so that I can refer to you without using your real name. So ensure that anything you say remains confidential, the recordings and what I write out from them will be kept on a computer system with university password protection. Your name will not be associated in any way with anything I write for a general audience or that will be published. The university says that I need to keep this information for a minimum of five years, or as long as I will need it, and it will remain secure for the entire time.

Outcome / Publication of Results (if applicable)

I will be publishing work in the form of a thesis, conference papers, journal articles, book publications, and internal reports. All of these will be anonymous and you will not be able to be identified from the work.

Consent

To ensure that you understand what is going to happen, I will ask you to sign a Consent Form. This is quite a formal form, and I will be discussing what it all means with you prior to you signing it.

Right to Withdraw

At any time, if you do not feel like continuing with the study, you can withdraw. This will not result in any questions or repercussions and you will not need to participation any further. This includes if you wish to withdraw during an interview. Once I transcribe your interview, I will be using the data for publications and so you will not be able to withdraw any past interview information once that has happened. Again, if you have any concerns, please contact one of the people below.

Feedback

You will be able to ask me for any feedback or for the results of this study from my contact details below.

Questions/ Further Information

Researchers:

My name is Dr Gemma Mann and I am a student in the Masters of Education. I will be doing the majority of the project including your interviews.

Please contact me by email (preferred) g.mann@cqu.edu.au or phone 07 4930 9294.

As a student I have two supervisors. My Principal supervisor is Dr Teresa Moore who can be emailed on t.moore@cqu.edu.au and my Associate supervisor is Professor Bobby Harreveld who can be emailed on b.harreveld@cqu.edu.au

Concerns / Complaints

Please contact CQUniversity's Office of Research (Tel: 07 4923 2603; E-mail: ethics@cqu.edu.au; Mailing address: Building 32, CQUniversity, Rockhampton QLD 4702) should there be any concerns about the nature and/or conduct of this research project.

This project has been approved by the CQUniversity Human Research Ethics Committee, approval number (*this will be the number shown on your approval letter*).

(d) Informed consent

<<insert logo or print on letterhead>>

Developing quantitative literacy: Students' perceptions of the influence of enabling mathematics courses on the 'real-world' numeracy applications of students

CONSENT FORM

I consent to participation in this research project and agree that:

1. An Information Sheet has been provided to me that I have read and understood;
2. I have had any questions I had about the project answered to my satisfaction by the Information Sheet and any further explanation provided to me;
3. I understand that my participation or non-participation in the research project will not affect my academic standing or my employment.
4. I understand that I have the right to withdraw from the project at any time without penalty;
5. I understand the research findings will be included in the researcher's publication(s) on the project and this may include conferences, reports, articles written for journals, the researcher's thesis and other methods of dissemination stated in the Information Sheet;
6. I understand that to preserve anonymity and maintain confidentiality of participants that fictitious names may be used any publication(s);
7. I am aware that a Plain English statement of results will be available from the contacts provided in the Information Sheet;
8. I agree that I am providing informed consent to participate in this project.

Signature: ____ Date: ______________

Name (please print): ____

Where relevant to the research project, please check the box below:

Postal Address: ____

E-mail Address: ____

I wish to have a Plain English statement of results posted to me at the address I provide below.

YES __ NO __

CQUHREC clearance number: ________________

Appendix D

(a) Interview guide – initial

(b) Interview guide – subsequent

(a) Interview guide – initial

The introduction would come from the information sheet.

Initial questions:

Thinking about in your life at the moment:

Can you give me some examples of how you use maths?

- Guiding Topics:
  - Home: How do you use maths around the home?
    - Budget, money, banking, mortgage, calculating expenses;
    - renovations, building, painting, garden, making things;
    - sewing, patterns, stitching;
    - cooking, weights, measures, times;
    - kids, homework, projects;
    - reading the newspaper, understanding things on TV;
  - Work: How do you use maths at work? (will depend on what they do for work)
    - Costs, budgets, buying;
    - Pay, salary;
    - Invoices, payments;
    - Balancing books;
    - Measurements, scales, construction;
    - Drawings, maps, diagrams;
    - Weights, distances, measuring;

Early learning in maths questions:

How do you think your learnt how to do this maths?

Who was involved in you learning this maths?

What are your earliest memories of doing maths?

- Prompts: maths games, counting games, adding games, patterns.

Thinking about primary school:

Can you please tell me about your experiences with maths in primary school?

What do you remember about doing maths in primary school?

Can you remember how the teachers taught you maths?

Can you recall your feelings about maths at this stage?

Thinking about high school:

Can you please tell me about your experiences with maths in high school?

Did your views of maths or feelings towards maths change at this time?

Can you recall how you were taught maths?

Prompting questions

Please tell me more.

Can you tell me more specifically about how you do that?

How would you go about working that out?

Did you ever wish you knew more about that?

STEPS questions:

Can you please tell me about your experiences in your maths course at the moment?

What topics do you like best? Why do you think that might be?

What topics do you do well in or find easier? Why do you think that is the case?

Can you relate these topics to anything you have learnt before such as in school?

Can you relate any of the maths you are learning now to maths you use at home?

Is there anything particular that you can describe that you do to help you learn maths?

Is there anything particular that you can describe that the lecturer does that helps you learn the maths?

Can you please tell me about what degree you want to go into once you have finished STEPS?

How do you think you might use maths in that degree?

How do you think what you are learning in STEPS now will help? Are there any tips and tricks that will help you do you think?

QL questions:

So we have been talking about maths. Now, I want to use the words quantitative literacy, what do you reckon that means?

Good, now here's a definition Australian Council for Adult Literacy (2001, p. 8) -

> the knowledge and skills required to apply arithmetic operations, either alone or sequentially, to numbers embedded in printed materials, such as balancing a

chequebook, figuring out a tip, completing an order form or determining the amount of interest on a loan from an advertisement.

Does that mean anything for you?

Can you see any links between QL and some of your experiences that we have talked about? What links do you see? (prompts here if need be just to get the participant thinking in the right direction).

Do you see any differences between QL and maths?

Okay so we now have this understanding of what QL might be, how do you reckon you might “get” quantitative literacy/ or become quantitatively literate?

How could STEPS maths courses help with that?

What could someone like me do to help you get quantitatively literate?

(b) Interview guide – subsequent

Most of this interview will be talking about previous answers:

I'm just wondering if you have thought any more about what we said last time? (prompt with last interview excerpts).

Can you tell me any more about your experiences of quantitative literacy that we discussed?

Additional areas for discussion:

When you are in the maths class, have you ever found there are some questions that you can relate to and some that you find a bit daunting? Tell me about that experience. Okay so what could we do to improve this?

For example if the question involved brick laying/sewing would that change your opinion of the question and hence your motivation to solve the question?

Do you think it is easier to learn maths now because you can relate it to more things in real life now than you could at school?

When you were learning maths at school, did you think you learnt maths in classes that were not specifically your maths class?

Business Principles, Hospitality, Manual Arts, Technology, Marine Studies?

Do you think this helped because it was applied? Do you think that the maths you learnt in those subjects was different from the maths in the maths class? How and why?