An Enactive Inquiry into Mathematics Confidence: A Case-Study of Nine Pre-Service Primary School Teachers

A minor dissertation submitted in partial fulfilment of
the requirements for the award of the
Degree of Master of Education (Teaching)

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2007

Declaration

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

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Abstract

Many learners and teachers of mathematics experience a lack of mathematics confidence. Research has posited that beliefs teachers have regarding mathematics, including their level of mathematical confidence, impact greatly on their practice of teaching, and hence on the confidence of their students. This dissertation reports on a study undertaken at the University of Cape Town with a group of nine pre-service primary school teachers who all experienced a lack of mathematics confidence. The study explored how the participants understand the notion of mathematics confidence and the reasons why they lack confidence. Results of the study indicate that the participants' understanding of mathematics confidence is having the ability to do the mathematics, as well as understanding the processes involved. In order to understand why they lack confidence, their previous experiences in the mathematics classroom were also explored. The participants' prior experiences as students in the mathematics classroom have led to a lack in the understanding of mathematics, resulting in the individuals having little or no mathematics confidence. Additionally, mathematics anxiety was an important aspect of their prior experiences. The theory of Enactivism has been used to explain their understanding of mathematics confidence as well as their prior experiences. Furthermore, various coping strategies used during their teaching practicum will also be discussed.

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Chapter 1

Beginnings

Haskell, Linds and Ippolito (2002) explore the origins of the word "research" by examining the root of the French word "rechercher". They state that it is derived from "recerchier", which means to "travel while searching". Thus, research could be seen as a journey, with no fixed beginning or ending, because as researchers we are always in the middle of something. Thus, my research did not begin when I thought of a topic I might explore, but long before that. Since teaching and learning and researching are intertwined so deeply with experience, it is necessary for me to talk a little about how I got to this point.

While doing my Bachelors degree in mathematics, I tutored mathematics to high school students during my free time. These students generally did poorly in mathematics and I had the responsibility to help them improve their understanding and obtain better results. Many of them also lacked confidence in their ability to be successful in mathematics. Other teaching I have done includes an intervention program at the University of Cape Town for those performing poorly in mathematics and quantitative literacy. Again, many of these students seemed to experience a lack of confidence in their mathematical skills. In most of the mathematics teaching I have engaged in, I have always seemed to work with those who lack mathematics confidence. For this reason, I have for a long time been interested in the area of mathematics confidence.

As a mathematics educator, I have often heard students talking of their lack of confidence as they do mathematics. Students would talk about how in a test they would "blank out" and forget everything they had previously learnt

and practised. They would tell me how discouraged they felt as a result. For some students, it seemed that no matter how well I felt I explained the mathematics, they would lack confidence in their ability to do the mathematics. I grew more and more curious as to why certain students would lack confidence in doing mathematics.

I knew that many learners, in both primary and secondary school, recognising that success in Grade 12 mathematics examinations is a prerequisite for tertiary study in a wide variety of disciplines, come to regard the subject as an important domain for accomplishment. As I began reading about mathematics confidence, I learnt that learning and success in mathematics as a discipline seems to be strongly connected to students' beliefs about the subject and also to their beliefs about their own ability (Hannula, Maijala & Pehkonen, 2004).

As I began my masters in education, I also attended a class which was part of the PGCE (Postgraduate Certificate in Education), the methods module, aimed at student teachers hoping to teach high school mathematics. As I observed this class and interacted with these teachers, I began to see for myself how many of these future mathematics teachers lacked confidence in their ability to teach and do mathematics. I knew that somehow their lack of mathematics confidence would likely have some impact on their students. I began to read more about teachers and mathematics confidence and it became evident that what teachers believe about mathematics has a great impact on the way they teach (Uusimaki & Nason, 2004a) and hence, on their learners. Thus, the self-confidence of teachers in their learning and teaching of mathematics is likely to impact, whether negatively or positively, on the self-confidence of their learners. Discovering why teachers lack mathematics confidence is a first step towards helping them to overcome their negative beliefs and lack of confidence.

In this light, this thesis aims at examining some of the reasons why a group of pre-service teachers lack self-confidence in learning and teaching mathematics. First, though, how this group of pre-service teachers understands the notion of mathematics confidence is explored. Reasons for the experience of mathematics anxiety, a concept tightly woven with a lack of confidence, is also examined. Several of these pre-service teachers spoke of some of the strategies they use to conquer their lack of confidence. These are also briefly investigated.

Chapter 2

Literature Review

It is now recognised that activity in mathematics is not a purely cognitive behaviour. However, traditionally, research on the performance of students has focused more on cognition, less on affect, and still less on the interactions between them. Goldin (2002, cited in Furinghetti & Morselli, 2004, p.369) stated, "When individuals are doing mathematics, the affective system is not merely auxiliary to cognition, it is central".

In mathematics education research, affect has been an area of interest because of the belief that it is suggestive of learning outcomes and future success. Affect in the domain of mathematics education includes: emotions, attitudes, beliefs, values, ethics and morals (Hannula, 2004; Schlöglmann, 2002). Where emotions are the most intense and the least stable, beliefs are the least intense but the most stable. Attitudes fall somewhere in between. Emotions are also the least cognitive, while beliefs are the most cognitive. Furthermore, emotions are perceived to arise as an affective response to a particular context. There are a number of affective variables which have been used in research, such as mathematics anxiety, confidence, perceived usefulness of mathematics, perceived difficulty of mathematics, and finding mathematics interesting and/or enjoyable. However, both mathematics anxiety and confidence are used most frequently. Evans (2000) maintains that this is because they are believed to be both powerful and oppositional influences in learning and performance. Furinghetti and Morselli (2004) proposed that beliefs are a greater factor in students' performances than emotions and attitudes.

2.1 Beliefs

The term "belief" does not have a single definition, although the definitions used are often closely related. Schoenfeld's definition of mathematical beliefs is used widely: "an individual's understandings and feelings that shape the ways the individual conceptualises and engages in mathematical behaviour" (Schoenfeld, 1992 cited in Hannula et al., 2004, p. 17). This definition implies that beliefs impact on the way in which an individual engages with mathematics. Hence, a belief that one cannot do mathematics is likely to have a negative influence as one engages with mathematics. In accordance with Schoenfeld's definition, much research has shown that the beliefs that students have regarding mathematics and themselves as learners are central in their learning and success in mathematics (Hannula et al., 2004; Nurmi, Hannula, Maijala & Pehkonen, 2003).

Furinghetti and Pehkonen (2000 cited in Schlöglmann, 2002, p. 186) describe the role of beliefs in the following ways: "(a) beliefs form a background system regulating our perception, thinking and actions; and therefore, (b) beliefs act as indicators for teaching and learning. Moreover, (c) beliefs can be seen as an inertial force that may work change, and as a consequence, (d) beliefs have a forecasting character." Thus a person's beliefs about themselves and mathematics will lead them to interpret a teacher's response or a mark from a test in a particular way and even have an impact on the individual's identity.

Mathematics beliefs are divided into four areas: (1) beliefs about mathematics; (2) beliefs about oneself as a learner of mathematics; (3) beliefs about teaching mathematics; (4) beliefs about learning mathematics (Hannula et al., 2004; Nurmi et al., 2003). Pehkonen, Hannula, Kaasila & Laine (2004), on the other hand, in a similar way, state that views of mathematics can be distinguished by 2 components: the view of oneself as a learner and teacher of mathematics, and the view of mathematics and its

teaching and learning. Thus, mathematics confidence is an example of a belief about oneself as a learner (or teacher) in mathematics.

2.2 Definitions of mathematics confidence

It is evident that just as belief lacks a single definition, there is not just one definition of mathematics confidence. Furthermore, while some studies ascribe different definitions to mathematics confidence, many studies do not define what mathematics confidence is. For example, Hannula, Maijala, Pehkonen and Soro (2002) proposed that a student's confidence can be gauged using 3 different measures: success expectation; solution confidence; and self-confidence. Stankov and Crawford (1997), who investigated individual differences in judgements which participants made regarding their confidence on the accuracy of their answers to psychological test items, define self-confidence as the judgment of the degree of accuracy of one's own performance in the course of working through the items of a cognitive test, that is, the perception of one's own work. Similarly, Furinghetti and Morselli (2004) define confidence as a belief about one's competence in mathematics.

Burton's (2004) study aimed to explore how the concept of confidence was understood by A-level students who had chosen to study mathematics. She also examined how teachers define how a confident learner can be recognised as a result of his or her behaviour. She states that every learner makes his or her own meaning; however, this meaning is mediated through the cultural climate in the classroom. Burton (2004, p. 361) states: "What meaning learners make of their experiences is fundamental to their learning as well as their engagement in mathematics." Burton found that teachers have particular criteria for characterising certain learning behaviours as confident: confidence is about willingness to explore, to ask questions, as well as to challenge the teachers. Thus, it is evident that teachers defined confidence in behavioural terms. However, the teachers in Burton's study

stated that always being willing to provide an answer is at times seen as overconfidence, which is not the same as confidence. In contrast, the students described confidence in terms of how they feel and how the classroom should function. For the students, confidence related to understanding and knowledge, and having the ability to do the problem set before them. It was also a factor of working collaboratively with other students. Furthermore, the students stated that confidence and success feed off each other and are interrelated. Although both students and teachers asserted that confidence is important, confidence was spoken of in different ways: for teachers, confidence was recognised through behaviour and reflected various stereotypes in society (such as the independent male and the dependent female); for students, confidence was a product of how they felt where discussion, how they worked, and challenging activities were factors of the confidence levels they experienced.

2.3 Mathematics beliefs and confidence of students

Many studies have shown that beliefs about mathematics and about oneself as a mathematics learner have a central role in learning and success in mathematics. Nevertheless, it has been difficult to show any kind of causal relationship between beliefs, such as self-confidence, and success (Hannula et al., 2004).

Much of the research of mathematics confidence has examined the relationship between confidence and participation, and confidence and performance. In addition, a great many studies have attempted to determine gender differences in self-confidence and success in mathematics. More specifically, gender differences in mathematics confidence in favour of males are fairly well-recorded (for example, Cretchley, 2004; Hannula et al., 2004; Hannula et al., 2002; Jones & Smart, 1995; Nurmi et al., 2003; Sanchez, Ursini & Orendain, 2004; Walter, 1997). However, there are less clear differences between the genders in mathematics achievement, and in

recent years, these gender differences in mathematics achievement have decreased (Hannula et al., 2004).

Grootenboer (2003) declares that the general consensus seems to be that the beliefs many students develop about themselves and mathematics were negative and debilitating, leaving many anxious about mathematics and actively trying to avoid it. He states that it has been suggested that beliefs and feelings that individuals develop during their schooling limits their ability to use or understand mathematics throughout their lives.

Hannula et al. (2002) performed a two-year longitudinal study examining gender differences in success and confidence among grade 5 to 6 and grade 7 to 8 students. They found that the three measures of mathematics confidence, namely success expectation, solution confidence, and self-confidence, correlated, and that in the fifth grade, success and confidence favoured boys, but in the seventh grade, no gender differences were found.

Nurmi et al. (2003) state that there is a circular relationship between mathematical beliefs and mathematics learning. That is, while the way in which mathematics is taught in the classroom influences the pupil's beliefs about mathematics, beliefs can influence how pupils can receive mathematics teaching. The beliefs about mathematics which a pupil possesses act as a filter influencing all his or her thoughts and actions regarding mathematics.

While it has repeatedly been reported that female learners have weaker mathematics self-confidence than male learners and that girls tend to show more mathematics anxiety than boys, Nurmi et al. (2003) also explained gender and grade differences. In particular, they explored three affective variables: success orientation, defence orientation, and self-confidence, and found that mathematics self-confidence explained 26% of the variance in

mathematics achievement. Success orientation and defence orientation explained 12% and 10% of the variance respectively. They found a high statistically significant difference between the various grades in self-confidence and success orientation, where fifth graders have higher means than seventh graders in both constructs. In the seventh grade, male learners had more confidence than female learners, but there were no differences in the other two variables. In the fifth grade, boys also had more self-confidence than girls. Among the three variables, the largest gender differences were found in self-confidence. The strongest correlation with success in mathematics was self-confidence. They found that learners who were less successful had weaker self-confidence.

Mathematics confidence was found to be higher in smaller classes in a study done by Cretchley (2004). She found that the eight females in the class showed a higher self-confidence than the 51 males in the class. However, in the larger class (88 females and 71 males), the gender effects were reversed.

Sánchez, Ursini and Orendain (2004) proposed that with the increasing presence of technology in the mathematics classroom, there is a need to monitor the attitudes and self-confidence of the learners. In their study, they found significant differences in self-confidence among male and female learners. More boys than girls were found to be unsure about their abilities to work in mathematics, but more girls considered that they were not good in mathematics. They found that more girls obtained higher marks, as well as a positive correlation between high marks and self-confidence for girls.

The focus of the study by Hannula et al. (2004) was to reveal the development of learners' understanding and self-confidence from grade 5 to grade 8. They looked for the most important predictors of results, and saw a decline in confidence from grade 5 to 6 and from grade 7 to 8, while there was a slight increase in confidence from grade 6 to 7. They found that self-

confidence is an important predictor for future development and that a pupil's self-confidence predicts the development of their self-confidence in the future as well as in achievement.

Furinghetti and Morselli (2004) propose that when a learner engages in mathematical activity, the student follows two intersecting pathways: the cognitive (including reading the text, understanding it, designing and developing a plan) and the affective (including self-confidence and anxiety). In their study, they focused on the role of beliefs, which they state are the dominant factor in mathematics performance. In their case-study, they found that the student's first reaction is emotional and was an expression of panic. They maintained that this panic was as a result of the learner's low self-confidence because she already judged the mathematics as beyond her ability. They found that the affective factor (low self-confidence) in fact influenced the way she read the text. They argue that if one examines the mathematical activity of a student through only one lens (affective or cognitive), important details are left out.

Schuck and Grootenboer (2004) in their review of affective research state that much of the affective research in Australasia has been done on teachers and student teachers, while little research has been done in school classrooms. Additionally, they found that many studies have examined the impact of teacher education programs on pre-service teachers' beliefs and emotions.

2.4 Pre-service teachers: negative beliefs and mathematics confidence

Pehkonen et al. (2004) investigated the mathematics confidence of pre-service primary school teachers as learners of mathematics at three different universities in Finland. The study found that the views that students had of themselves as learners of mathematics differed from each other in different

universities. The results showed that about one fifth of the student teachers had weak mathematics confidence.

Uusimaki and Nason (2004a) declare that the beliefs which a teacher has about mathematics can have a powerful effect on their practice of teaching. Suggestions have been made that those teachers with negative beliefs about mathematics create a learned helplessness response from their students. This learned helplessness occurs when an individual has experienced repeated failures in the past and believes that they will continue to fail no matter what effort they put in (Cohen & Green, 2002). In contrast, teachers who possess positive beliefs about mathematics help their learners to have successful experiences with mathematics. Therefore, the experiences which learners have in the mathematics classroom may be related to the teacher's beliefs regarding mathematics. These experiences then have an impact on the learner's achievement as well as their beliefs and attitudes towards mathematics (Uusimaki & Nason, 2004a). However, very little research has examined this relationship between pre-service teacher education students' experiences with formal mathematics instruction and their future practice; that is, how their past experiences at school influence their confidence in teaching mathematics (Brady & Bowd, 2005).

In a longitudinal study performed by Graven (2004) investigating teacher learning, the phenomenon of confidence emerged as the teachers described and explained their learning of mathematics. She attempted to explain confidence within a social practice framework. As a result, she proposes a concept of confidence in relation to teacher learning which is viewed as "learning as mastery", and confidence is both a product and a process of learning. Mastery involves becoming confident in relation to one's mathematical knowledge and experiences as a teacher and one's participation in professional activities, one's membership in a range of professionally-related communities and one's identity as a professional

mathematics teacher. Graven argues that the concept of confidence is central to gaining an understanding of mathematics teacher learning. It was argued that for ongoing learning to take place in the profession of teaching mathematics, teachers must be able to assert their confidence as mathematics teachers, as well as be confident to admit to what they do not know and still need to learn.

A vital element of teacher education programs is the school-based practicum where the pre-service teachers have an opportunity to develop their skills and knowledge in the classroom. Grootenboer (2004) suggests that these experiences are powerful in shaping prospective teachers' views of teaching and learning. Thus, it is possible that positive changes can be made in their affective responses towards mathematics. Grootenboer notes that there have been many studies which have examined pre-service teachers' affective responses towards mathematics and these studies have often shown that teachers are fearful and resentful towards mathematics and that their beliefs towards mathematics are often debilitative and narrow. Grootenboer suggested that often the practicum experiences are similar to their previous school experiences and as a result, reinforce their negative beliefs. Hence, these experiences can then negate the experiences of the education course because it is viewed as idealistic.

In his study, Grootenboer found that those pre-service teachers who went to classes of learners between year 1 and year 5, had positive mathematical experiences and continued to hold positive views of mathematics. However, half the participants who taught learners in the more senior primary classes had less positive experiences. Their experiences were similar to their previous experiences in school and reinforced their negative beliefs about mathematics which they had prior to joining the teacher education program. It was found that those pre-service teachers who had negative experiences often worked in classes which were streamed and taught in a more

traditional, routine way. This study led Grootenboer to question the strength of the beliefs and attitudes formed at university due to half of the participants reverting back to their previously-held negative beliefs.

In another study, Grootenboer (2002) performed a case-study of two pre-service teachers, whom he calls Brad and Marina. Grootenboer states that pre-service primary school teachers come to their teacher education programs with beliefs, feelings and attitudes about mathematics and mathematics education which have been formed prior to their tertiary education and which can powerfully impact on their development as a teacher of mathematics and their future classroom work. Grootenboer states that in general, mathematics is perceived in a negative way and they may feel anything from lacking enthusiasm to feeling completely terrified. In general, students could remember very little of the mathematics from primary school, other than having quizzes and tests on their "times-tables". Brad and Marina were able to remember more details of their high school mathematics classes, and in particular were able to describe their teachers in great detail. Neither could remember a teacher whom they liked or respected and they felt that their mathematics teachers were sarcastic, disinterested and incompetent. After school, both participants thought mathematics was important, but neither knew why it was important because it seemed to them to be irrelevant to life and difficult to understand. Brad and Marina considered the experiences with school mathematics as negative, and as a result they had developed feelings of anxiety and inadequacy. But, when describing their experiences, they recalled teaching characterised by a transmission-model. Grootenboer then described their experiences during the teaching practicum. Brad's experiences confirmed his views and feelings prior to entering the teacher education program. Grootenboer suggests that this may be a result of his practicum experiences matching his prior school experiences. Marina, on the other hand, had a positive experience during her practicum as her experiences supported her new perspective of mathematics.

2.5 Mathematics anxiety

Fear and anxiety are signifiers that fall under the general heading of affect. Anxiety has been described as "an unpleasant emotional state of fear. It is directed toward an unwanted possible future outcome, and is typically out of all proportion to the threat" (Hannula, 2001). Mathematics anxiety then is anxiety within mathematical situations and is related to general anxiety and the sub-constructs of anxiety, including test-anxiety. Mathematics anxiety can be defined as "a feeling of intense frustration or helplessness about one's ability to do mathematics" and it has been described as a learned helplessness response when in situations involving mathematics (Uusimaki & Nason, 2004a, p. 370). Richardson and Suinn (1972, p. 551 cited in Sherman & Wither, 2003, p. 138) defined mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations." More recently, researchers have identified various components of mathematics anxiety, including: test anxiety, problem-solving anxiety, abstraction anxiety, and fear of the public aspects of doing mathematics in the classroom (Cohen & Green, 2002).

The definitions of mathematics anxiety imply the assumption that mathematics anxiety is the cause of some impairment of functioning in mathematics. A moderate but significant negative correlation has been found between functioning in mathematics and mathematics anxiety by a number of researchers (Sherman & Wither, 2003). Mathematics anxiety has also been shown to relate inversely to mathematics performance and is directly correlated with avoidance of the subject. In addition, it was shown that females are more likely to exhibit mathematics anxiety than males. Furthermore, students who have been instructed in mathematics in a traditional way often report more anxiety than those who are taught in a manner which emphasised a problem-solving approach and discussion relating to the students' own informal strategies (Cohen & Green, 2002).

Uusimaki and Nason (2004a) declare that negative beliefs concerning mathematics are often manifest in mathematics anxiety. However, it needs to be recognised that mathematics anxiety is a highly complex construct which has "multiple causes and multiple effects interacting in a tangle that defies simple diagnosis and simplistic remedies" (Martinez & Martinez, 1996 cited in Uusimaki & Nason, 2004a, p. 369).

Sherman and Wither (2003) attempted to establish the causal relationship between mathematics anxiety and mathematics achievement. However, they found insufficient evidence for such a relationship. They described how other authors have endeavoured to find a third factor which would be caused by mathematics anxiety and which in turn causes poor performance in mathematics. However, they stated that these researchers have overlooked the fact that perhaps a third factor causes both mathematics anxiety and performance.

2.6 Pre-service teachers: mathematics anxiety

It has been established that pre-service elementary teachers often display mathematics anxiety. Moreover, it has been claimed that these teachers pass on their anxiety to their students (Cohen & Green, 2002). Cohen and Green (2002) found that those teachers who experienced mathematics anxiety generally had negative experiences in their own schooling during high school. These teachers also stated that they were taught in a traditional, textbook-based style where computation and drill were emphasised. They worried about their insufficient mathematics knowledge which they felt would impair their teaching. They also worried about being asked difficult questions in class which they would be unable to answer. Thus, the type of anxiety which was most prevalent was problem-solving anxiety (where they would be asked to solve an unfamiliar problem in front of the class). Their

coping strategy was to over-prepare for their lessons by doing all the exercises in the textbook ahead of time.

Breen (2001) discusses how traditional techniques for teaching content and method to pre-service teachers fail to address the issue of fear of mathematics. He describes some of the ways he has dealt with this problem. Using an Enactivist approach, the students are required to participate with both body and mind in the course because they bring feelings to the class as well as their hopes and fears. They begin by writing up their hopes and fears as well as expectations of the lecturer on the board. Thus, before they begin talking about mathematics, they have engaged in a conversation relating to their thoughts and feelings. Then Breen leaves the room and re-enters wearing an academic gown and begins a role-play of a fierce and stern teacher whom he calls Mr Smith. Mr Smith makes most of the students feel bad about themselves and their ability to do mathematics. He then leaves the room and Breen re-enters to discuss how they felt. Breen states that many students can identify a "Mr Smith" from their own mathematics experience and some tell stories about how they were physically abused or emotionally damaged by the teacher. This role-play evoked strong memories of past mathematics teachers and the topic of fear of mathematics could be owned by them at the beginning of the course. They could now begin to talk about the source of their fear and be aware that their fear often had more to do with the personality and style of their teacher than with the content of mathematics.

Breen (2003) describes how, in his teaching of pre-service primary school teachers every year, there would be at least one student who had severe problems with mathematics. He notes that upon examining the classroom dynamics, it became clear to him that many student teachers would pass their fear of mathematics on to their future pupils. He also declares that this problem of fear of mathematics is not restricted to those few students with

poor mathematics backgrounds, but that even successful graduates who had good mathematics backgrounds experienced distress with mathematics sometimes. He then describes the course he designed to help meet their needs. The theoretical principles which guided him are based on the theory of Enactivism.

Grootenboer (2003) examined the affective changes regarding mathematics in pre-service primary teachers before and after the teacher education course. In general, he found that the feelings were negative and that their emotions were based on their experiences of mathematics at high school. However, after the teacher education course, the students' feelings about mathematics appeared to be more positive. He stated that the predominant feeling expressed now by the participants was confidence, which related to a broader conception of mathematics and was rooted in the experiences they had had in the course as well as their perceived success. There were a small group of six students, though, who were mostly older, who felt particularly anxious about a numeracy test (not associated with the course) which they had to do. So, while these participants expressed some negativity towards mathematics, their feelings were not related to the mathematics education course. Grootenboer noted four significant themes which emerged relating to their affective changes: the class atmosphere; the course lecturers; features of the course; and key events of the course.

2.7 The origins of mathematics confidence and anxiety

Nurmi et al. (2003) maintain that beliefs originate in social interaction. Consequently, an individual's beliefs about mathematics (including their beliefs regarding themselves as mathematics learners) are developed from personal experiences in and outside of school, including mathematics teachers, other teachers, school friends, parents, learning materials, previous achievement in mathematics, the media, job opportunities, and so on.

The origins of negative beliefs about mathematics and mathematics anxiety have been classified by Uusimaki and Nason (2004a) into three categories: environmental, intellectual, and personality factors. Personality factors include a low self-esteem, a view that mathematics is a male domain, as well as shyness which leads to an unwillingness to ask questions. Intellectual factors consist of being taught with mismatched learning styles, student attitudes and a lack of persistence, self-doubt, a lack of confidence in one's ability, as well as a perception that mathematics is not useful. Lastly, environmental factors entail negative experiences in the classroom, parental pressure, insensitive teachers, mathematics being taught in a traditional manner and non-participatory classrooms. Thus, the origins of mathematics anxiety and negative beliefs about mathematics are varied and wide-ranging. However, very recent research has found that mathematics anxiety emerges when the learner is either being evaluated or is perceived to be under evaluation.

In the occurrence of anxiety and a lack of confidence among pre-service teachers, these often originate in prior school experiences, the influences of teachers, as well as their teacher preparation program. Frequently negative beliefs can be traced back to the frustration as well as failure in learning mathematics as a result of unsympathetic teachers who assumed that the computational processes they were teaching were simple and self-explanatory (Uusimaki & Nason, 2004a). However, the origins of negative beliefs and anxiety in mathematics are as diverse as individuals experiencing it. For some, mathematics anxiety is related to poor teaching, or humiliation or belittlement, while others may have learnt to have mathematics anxiety from their mathematics-anxious teachers, parents, siblings or peers (Uusimaki & Nason, 2004b).

Uusimaki & Nason (2004a) argued that a teacher's prior school experiences (most often at a high school level) influenced the development of negative

beliefs and anxiety about mathematics. They performed a study in which they interviewed 18 mathematics-anxious pre-service primary school teachers. They found that 66% of the pre-service teachers perceived that their negative beliefs and anxiety stemmed from primary school. Two of the 12 participants spoke of specific content which caused their anxiety, while one claimed that her negative beliefs developed from her mother and the remaining nine participants spoke of specific primary school teachers who caused their fear of mathematics. Only 22% believed that their negative beliefs stemmed from high school, and all of these participants referred to specific teachers who contributed to their anxiety. Just 11% identified tertiary education as the place where their anxiety originated. They declared that their anxieties arose not as a result of the way that the mathematics was taught, but rather due to specific content. Forty-eight percent of the participants stated that the situation in which they felt most anxious was one where they had to communicate their mathematical knowledge, either in test situations or in verbal explanations. Thus, they felt anxious when they perceived themselves to be under some sort of evaluation. One third of the participants said that their biggest fear about teaching mathematics in practicum situations was due to their insecure feelings of making mistakes or not being able to solve a problem correctly.

Hoyles (1982 cited in Breen, 1991) provided three broad explanations for mathematics anxiety: (1) the nature of mathematics; (2) past experiences in mathematics and one's self–confidence in the topic; (3) how mathematics is taught and learned. Hoyles also reported that 22% of all the negative stories in her research included statements about teacher pace and pressure. Buxton (1980 cited in Breen, 1991) suggested that time pressure and an authoritarian teaching style could induce anxiety among adults in mathematics classes. Breen then describes the strong reactions of fear and anxiety that students felt as he role-played a stern teacher, Mr Smith.

Chapter 3

Theoretical Perspective and Research Design

In deciding to examine why a group of nine pre-service teachers lack mathematics confidence, I began to wonder what I could contribute to the field of mathematics confidence. I knew that I would be interviewing pre-service teachers and obtaining data from them, but this seemed to me at the time to be no different from the other research that has already been done. I knew that I would not be adding anything new to what is already known in this area. However, while completing the coursework for my masters, I did a course with Chris Breen called 'Re-Searching Teaching'. The class emphasised the theory of Enactivism as a means for doing research in the classroom. This course disrupted my rationalist and empiricist way of seeing education and the world.

Having been a student in mathematics and now being involved in mathematics education, I became fascinated with the idea of chaos and complexity theory, and I began to think about how science has had such a profound impact on the way we see the world as well as the way in which we do research. As a result, the theory of Enactivism intrigued me. What I read resonated with me and the experiences I have had. I started reading several of Brent Davis' works and in one of his books (Davis, 1996) he applied Enactivism to the mathematics classroom and contrasted various types of teaching styles. These ideas had a profound effect upon me.

As I thought about how I would do my own research, I knew that many problems exist in the research on mathematics confidence. For instance, one

fundamental problem is that throughout the research, the definitions of both mathematics confidence and anxiety vary considerably. Furthermore, the studies focus on varying groups of people, such as in-service teachers, pre-service teachers, university and school students, male and female learners and so on. These factors make it difficult to compare studies. Also, the relationship between learning and confidence appears to be far more complex than these research findings suggest. Additionally, too few of the studies examined reasons why learners and teachers might experience anxiety and a lack of confidence. Moreover, the link between mathematics anxiety and confidence is never appropriately and conclusively explained. In addition, both cognition and the self are isolated entities within the research. Researchers also seem unable to rid themselves of the idea that knowledge has a material existence. For representationist accounts of knowledge, knowledge is thought of as something which the individual needs to acquire. For constructivists, knowledge is internal and a fundamental element of cognition is externalising knowledge. Social constructivists view knowledge as neither within nor outside the individual but rather something which exists between the individual and the social context (Davis, 1996). I believe that these ideas need to be challenged and Enactivism assists in disrupting this way of thinking.

3.1 Motivation for Enactivism

Complexity Theory makes a distinction between systems which are complicated and systems which are complex. An example of a system which is complicated is a mechanical device, where such an object is predictable and where the whole is made up of the sum of its parts. Therefore, if one becomes familiar with each of the components, it is possible to understand the whole. In addition, the behaviours of complicated systems are planned and directed. In traditional Western science, most phenomena in the universe have been assumed to be simply complicated

and that an understanding of these phenomena comes from understanding the fundamental discrete elements.

Complexity theorists have realised that not all phenomena are simply complicated, but rather are complex. Complex systems are more than the sum of their components. They are unpredictable and spontaneous. They are self-organising, dynamic and adaptive. In a complex world, it is not enough to understand discrete events. Interdependencies and interrelationships become vital. Complexity theories draw on biology when discussing social phenomena, such as learning and teaching, where traditional theories have viewed learning as a complicated or mechanical process (Davis, Sumara & Luce-Kapler, 2000; Davis, 1996).

The distinction between complex and complicated systems can be better understood by the roots of the words. The root *plic* in Latin is *fold*, while *plex* is to *weave*. When one folds, elements or facets are hidden, however when one weaves, connections are made and mutual dependencies are introduced. Thus, complicated systems and phenomena are folded or twisted together so as to be combined intricately. It becomes difficult to understand and analyse. Complex systems, on the other hand, are composed of two or more intricate parts which are composite and not simple (Lissack & Roos, 2000).

Most research studies seem to have taken a complicated approach. Mathematics learning, performance, confidence and anxiety are seen as discrete elements and are explored separately in an attempt to understand the affect of a mathematics learner or teacher. When a particular study examines the relationship between confidence and anxiety, for example, these two constructs are viewed as distinct from one another and as either causing each other, or that there is some third variable.

However, I believe that mathematics confidence and anxiety are interconnected and interrelated. These form threads of a woven whole. When the thread of confidence is tugged at, the thread of anxiety is disturbed as it links to and interacts with mathematics confidence. Hence, it is impossible to explore mathematics confidence without examining mathematics anxiety. Thus, both confidence and anxiety are threads in the cloth of teaching and learning mathematics. Without Enactivism, mathematics confidence and anxiety are not perceived to be inherently connected to each other but are viewed as being distinct and separate from each other. For this reason, the theory of Enactivism, which views mathematics anxiety and confidence through the lens of complexity theory, has been chosen as the theoretical framework for examining the reasons for a lack of confidence and the mathematics anxiety which student teachers experience.

3.2 The theory of Enactivism

Enactivism stems from the work of Maturana and Varela (1986) and Varela, Thompson and Rosch (1991), and is based on the theories of Merleau-Ponty and ecological understandings from chaos and complexity theory. The starting point of this theory is that every individual is a "complex fabric of relations", deeply and inextricably intertwined with all else (Merleau-Ponty, 1962 cited in Sumara & Davis, 1997, p. 414).

Enactivism is primarily a theory about cognition and redefines it as an ongoing process of adaptive activity. Davis (1996, p. 190) states that "Cognition involves both becoming part of an ongoing world and the shaping of a new one." Enactivism views the cognising agent as an autonomous form and/or as one coupled to other cognising agents. Thus, the cognising agent is part of a grander form. Furthermore, cognition does not occur within an agent, but rather cognition includes all active processes

(which are both internal and external to the cognising agent) that are part of the agent's ongoing adaptive actions.

But, Enactivism cannot discuss cognition without discussing identity. The self is referred to as a "structure" (Davis, 1996, p. 9). Along with all complexity discourses, Enactivism rejects the assumption that there is a core or essential self. Thus, while the term "self" has a connotation of permanence and inflexibility, one's structure is fluid, temporal and constantly undergoing change. Maturana and Varela (1986, p. 100) state that "ongoing structural change of living beings… is occurring at every moment, continuously, in many ways at the same time. It is the throbbing of all life." This notion stands in contrast to the conception that the self is a product. Rather, one's structure is product, producer and process. That is, not only is the structure constantly undergoing transformation, but this process of change is the structure itself. Thus, the structure is defined as a complex network of relationships and consequently as histories, contexts, and biology. There is a focus on the interdependence of the individual with the environment. While in the Western world, the self is viewed as being separate from the world, Enactivism views the individual to be part of (and in fact, embedded in) a series of increasingly complex systems, such as the classroom, the school, the community, culture, humanity, and the biosphere. Consequently, as participants vary, the identity varies. However, identities are held together by particular habits, language, narratives, and other knowings. Hence, the structure is formed from the combined influences of biological constitution and one's history of interaction in the world (Davis, 2004; Davis, 1996).

Cognition and knowing cannot be separated from action and interaction. Cognition and knowledge is what *weaves* us together and it is where individual and collective identities are formed. Thus, cognition does not

occur in the mind but in the possibility for shared action, which is larger than the solitary individual.

The term Enactivism points to the idea that identities and knowledge are in fact enactments and not ideal forms. Individuals are constantly enacting their knowledge and they are continuously knowing and doing as determined by their structures and situations. But, much of this knowing and doing is unformulated. Enactivism asserts that our unformulated knowledge, which is knowledge that we enact, is in the background of our conscious experience. As a result, we are generally unaware of these understandings which are not formulated. They often go unnoticed. Enactivism then states that our actions are not just manifestations of our understandings but rather they are our understandings (Sumara & Davis, 1997). Formulated and unformulated knowledge are not opposites from each other; rather, formulated knowledge arises from unformulated actions. Formulated knowledge are those thoughts, knowledge and behaviours which we are aware of and link in narratives, and formulated actions represent just a small portion of an individual's total action even though they dominate one's conscious awareness. However, most of a person's everyday living is a matter of unformulated action.

In fact, life and learning are perceived as explorations of ever-changing "landscapes of possibility" and selecting actions (often unconsciously) which fit particular situations (Davis, 2004). But, an individual's range of possible action is contingent on his or her own structure. Varela and Maturana state that, "[The] perturbations of the environment do not determine what happens to the living being; rather it is the structure of the living being that determines what change occurs in it. This interaction is not instructive, for it does not determine what its effects are going to be… [The] changes that result from the interaction between the living being and its environment are brought about by the disturbing agent but determined by

the structure of the disturbed system" (Maturana & Varela, 1986, p. 95-96). Thus, it is important to note that these environmental patterns do not cause a person to act. Rather they provide an occasion for the individual to act in accordance with his or her structure (Davis, 1996).

Thus, the most appropriate way to think of the interaction is as a choreography in which one influences but cannot determine the other's actions. In this way Enactivism is more concerned with "the collaborative construction of a subjective world" (Davis, 1996, p. 190). For this reason, Davis (1996) states that learning is occasioned as opposed to caused since all that we understand is situated in and emerges from complex webs of experience. As a result, it is not possible to establish a causal relationship between teaching and learning.

During interaction, one's structure is affected (whether visibly or invisibly) and emerges as a different person. The other involved person is also affected and thus the two people "co-emerge". The term "co-emergence" is used by Varela, Thompson and Rosch to emphasise the way in which the person and the environment are reciprocally bound together. The structure and the environment shape each other and thus co-emerge. Therefore, the structure is not separate from the world but both are entangled in the "fundamental circularity" of existence. In this way, the cognising agent is actively engaged in changing and shaping the world. Davis (1996, p. 13) asserts that "the world is not preformed, but is performed. We are constantly enacting our sense of the world – in the process, because we are part of it, altering it."

Enactivism, in opposition to rationalism, where the main premise is "I think", and in opposition to empiricism, where the major assertion is "I observe", asserts that the key principle is "I act" because acting requires the reunion of the body and the mind as well as subject and object. It is action

that has a primary role in shaping experience, perception and indeed the world (Davis, 1996).

Merleau-Ponty maintained that the body causes the mind and the world to be inseparable. The body is both of the world and oneself. In fact, the body is what enables the self to belong to the world, which both shapes the self and is shaped by the self. In this way, the body is understood as both an outer and an inner structure. Thus, it is both biological and physical as well as experiential and phenomenological. Individuals continuously move between these two structures (Davis, 1996). The notion of "embodied" implies that cognition is dependent on the types of experiences that originate from having a body with sensorimotor capabilities. But, furthermore, a person's sensorimotor capacities are embedded in and shaped by biological, social and historical contexts. In this way, knowledge and identities depend on being in a world which is not separate from one's body, language and history.

Enactivism acknowledges the role of the individual in affecting the world's form as he or she becomes part of an ongoing existing world as well as shapes a new one. It is this that Davis (1996, p. 190) declares "pushes Enactivism into the realm of the moral." For this reason, Enactivism provides a rich framework for comprehending the idea that it is possible to create new possibilities for the teaching and learning of mathematics. Moreover, it is through the individual that this is possible.

3.3 The usefulness of Enactivism in this study

Through the lens of Enactivism, teachers and learners are viewed as structures and these structures are inextricably intertwined with the teaching of mathematics, the learning of mathematics, and indeed all else. The structures of teachers and learners are constantly undergoing change as they interact with the world, including each other and the discipline of

mathematics. With this in mind, the identities of both learners and teachers are made up of their histories, contexts and biologies. Thus, as one explores a person's history, it is possible to gain insight into the structure of that individual at that moment. That is, as I seek to understand the experiences a group of pre-service teachers, who lack mathematics confidence, have had in the mathematics classroom, I am then able to gain some understanding as to some of the reasons why they lack confidence.

As discussed previously, Enactivism maintains that while a structure interacts with another or with the world, that structure will be affected and will in fact co-emerge. This interaction between individuals is regarded as a choreography in which one structure is able to influence, but not determine, another's actions. Thus, Enactivism supports the notion that the lack of mathematics confidence that some teachers possess will have an impact on their learners.

Davis (2004, p. 184) states that "teaching and learning seem to be more about expanding the space of the possible and creating the conditions for the emergence of the as-yet unimaginable, rather than about perpetuating entrenched habits of interpretation. Teaching and learning are not about convergence onto a pre-existent truth, but about divergence – about broadening what is knowable, doable, and beable. The emphasis is not on what is, but on what might be brought forth. Thus learning comes to be understood as a recursively elaborative process of opening up new spaces of possibility by exploring current spaces." For this reason, it has been necessary to explore these pre-service teacher's previous experiences in the classroom and where their confidence lies now because by exploring where these teachers are now, it is possible to open up new possibilities. Hence, by using Enactivism, it will be possible to examine ways whereby teachers and learners can perceive mathematics teaching and learning differently and as a

result, overcome the lack of confidence they experience in their ability to learn or teach mathematics.

3.4 Purpose

The purpose of this study is to gain a better understanding of some of the reasons why a particular group of nine pre-service primary school teachers lack mathematics confidence. Mathematics confidence, as opposed to mathematics anxiety, has been chosen as the topic for exploration because while mathematics anxiety is an emotion, mathematics confidence is a belief. While emotions are perceived to be very unstable, beliefs are far more stable and it is this stability that has motivated me to explore confidence rather than anxiety.

Enactivism, with its roots in complexity theory, provides a way of looking at the whole experience of teaching and learning, including mathematics confidence, with its myriad interactions, in a particularly insightful way. While my particular focus is on mathematics confidence, mathematics anxiety is woven inextricably with the experience of a lack of confidence. Each of these phenomena is explored in this study and although it is understood that there is an interdependency between the two, this interdependency is not examined. This study is done with this interaction as background.

In examining the factors that lead to a lack of mathematics confidence, it is first important to gain an understanding of how these pre-service teachers perceive mathematics confidence. Thus, how this group of pre-service teachers understand the notion of mathematics confidence is explored. Second, some reasons why these student teachers lack confidence are investigated. Gadamer (1990 cited in Sumara & Davis, 1997, p. 414) suggests that what matters more than understanding who we are and what we do is "that we come to interpret the conditions that circumscribe

identities and actions." As a result, I have felt it appropriate to examine the prior experiences of this group of pre-service teachers to determine the conditions that lead to their lack of mathematics confidence. Third, mathematics anxiety is also discussed and in particular, reasons why mathematics anxiety arose, are looked at. Fourth, while discussing their lack of confidence, several talked about their strategies for coping with their anxiety and lack of confidence. These coping strategies which these student teachers have been employing in the mathematics classroom during their practicum are briefly examined.

Furthermore, these themes are discussed in light of the theory of Enactivism. Davis (1996) has suggested alternative ways of teaching and these ideas will be incorporated after each theme.

3.5 Method

Sample: This is a qualitative case-study of a group of pre-service primary school teachers from the University of Cape Town. The participants consist of nine individuals (out of a class of 34 students) who self-identified themselves as lacking in mathematics confidence. In this class, two were male while the rest were female, although all the participants who were interviewed were female.

Of the nine participants, eight had taken mathematics in grade 12 and had changed from a higher grade level to a standard grade level either in grade 11 or in grade 12. One participant had dropped mathematics in grade 9 and another participant had done statistics at a first year university level, while the others had not engaged with any mathematical course since their school days. All the participants completed grade 12 more than five years ago with one participant having completed grade 12 in 2001 and the oldest participant completing grade 12 seventeen years ago (in 1987). On average, the participants completed grade 12 a little over ten years ago. All the

participants had completed a bachelor's degree and were now enrolled in a Postgraduate Certificate in Education, which is a one year program consisting of method courses for English, Mathematics, Expressive Arts, Human and Social Sciences, Natural Science and Technology, and Lifeskills. Other courses involve subjects such as Education, Professional Studies and School Experience. The Mathematics Method course was for 1 hour and 45 minutes on Mondays and Fridays.

Data Collection: The study is qualitative in nature and used oral responses to a small range of questions because it is asserted that the structure of each student teacher, who sees his- or herself as lacking in mathematics confidence, is defined as a complex network of relationships, including his or her history, contexts, and biology. By exploring their experiences from the past, it is then possible to gain an understanding of how that structure came to be and how it is possible to avoid classroom contexts which lead both learners and teachers to lose their mathematics confidence because those structures are fluid and ever-changing. The interviews were semi-structured and lasted 15 to 20 minutes. They were conducted over the period of a week. Participants were first asked when they last did a mathematics course. Questions exploring their mathematics confidence were explored. These questions ranged from asking them how they define mathematics confidence, how confident they feel in mathematics, and why they lack confidence. They were also asked to share both a positive and a negative experience they have had in the mathematics classroom. It was hoped that by having them describe a particular negative and positive experience, that a further understanding regarding their confidence would be elicited. Then the topic of anxiety was explored, specifically regarding when they feel mathematics anxiety. Finally, they were asked how they feel about teaching mathematics. Grootenboer (2003) maintains that students' views of mathematics are firmly grounded in their school experiences. Thus, questions regarding their previous school experiences were central in

exploring reasons for their lack of confidence. The study uses the participants' own words to identify key themes. When quoting their words, the participants are hereafter referred to by using the letters A, B, C, and so on.

Chapter 4

Findings and Discussion

These findings are based on the transcripts of the interviews with nine pre-service primary school teachers. The pre-service teachers' understandings of mathematics confidence are first explored. Following this, some of the reasons why this group of student teachers lack confidence are considered. Those factors which provide occasions for them to experience mathematics anxiety are investigated as well as what they do to counter their lack of confidence. Furthermore, I am not suggesting that there exists a cause-effect relationship between these factors and the teachers' lack of confidence and experience of mathematics anxiety. Rather, these experiences which they describe provided occasions for them to experience a lack of confidence or anxiety. They are important experiences in the evolution of their enacted conceptions of themselves as learners and teachers of mathematics.

Most of these themes are then further explored while considering the theory of Enactivism. Davis' (1996) suggestions for alternative ways of understanding the teaching and learning of mathematics have been incorporated into this further exploration. Although it is not always possible to neatly mesh the theory of Enactivism with the themes I have found, I have attempted to find a link in many instances where, in fact, a natural connection does not exist. However, using Enactivism has been helpful in exploring alternate perspectives of this topic.

This notion of diverse perspectives is embodied in Varela's description of carrying out research. He declared that when we do research we are "laying down a path in walking" (Varela, 1989, p. 48). That is, as research is done, a

path is laid to be re-walked. This path, which stakes out the exploration space, can be re-travelled, and the landscape can be re-examined over and over, looking at it from different angles and different perspectives. Thus, each section which discusses the new ways of seeing teaching and learning is entitled, "Re-travelling the path laid in walking."

4.1 What is mathematics confidence?

The pre-service teachers were first asked about how they understand the concept of mathematics confidence. Two main ideas arose as the teachers discussed their understanding of confidence: (1) having the ability or knowledge to do the mathematics and get to a correct answer; and (2) understanding the mathematics and being able to explain how the problem was solved. Both of these themes are then further explored together using Enactivism at the end of this section.

Theme 1: Ability

One pre-service teacher stated that confidence is knowing how to do the mathematics without any help from others. She also spoke of doing the mathematics on the blackboard. Thus, for this student teacher, mathematics confidence is when she is able to do the mathematics in front of the rest of the class, without help from either the teacher or her fellow learners:

> *"I think it means that they know how to answer something and if they're solving a problem like in front of the class they'll know how to do it.... Um, I think it's, ja, the confidence comes with knowing how to do the stuff yourself."* (A)

Another student teacher stated that she feels mathematics confidence is when one is able to arrive at the right answer in the end. She spoke nothing of the process of getting there or knowing why a particular method was chosen:

> *"I suppose it is to get the right answers in the end."* (C)

This pre-service teacher emphasised knowing how to do the mathematics and that confidence comes from knowing, possibly before attempting the question, that one is able to obtain the correct answer at the end.

> *"To be confident in mathematics you should be able to do the mathematics. That's what I'm thinking. And you should know that you are able to do it."* (H)

Another pre-service teacher explained how, once she began working really hard in mathematics, she realised she could actually do it and this is when she began to enjoy mathematics, even though, as she continued to explain, it would not be her first activity to choose from. Thus, being able to do the mathematics enabled not only her confidence to increase but also gave her a sense of enjoyment:

> *"I ended up working really hard on it sort of afternoons after school and the weird thing was that I ended up enjoying it because once you start realising that you actually can do it, um, ja, I did start enjoying it."* (D)

Finally, one of the pre-service teachers stated that mathematics confidence comes from having the tools (or the ability) to do the mathematics, which she refers to as a map or journey. For this teacher it was not enough being able to answer the first question, but rather being able to answer a series of mathematical questions where there is perhaps a progression in difficulty:

> *"Confidence – I think you've got the tools to help you go on that map, to go on that journey.... For example, you know they would give us an example at school and then they would say, "Try there" and a lot of people could do the first one but they couldn't do the second, third, fourth, fifth."* (B)

Burton (2004) also found that learners felt that ability was an important element of mathematics confidence. Hannula et al. (2002) talked of solution confidence and success expectation as measures of mathematics confidence. Thus, a learner experiencing mathematics confidence from knowing that he

or she can do the problem set before them is associated with having solution confidence and expecting to succeed. Consequently, this aspect of confidence is related to Hannula's measures of confidence. It was previously stated that Furinghetti and Morselli (2004) defined confidence as a belief about one's competence in mathematics. This theme of knowing that one has the ability to do the problem set before them is a belief about one's competence in mathematics. Thus, although many definitions are worded differently, aspects of these definitions are related to how this group of teachers understand the notion of mathematics confidence.

Theme 2: Understanding

The idea that confidence is understanding mathematics and the problems set before them was the most prominent opinion for this group of pre-service teachers. So, while for some of these teachers, it is important to get the answers right, for others the right answers are not as important as understanding the process. Burton (2004) also found that students believed that confidence related to understanding the mathematics. This student teacher states that for her it is not about the right answer but about understanding the questions and the methods involved:

> *"To feel like you can actually do like you can actually work with it, even if you're not getting the right answer, to actually understand the processes of what's happening."* (C)

For the following pre-service teacher, both having the ability and an understanding of the mathematics is essential to experiencing mathematics confidence:

> *"I think it is to be able to do the sums, to do the calculations and to understand what you're doing."* (D)

For this pre-service teacher, confidence stems from being able to complete all the questions. But, it is also important that for this teacher she is able to

explain why she is doing what she is doing and that not being able to answer such a question can lead her to experience a lack of confidence:

> *"I think it comes from understanding. A complete understanding and being able to deal with all the problems. It's the question. You think that you know something, but when someone comes up with a why question and that then it can throw you completely."* (E)

This same participant also states that understanding and succeeding in mathematics brings confidence because she can prove to herself that she does understand. She then is able to feel more relaxed and for her, the mathematics then becomes easier:

> *"I think it depends on your level of understanding. I mean once you are familiar with the work. Once you understand it and you can do it that breeds confidence. ... You can prove that you can do it. ... That improves your confidence. The more confident you are, the more relaxed you are when you're doing the maths which makes it easier."* (E)

Thus, for this group of pre-service teachers mathematics confidence encompassed two elements: having the ability to do the problem set before them, as well as understanding the process involved, which includes being able to answer questions set before them regarding the steps they are taking or the method they are using.

Re-travelling the path laid in walking

Complexity theorists state that learning is conventionally understood to be developing internal representations of a reality which are viewed as being external and independent of the learner. Knowledge is given a corporeal existence and is discussed as if it were an object which can be grasped, held or stored. As a result, understanding is then the level of correspondence between the subjective representations and the objective, external world. Learning is then perceived to be a direct result or cause of teaching. However, it is impossible to prescribe what will be learned because the

theory of Enactivism declares that learning is "occasioned" rather than "caused". Thus, student learning, although dependent on, is not contingent on the teaching which takes place. In this way, the teacher participates in student learning, but does not cause it to occur. Thus, understanding (and what is learned) is situated in and co-emerges with complex webs of experience and is a matter of history, the immediate context and anticipated activity. What is vital for teachers is a responsive attunement to the learners. As the teacher attends to the interpersonal relationships which exist in the classroom, better understandings can occur because deeper and better understandings are not the result of better classroom management, clearer explanations or sophisticated technologies (Davis & Sumara, 1997).

Just as the topic of a conversation cannot be predetermined but arises while conversing, understanding emerges in a similar way. Davis (1996) states that the notion of understanding implies fluidity, negotiation, engagement, conversation and social integration. Thus, understanding is an interpersonal phenomenon and occurs within the context of social interaction. Furthermore, actions are not just manifestations of our understandings but they are themselves understandings. For instance, a student's understanding of a mathematics concept is demonstrated by answering a mathematics question and by being able to answer questions regarding what he or she is doing. That is, both action and vocalisation are fundamental elements of cognition.

Truth and collective knowledge exist in the possibility for joint action and is larger than the individual, because the individual is viewed as being part of a subsystem of increasingly complex systems. Thus, understanding is defined in terms of our capacity for action. When understanding is deepened, the sphere of possibilities for action is expanded. For instance, two individuals, in structural unity, have a far greater range for potential action than if they were to act distinctly from each other (Davis & Sumara, 1997).

As the learner learns and comes to understand the mathematics taught, the context changes simply as a result of the learner being part of the context. Conversely, as the context changes, so does the identity of the learner. As the learner fails to grasp a mathematics concept, it is reasonable that this impacts on his or her identity and as a result leads them to experience a lack of mathematics confidence. But, just as understandings are dynamic as well as contextually and temporally-specific, a feeling of mathematics confidence or lack thereof is not static, but is in constant flux as the learner engages in the learning situation. That is, as he or she understands or does not understand, an increase or decrease of confidence may be experienced. Therefore, everything in a learning and teaching situation is complexly related and the learner, along with everything associated with it, is in constant flux, where each adapts to the other (Davis & Sumara, 1997).

4.2 Factors leading to a lack of mathematics confidence

The teachers were asked why they think they lack mathematics confidence. Now, as previously mentioned, I am aware that there are many themes that can arise when analysing interview transcripts. For instance, when examining what this group of pre-service teachers explained led to a lack in their mathematics confidence, it was evident that there were many themes I could have chosen to focus on, such as negative self-talk, insensitive teachers, not using mathematics regularly, a low self-esteem, lack of perceived usefulness of mathematics, shyness, and so on. However, for this minor dissertation, I have chosen to focus on the following: (1) pace in the mathematics classroom; (2) comparison to and competition with other learners; (3) trauma with a particular teacher; (4) negative beliefs about mathematics of family members. Thus, I do not maintain that this is by any means an exhaustive list of why pre-service teachers experience a lack of mathematics confidence. Each theme is then individually explored using Enactivism.

Theme 1: Pace in the mathematics classroom

In speaking of their prior experiences, six out of the nine student teachers spoke about the pace at which they were required to understand the mathematics in the classroom. They repeatedly spoke of their difficulty to keep up and how, when they felt they had finally understood, the teacher had moved on to explain something else and they had missed it and again they lacked understanding.

One pre-service teacher associated the fact that her teacher taught her class at a rapid pace with the fact that this same mathematics teacher would later teach the learners from the top set. She connects teaching of the top stream with a fast pace in the classroom and felt that this teacher was unable to or struggled to teach at a slower pace. She also felt that she did not understand all the mathematics which was taught to her due to the fast pace of the teacher and this led to her feeling frustrated with mathematics. She had previously defined mathematics confidence as understanding the mathematics, thus it is not surprising that this lack of understanding could have created a lack of confidence:

> "*I know that when I was in standard, ja, I think it was when we were in standard six, initially we had, before we were streamed and they divided all the maths classes up according to ability, um ja, the maths teacher who later on became the teacher who took the top kids, she ja, I just … I think I lost a bit of ground there, because ja, she did tend to kind of rush ahead and I was fed up with maths in general at that stage.*" (E)

This same pre-service teacher spoke of how when she changed to standard grade mathematics, her new teacher worked at a slower pace and this had a positive effect on her:

> "*I enjoyed that teacher, that standard grade teacher. She was ja, she worked at a good pace and she was always there to go over things 100 times. So, that was much more positive than being in other maths classes with teachers who rushed ahead with people who were at the top of the*

> *class and you know you missed a few points and then lose it, so that was better.*" (E)

Another pre-service teacher spoke of the frustration she felt when the teacher would change topics before she was ready to move on. She felt that she did not have enough time to make relevant notes for herself on the particular topic:

> "*I would always be frustrated when I'm just about to get it and the teacher says, "Ok, we're moving on." Or I'm writing it down to remember and I look up at the board and they've moved on – that really drives me nuts.*" (B)

The following student teacher would switch off when she realised she had missed one step because she realised that it was vital in order to understand the rest and so she felt it was pointless continuing to concentrate:

> *"I lack confidence when we're doing it in class, when things go very fast, then I like, if I miss one step then I switch off, so I need to like understand every single step. I can never like copy it all down and then like work back, like figure out the concepts like that."* (A)

Lastly, when the following pre-service teacher was asked what the main reasons were why she lacked mathematics confidence, she stated that she did not like to put her hand up because the teacher would say that there was not enough time to answer the question:

> *"I would hate to put my hand up in the classroom, because the teacher would be like, 'No, we don't have time, we don't have time'."* (C)

The way in which mathematics teachers use time has an impact on their learners. Those who need more time to understand a particular concept feel left behind and often frustrated. This is usually the beginning of not being able to understand the particular topic of mathematics as some learners may stop listening and concentrating. Then as a result of not understanding the

mathematics, a lack of confidence will result. It seems reasonable that the teacher's pace in the classroom can lead to a lack of mathematics confidence for some learners, because of the idea that understanding is associated for this group of pre-service teachers with mathematics confidence. Consequently, as the pace is too fast, they are not able to understand everything, leading them to experience a lack of mathematics confidence.

Hoyles (1982 cited in Breen, 1991) found that when student teachers were asked to relate a negative experience from the mathematics classroom, 22% of these stories were about pace and time pressure. Buxton (1981, cited in Breen 1991) stated that this time pressure could lead to anxiety in learners. However, within this sample, the mention of time pressure and teacher pace arose when they spoke about mathematics confidence, rather than anxiety.

Re-travelling the path laid in walking

The aspect of pace in the classroom is founded on our concept of time. Time has been understood, throughout most of the world, as steadily and linearly progressing, since the invention of the mechanical clock. This linear conception of time leads to a mechanisation of other elements in the world. In particular, formal education is embodied by this way of viewing time. Furthermore, curriculum documents are based on a linear concept of time where students must understand certain concepts before others and within a certain time period and learners are expected to progress at a steady pace (Davis et al., 2000).

The attitude that teachers have towards time in mathematics classrooms is one where time is a commodity. It is believed that the most efficient use of time will produce the best results. Along with the criterion of efficiency and planning, teachers view time as a resource which is limited and valuable. Thus, homework is often checked within the first 10 minutes, after which the teacher goes through a few examples and the remaining time is left for

learners to work individually through a set of exercises either from a worksheet or the textbook. If an interesting question is asked, the teacher will likely check his or her watch to determine if there is enough time to answer it. If a learner plays during the time when he or she is meant to be working, the learner is to make up that time during break-time or after school. This sort of time is called "mechanical time." Mechanical time is the time for telling, rote-learning, recitation and regurgitation (Davis, 1996).

The time for play "moves in fits and starts to the rhythms of moods, desires, heartbeats. It is the time that races between the bells that mark the breaks and that slows between the bells that bound classes. It is time that can be frozen by an icy glare, or that can fall away when absorbed in conversation. It is a time that obeys the body." (Davis, 1996, p. 218) This type of time is called "body time." It is a time that listens to the body. It is a time which is not used in the classrooms because the body is to yield to mechanical time: "Continue with your work. You can play at lunch-time." Body time is for listening. It is a time that takes the time that is needed and spills from break into the classroom, from one day into the next, and from one topic to the next.

Thus, those who take slightly longer to understand a concept in a classroom founded on mechanical time, will find themselves being left behind, unable to keep up with the pace of the teacher and others in the classroom. This may then lead them to experience a decrease in their confidence to understand and to do the mathematics required of them.

Davis (1996) states that there is no simple solution to this problem. But, learners are more prone to learn when they are completely occupied and engaged in what they are doing. Thus, it is vital to recast teaching as listening, because when listening takes place, the modern concept of linear time is forgotten.

In examining various human activities (especially those occurring within the classroom), it is essential to discuss human communication, and more particularly, listening. Listening is active and participatory because as one listens, one questions, smiles, frowns, challenges and so on. The conversation is the place in which listening occurs. Conversations are distinct from other types of interaction, such as debates, interviews and discussions, because a conversation does not have predetermined goals but develops within the joint actions of those involved. A new type of unity arises when a conversation takes place because, during the conversation, the barriers between the self and the other are suspended. Moreover, a collective consciousness emerges and those involved are able to gain greater insight and a deeper understanding, and hence create knowledge. Listening is embodied, enacted and not necessarily formulated, for listening occurs not just with one's ears and mind but with the body (including all the senses) which are tuned into not only the words of the conversation, but also to the subtexts and contexts of the conversation. Thus, listening is not just hearing. While hearing is the sensory capacity which underlies our ability to listen, listening goes beyond hearing, because listening consists of intentionality (listening *for* something while listening *to* something). People are obliged to listen because they perceive gaps in their understanding. Listening always occurs against the backdrop of personal histories which are shaped by cultural, historical, social and environmental factors (Davis, 1996).

There are three types of listening an individual can engage in. First, if one is engaging in "evaluative listening," listening and hearing are synonymous, for the individual listening is not aware of the biases which frame his or her listening. Within the classroom, a teacher engages in this type of listening when she takes a detached, evaluative position and she rarely departs from her rigid, intended plans. Here mechanical time governs the class and there is no play in the classroom. Moreover, there is little sense of collective action. Learner contributions are judged as right or wrong by the teacher

who is the unchallenged authority in the classroom and the contributions of the learner have little impact on the course of the lesson. This form of listening is a passive one where the teacher simply attends to the words uttered by the learners (Breen, 2004; Davis, 1996).

Second, interpretive listening is where the teacher attempts to gain an understanding of what the listener is thinking. Thus, "interpretive listening" is about access rather than about assessing what the learner understands. The emphasis is placed on the teacher developing the skill of questioning such that the learner thinks and then explains that thinking. Furthermore, these questions simply seek information rather than a variety of responses from the learners. All learning is directed by the teacher's understanding and the aim is for the teacher to help the learners gain this same understanding. There is increased opportunity for interaction among learners, but play is kept to a minimum. (Breen, 2004; Davis, 1996).

Both these types of listening are based on the notion that every individual is isolated, autonomous and subjective. They are based on the division between the role of teacher and the role of student. "Hermeneutic listening", on the other hand, is negotiatory as well as engaging. It involves participation of both parties in the formation and transformation of experience as taken-for-granted assumptions and prejudices which frame one's perceptions, and actions are interrogated. There is also a focus on the interdependence of agent and context, thought and action, knowledge and knower, self and other, individual and collective, and so on (Davis, 1996). Therefore, as a teacher engages in Hermeneutic listening, teaching is recast as listening. Learners will be more likely to be engaged with the mathematics. The teacher and the learners share in a joint project in which the objectives of learning are collectively identified and work and play come together in such a way that questions drive the interaction. Thus, what

occurs in the classroom is not a result of where the teacher intends to arrive, but rather the unfolding of play.

Theme 2: Comparison to and competition with other learners

Several of the pre-service teachers spoke of the negative impact of the competition they felt in their mathematics classroom. One pre-service teacher used the metaphor of a race to speak about the participation of the others in the mathematics classroom. This implies that she feels that others are trying to finish the sum first and she at times felt left behind and as if she could not compete:

> *"Because everyone seems to race forward and do it quickly and it just takes other people longer to get to the same point."* (I)

Another pre-service teacher stated that her lack of confidence comes from not understanding what is going on, but then when others exclaim that they understand, but she feels left behind, her lack of confidence increases. She uses the word streaming, implying that the other learners progress forward like an unstoppable river and she cannot catch up:

> *"But, usually when I feel like there was a lack of confidence it would probably be if it was something new, um, and I don't understand what's going on. Everyone around me suddenly like, 'Oh ja, we know how to do this' and everyone like starts streaming ahead and then you just feel like you're being left behind and then ja I just like feel even worse."* (C)

One pre-service teacher made a comparison between English and drama and mathematics classroom environments. She feels that in the English and drama classrooms, the members of the class work as a team, while in mathematics the class members compete. As a result, she felt that she preferred English and drama because she felt that she was more able to express herself:

> *"I think it is very competitive and um...quite silly...like the people who, ja, ... I didn't ever feel like that it was a team environment in maths class and I*

> *don't know, I much preferred English and Drama where you could express yourself and you know be creative and work together as a group.*" (A)

Another pre-service teacher also spoke of the competition she encountered in the mathematics classroom. She felt that this environment led her to compare herself to her peers and that feeling that she was not as competent as them resulted in an anxious feeling:

> "*There is a lot of competition in the class and a lot of...when you're younger performance is specially...you compare yourselves to other kids and if you feel you're not as good as them, you can get quite anxious.*" (E)

The following pre-service teacher also compared herself to her high school peers and believed that she was the only one in the classroom who did not understand. She spoke of feeling low self-esteem which means that she probably lacked confidence in her ability and understanding of mathematics. Feeling that she was the only one who did not understand made it impossible for her to ask questions in class because she feared others knowing that she did not understand:

> "*Because I don't have confidence in myself and each and every time when I look in my class mates, they all understand. I'm the only one who doesn't understand and then that gives me, I don't know, low esteem. Ja. So I'm always scared to even ask sometimes in class because I'm like, 'Ooh, I'm the only one who doesn't understand.'*" (G)

A competitive environment in the mathematics classroom results in those who take longer to understand feeling left behind. This is very much related to the theme of the teacher's pace in the classroom. They then compare themselves to others and feel that they are not as capable. This provides an occasion for the learners to experience a decrease in mathematics confidence. For some, asking questions for further understanding means displaying their lack of knowledge and understanding and this also presents an opportunity to feel anxiety.

Re-travelling the path laid in walking

Enactivism draws on various principles from a theory of neo-Darwinian evolution, which Varela, Thompson, and Rosch (1991) refer to as "Natural Drift" as opposed to "Natural Selection." The latter is founded on the idea that species adapt to fixed contexts and those organisms which are best suited to their circumstances will triumph over their competitors. On the other hand, natural drift proposes that species not only adapt to but participate in the altering of their contexts and in consequence, evolution is more a complex choreography with the criterion for survival being an adequate fit with a dynamic setting rather than an optimal fit to a fixed setting. Thus, it is not competition with other fitter species that leads to extinction; it is the inability to keep up with the dynamic, changing environment. Natural drift, as a result, highlights cooperation rather than competition and adequacy over optimality.

These pre-service teachers have stated that the mathematics classroom environment for them is one where natural selection prevails. Competition, rather than cooperation and collaboration, is the governing principle and those who cannot keep up with the "fittest" and most able, are left behind. However, if classrooms are based on the idea of natural drift, then teamwork and cooperation are prominent and those who do not have the strongest ability will not be left behind.

Theme 3: Trauma with a particular teacher

Three of the nine pre-service teaches spoke of an experience they found particularly traumatising. When asked to relate a negative experience in the mathematics classroom, one pre-service teacher spoke about how her mathematics teacher was not pleased with how she wrote and began to beat her on her back. Then, when asked when she felt she began to decrease in mathematics confidence, she said it was from when she was in standard seven:

> Pre-service teacher: *"Ah. A negative when I was in standard seven, whereby one of the...my class teacher who beat me all over my back and said I told you yesterday, 'Write like this!' I was like...I didn't even cry. I just looked at her. And then beat me and finish and then I went and sit down."*
>
> Me: *"So that was in a maths classroom?"*
>
> Pre-service teacher: *"Yes."* (F)

When asked how she feels about mathematics, she simply stated that she does not like it. When asked why, she explained that her mathematics teacher beat her so badly that she needed to be taken to the hospital. She explained that his anger rose when a student would be standing at the board and would feel unsure about what to write:

> Pre-service teacher: *"It was when my principal – that was in standard 7 – he liked to beat us a lot and then the day he beat me in my body and I still have marks. And then my mother took me to the hosp...no, not to the hospital, to the doctor. And then the doctor said, she's supposed to take him in. Open a case, sort of. And then my mom said, 'No, he was beating almost everyone in class.' So, that's when I started to hate maths because ..."*
>
> Me: *"Did he teach you maths?"*
>
> Pre-service teacher: *"Ja. He was ... He was a good teacher though. But the thing is he was very angry, even if you are in the board, you like...ok, you doubting...to put a minus instead of a sign, he will give you a big klap because you still undecided. That's when I started to hate maths. So, I don't like it anymore."* (G)

She continued to talk about how this experience has given her a reason to experience anxiety when she now encounters mathematics:

> *"I went to people for assistance but sometimes I get shivered. I shake when I'm writing because all those bad memories come and I'm trying to overcome them but it doesn't happen."* (G)

When asked to explain the reasons why she lacked confidence in mathematics, the third pre-service teacher spoke of a traumatic experience she had had in primary school when her teacher who taught her mathematics hit her hands for having her mathematics book covered incorrectly. She felt that this experience has obstructed her feelings of mathematics confidence:

> *"I think it had a lot to do with the particular teacher that I had in primary school, whose name I still remember, <laughter> who was an absolute witch. I mean she really was, to such an extent that the student body ... she used to hit you with a ruler if you didn't cover your book straight, never mind what your maths looked like, so, um, ja, it had to be, ja, she was.... Um, and my mother covered my books and she hit my hands because my mother didn't do it right. Um, I think it put a block up forever."* (I)

Each of these three experiences involved the mathematics teacher hitting the learner for a particular reason, whether it was an error made or simply a book which was covered imperfectly. These experiences left the learner feeling a dread for mathematics and a lack of confidence within themselves to be able to do the work.

Uusimaki and Nason (2004a) also declared that a lack of mathematics confidence can stem from unsympathetic teachers who presume that what they are teaching is obvious and very easy. They also maintain that anxiety can arise from humiliation or belittlement from their teacher. These three pre-service teachers felt humiliated in front of their peers and consequently feel a lack of lack of self-confidence and even anxiety. The way in which a teacher interacts with a learner can greatly affect how the learner views mathematics as well as how they perceive their ability to learn mathematics and be successful.

Re-travelling the path laid in walking

Experiencing trauma in a mathematics classroom is not specifically and directly addressed by the theory of Enactivism in the same way in which

pace and competition and comparison can be discussed. However, this was a reason for the lack of confidence that three of the nine pre-service teachers experience. In the telling of the first two traumatic experiences, the participants describe how the teacher reacted due to the participant not being able to do the mathematics. That is, the teacher became angry because the participant either made an error or lacked understanding. Making errors within mathematics classrooms is generally regarded in a negative way. For instance, in grading a test, the evaluation will focus on what the learner cannot do and what they get wrong. These errors imply that the learner is useless and thus errors are viewed as indicators of an underlying illness which the learners possess. The second participant in particular became unsure of what to write and, according to this way of viewing errors, this told the teacher that she has a problem and that through some corrective behaviour on the part of the teacher, this underlying problem would go away.

Enactivism, however, proposes that errors should be sought out, inquired about, and understood. But, once found, they are not used for the intent of grading and remediation, but for building on and revision because errors suggest incorrect assumptions which leads to the opportunity for new questions and new possibilities. Errors do not exist within a particular individual. Rather they exist within the collection of events taking place within the classroom. Errors should be viewed as moments of interruption and bringing that which is unformulated into conscious awareness. Thus, errors should not be viewed as something negative but as new possibilities for learning and growing from errors made (Davis, 1996).

Play is the fundamental element of learning and leads to a different conception of errors. Although play is commonly regarded as the opposite of work and is associated with distraction, purposelessness and disorder, play is in opposition to rigidity or motionlessness. Play is defined as the

possibility for movement. Ideas can be playful because they can be interpreted differently. If knowledge is perceived as fixed notions which learners need to acquire, then errors are things that need to be avoided, or corrected, or even punished. But, if knowledge becomes playful, then errors become interesting locations for exploration (Davis, 1996).

Theme 4: Negative beliefs about mathematics of family members

Nurmi et al. (2003) declared that beliefs originate in social interaction and that an individual's beliefs about mathematics and about themselves as learners of mathematics develop as a result of personal experiences in and outside of school. Attitudes and beliefs of parents, siblings and teachers can impact on how a learner feels about their ability to be successful in mathematics. Two pre-service teachers spoke of how the negative beliefs about mathematics of various family members impacted their beliefs about their own mathematical ability.

The following teacher had a sister who battled with mathematics and so she felt that she would struggle as well. Thus, the lack of ability (and possibly confidence) of her sister created a feeling of a lack of confidence in herself and this was demonstrated by her discontinuing studying mathematics at the first opportunity provided:

> *"I always feel like very daunted by maths. … Um, it's sort of…like my sister was a couple years older than me and I had the same teachers as she and she struggled and so they sort of put that onto me and so I felt no ways like I'd rather just get out of here as soon as I can sort of thing. So I dropped it at the first chance."* (C)

This particular pre-service teacher, along with her family, believed that the females in her family lack the ability to do mathematics. That is, she lacked confidence in her ability to do mathematics because her sisters had not

previously experienced success in the subject and as a result, she believed this would be her experience as well:

> *"I got three older sisters and it's kind of been a family thing that the girls can't do maths. Um, my dad was always good at it and so I think that was kind of the feed that was there already and then um, just, ja, going to school and kind of becomes more and more entrenched that I'm not really good at it."* (D)

These two participants felt that their lack of mathematics confidence came because other members of their family were not able to do mathematics. They then formed the belief that they were not able to perform successfully in mathematics either.

Re-travelling the path laid in walking

Davis et al. (2000) declare that perception does not result from information being channelled into the brain. Rather, Enactivism argues that perception is more a matter of expectation and past experience. These two pre-service teachers perceived a lack of ability in mathematics in their family members. The experience of seeing their siblings struggle with mathematics led to an expectation that they would also struggle in mathematics. Thus, their perceived ability in mathematics, and hence level of confidence, is a result of past experience and resultant future expectation.

4.3 Experiences leading to mathematics anxiety

While the specific relationship between mathematics anxiety and mathematics confidence is unknown, it was interesting that the teachers frequently referred to their experience of mathematics anxiety when asked questions about their mathematics confidence. For these pre-service teachers, anxiety and confidence were very much related concepts. For example, when the following participant was asked how confident she feels in mathematics, she said:

> *"So, confidence I suppose is understanding what is going on as well as being able to get the right answers in the end. So, usually when I start feeling ... out of control is when it is something new, um and like I don't know what's going on, I don't know what I must do, sort of thing. Um, ja, and in tests and ja, like there are certain sections where you know you just don't understand what's going on. As soon as you see that, like in a test, then I start going, 'Oh, my word....' Like, start panicking. Um, like in this one now, when percentages came up, I was like I don't know how to do this. Like, and then I started like, oh, I just left it out, like I didn't even really try."* (C)

So, even though she was asked about her current level of mathematics confidence, she began talking about her increased anxiety when she fails to understand something. Thus, for many of these teachers, there was a lack of differentiation between mathematics anxiety and a lack of mathematics confidence.

The participants were asked when they experience mathematics anxiety. The two actions, (1) writing a test and (2) displaying their knowledge publicly, were the two themes which arose frequently. In fact, Uusimaki and Nason (2004a) also found that 48% of the 18 pre-service primary school teachers stated that the situation in which they felt most anxious was when they had to communicate their mathematical knowledge either in a test or in a verbal explanation because they perceived themselves to be under evaluation. The Enactivist exploration is then considered at the end of each theme.

Theme 1: Assessment

Assessment was a prominent theme which arose when the participants discussed mathematics anxiety. Every participant, except for one, talked of how they feel some levels of anxiety during a test or exam. One aspect of anxiety is test anxiety (Cohen & Green, 2002). It is likely that this aspect of mathematics anxiety overlaps with test anxiety.

As quoted previously, the following participant talked about how, when certain sections which she does not completely understand, come up in a test, she begins to panic, and because she feels she cannot do it, she does not even try:

> *"Um, ja, and in tests and ja, like there are certain sections where you know you just don't understand what's going on. As soon as you see that, like in a test, then I start going, 'Oh, my word....' Like, start panicking. Um, like in this one now, when percentages came up, I was like I don't know how to do this. Like, and then I started like, oh, I just left it out, like I didn't even really try."* (C)

Another participant talked about how, when she is in a test and when she cannot do something she is attempting to do, she tells herself that she cannot do anything in mathematics. She also describes how she cannot even begin because she feels she cannot even move:

> *"It's when we are in class all of a sudden maybe I attempt to do anything, a test or whatever and then I can't. I can't move. I'm stuck. I can't even start. That's when I always say, 'Ag, I think I don't know anything that has got to do with maths.'"* (G)

The anxiety of these two pre-service teachers led to impairment of their functioning in mathematics. The first teacher talked of how in a recent test she began to panic and then did not attempt the question she felt could not do. The second teacher feels she cannot move, never mind start the question. She then tells herself she cannot do mathematics.

Another participant talked about mathematics anxiety as being like a drug and the anxiety she feels during a test is experienced immediately:

> *"I think maths anxiety would be the way I usually feel when I ... when we had that test the other day, that was immediate; it was like a switch – turn it on, pump in the drug of maths anxiety and there it was".* (D)

Re-travelling the path laid in walking

Traditionally, assessment has the general purpose of holding the learner accountable for what is taught and it also enables differentiation among learners. Furthermore, assessment and evaluation involve comparison where learners are compared against each other as well as against a norm or standard which is believed to exist. That is, the formal test is the device which distances one learner from another and interrupts the play that can occur with knowledge, while a non-negotiable identity is assigned to the learner. Davis (1996) states that many teachers regard tests as being able to provide objective evidence about their learners and hence become a justification for a learner's performance instead of providing an occasion for teaching action. The fluidity of a learner's understanding is often forgotten while the test result is viewed as a fixed indication of what a learner is able to do in the present.

Assessment, from an Enactivist perspective, is participatory and in fact inseparable from instruction. That is, it is directly associated with the idea of teaching as listening. A hermeneutic listening emphasis in assessment would facilitate classroom interaction, and assessment would not emphasise the effectiveness of previous classroom interaction. Testing would enable both the teacher's prejudices and the learner's understanding to be explored. Testing would occur during the process of learning and not after it (Breen, 2004). Davis (1996) also argues that after an assessment has taken place, occasions for listening arise.

Enactivism includes the view that assessment should not only be concerned with assessing the learner but also the teacher. In other words, the teachers need to interrogate themselves regarding the questions they ask, the competencies they view as important, the suggestions they offer and the beliefs they hold concerning mathematics, education, learning and teaching. It is often forgotten that assessments are also about the educational and

societal contexts the learners and teachers find themselves in. Thus, it is necessary that assessment should be based on hermeneutic listening (Davis, 1996).

Testing has become a substitute for listening. At best, testing provides information about what a certain learner could do on a particular day in a particular place. Although for the teacher it enables her to be able to locate those skills which need further refinement and for the learner it exposes gaps in formulated understanding, it does not encourage communication. The test is usually administered after the study of a particular topic (Davis, 1996).

While an alternative to teaching might be sought, it is also necessary to consider an alternative to testing. Thus, Enactivism proposes that testing should facilitate classroom interaction, and not be there strictly to assess learners. Testing would also not only exist in order to examine the learner's understanding, but also to explore the prejudices of the teacher. Moreover, testing should occur during the process of learning, but not after it. This orientation to testing arises from an emphasis on listening (Davis, 1996).

According to some of the pre-service teachers who were interviewed, testing leads to a feeling of anxiety. Additionally, testing enables a comparison to be made between the learners and this comparison leads to some learners to feel a lack of confidence. Thus, as mentioned previously, anxiety and a lack of mathematics confidence are intricately intertwined. If an alternative means of assessment is used, involving and facilitating classroom interaction, testing would not lead to the differentiation between learners because it would involve the process of learning. This would then provide the occasion for the learners to be assessed without the resultant loss of confidence and feelings of anxiety.

Theme 2: Public display of understanding

Several of the participants declared that they felt anxiety when their knowledge and understanding would be publicly displayed before the rest of the mathematics class. The following teacher was asked in what situations she experiences mathematics anxiety. She explained that when she knows that someone else will view and then evaluate or judge her on what she has written, she feels a great amount of mathematics anxiety:

> *"I think mostly when I'm under pressure and I know that somebody's going to be marking it but with the exercises we do in class we can sort of hide from anyone else you know and only you'd know whether you got it wrong or how you're really doing. So when I know somebody else is going to be marking it and probably judging me on my mark, it ups the anxiety ten-fold."* (D)

Teaching mathematics is an action whereby one displays to others one's understanding of mathematics. Thus, for some the act of teaching others will lead to feeling mathematics anxiety. When a participant was asked when she experiences mathematics anxiety, she stated that it is when she must teach or write a test:

> *"Especially when I'm dealing with mathematics in a process of supposed to teach or to have a test."* (F)

One pre-service teacher, when asked what she thought mathematics anxiety was, declared that anxiety is when her teacher would make her lack of understanding and/or ability an example for the rest of the class of what not to do:

> *"I think it's about being put on the spot. Um. Anxiety that the teacher will make an example of your mistake or I think it's things like 'Oh, you're so stupid!' or 'Why can't you get this?' or 'You're not fast enough!' That kind of thing."* (A)

Similar to the findings of Uusimaki and Nason (2004a), it was found that learners of mathematics are likely to experience mathematics anxiety when asked to communicate their mathematical knowledge, whether it be in a test or publicly to the rest of the class. This anxiety came from the perception that they were being evaluated in some way because they feared making a mistake.

Re-travelling the path laid in walking

These three participants felt anxiety when their teacher would have them display their (lack of?) knowledge to them or to the class. They felt that they would be judged because of their lack of understanding. But, if teachers engaged in Hermeneutic listening, learners would not feel that they were being judged because both the learner and the teacher would enter into a shared project of coming to a joint understanding of each other's position. As the learners and teachers share in Hermeneutic listening, the errors made by the learner will be viewed differently, as discussed previously because the learner's understanding and errors would be understood not to exist within the individual but to exist in the series of events taking place in the classroom (Davis, 1996). The errors that the learner then displays is viewed as an opportunity for learning, which would diminish the occasion for the learner to experience mathematics anxiety.

4.4 Some coping strategies of the pre-service teachers

I did not originally attempt to examine the coping strategies of this group of pre-service teachers, but when the participants were either asked how they felt about mathematics now or how they felt about teaching, many talked about the various positive and negative experiences of their recent teaching practicum and stated various strategies they employed during their practicum which enabled them to cope with their anxieties and lack of confidence in mathematics. Thus, I have decided to discuss briefly what

they shared. I do however feel that had I asked more thorough questions on their various coping strategies, more could have been extracted.

It was evident that certain experiences during the practicum provided an occasion for the student teacher either to decrease or increase in the amount of confidence she experienced. The following pre-service teacher spoke of the increased confidence she felt when a learner understood her:

> *"Having done the prac, I find it really exciting, trying...getting a concept across to someone I know, I can see is really struggling. And when just they get it, then you can see that they just suddenly twig – that , I don't know, that makes it all worth tackling the lesson, so ja, I think I actually do enjoy it and I think that feeds on your ... the more those kind of situations happen, the more confident you become."* (D)

On the other hand, the following pre-service teacher spoke of her experience when the class she was teaching failed to understand what she was explaining. She attributed this experience to not being completely prepared. She spoke of how this made her feel anxious about her ability to teach. It is evident that she now lacks confidence in her ability to explain mathematics in a teaching situation:

> *"Well, I mean I think I'm probably quite anxious now. ... I'm quite nervous especially that I will make it more difficult for children to learn if I'm not 100% prepared and I know how to deal with everything and answer their questions. I mean, my last prac ... I did a lesson ... and I tried to give them an example and it threw them off completely and they got everything wrong. All of them for the whole lesson. And then I went home my goodness, now I have muddled them. How I'm going to correct this? ... I mean it all seemed quite simple to me. I gave them an example on the board; I showed them what they did yesterday and what they did on that day – just with different things and how it should be compared, but they weren't able to take it all in, and ja, that certainly made me very anxious that I'd undone a whole lot of*

> *work that the teacher had been doing with them for the last couple of weeks."* (E)

Two themes arose as the student teachers talked about ways in which they coped with their lack of mathematics confidence: (1) studying the mathematics to be taught and (2) practising the mathematics to be taught. Following a discussion of these two themes, they will be explored together through an Enactivist lens.

Theme 1: Studying the mathematics to be taught

Several of the pre-service teachers stated that gaining a personal understanding of the mathematics they taught increased their confidence to teach it. The following teacher was asked how confident in mathematics she was currently feeling. She immediately began to talk about her experience on the teaching practicum. She explained that studying the topic ahead of time enabled her to feel confident enough to teach it:

> *"When I was on teaching prac now, I felt confident once I'd gone through the stuff. I basically taught it to myself and then I was like, 'Ok cool' and then I was able to teach it."* (C)

The following teacher felt that her lack of understanding or ability in mathematics aided her in having to understand the mathematics from the beginning. She felt that by studying the work thoroughly and by finding creative, easy ways to demonstrate the various concepts, she was able to teach the mathematics with confidence:

> *"But like when I was teaching in the teaching prac I would just study the section of work and then be ok with it and I think I actually did a good job of teaching it because um I had to really understand from the very beginning myself. So, I really thought of interesting ways to illustrate the concepts so I think it actually did help that I myself am not good at maths."* (A)

Theme 2: Practising the mathematics to be taught

A few of the teachers spoke of going through various examples in order to increase their confidence to teach the mathematics. When the following pre-service teacher was asked how confident she feels, she felt that with more exposure and a bit of practice, she would feel confident in her ability to teach. However, she feels that without preparation she would be quite anxious:

> *"I think I would be able to understand it now and once I've, ja once I've been a bit more exposed to it and had a bit of practice I'd be able to teach it. I'm not concerned about that. I'm a bit scared about going into teaching initially when I haven't...<laughter>... I haven't done all of that."* (E)

Additionally, after asking the following teacher how she feels about teaching mathematics, she exclaimed that after making sure that she understands it by doing examples herself, she will be able to teach it with confidence:

> *"I feel if I remember the stuff, and I've done it and I do some examples. I go through it. I make sure I'm fine. Then it will be alright."* (B)

Cohen and Green (2002) found that anxious teachers worried about their own inadequate knowledge of mathematics as well as being asked difficult questions which they would be unable to answer. They stated that the teachers' coping strategy was to over-prepare for their lessons by doing all the exercises in the textbook before the lesson. These teachers also spoke of their coping strategies so as to overcome their anxiety and lack of confidence. Most of them spoke of gaining a deeper understanding of the topic they were required to teach, while a few asserted that their confidence to teach comes from doing exercises on the topic in preparation for the lesson.

Re-travelling the path laid in walking

Varela (1999) stated that as structures we operate in the moment of any given situation, having a readiness-for-action for every lived situation. He calls a readiness-for-action a microidentity and its corresponding situation a microworld. We constantly move from one readiness-for-action to another and much of the time these transitions are so slight that they are unnoticeable. However, when something surprising or unexpected occurs, a breakdown occurs and we become aware of the change that takes place between one readiness-for-action and another. Varela maintains that it is vital to observe human experience during breakdowns, because the composition of the structure in any situation is a matter of the emergence of an appropriate behaviour from the history of the life of the structure, since these microidentities are historically constructed.. As the structure enters into a new microworld, an appropriate action is selected from its own repertoire gathered from previous experience. Thus, when a teacher is asked a question she cannot answer, a breakdown occurs as her behaviour is no longer planned and this leads to creativity and autonomy. If a teacher feels a lack of confidence about her ability to explain mathematics and has acted previously with anxiety or a lack of confidence, this behaviour may be drawn from a repertoire which includes less than confident behaviour.

Furthermore, exploring the mathematics as well as various teaching ideas beforehand leads to the teacher being able to broaden the possibilities for teaching as listening hermeneutically, as discussed previously. This task of careful preparation enables the teacher to consider not just the mathematics but also a range of different responses from the students, and thus diminishing the prejudices that limit his or her listening in the classroom (Davis, 1996). In this way, learners will be more likely to engage with the mathematics as the teacher and learner share in their joint project of learning and discovering.

Chapter 5

End of a journey

This research has been a journey for me. I previously stated that the word "research" is derived from a word meaning to "travel while searching" and that my research began long before I enrolled in the Masters program at the University of Cape Town. Furthermore, since teaching, learning and researching are inextricably interwoven and I am woven into the fabric that I seek to understand, it has been necessary for me to share my experience of this journey. In this way it is possible to determine the impact my own views and perspectives have had on this research process.

As I initially began to think about my research, I began to read much of the research and literature that was available on the topic of mathematics confidence and anxiety. I then attended a course in research methodology which emphasised the positivistic manner in which one should do research. Following this course, I started my research, performing interviews and then analysing the data. Several themes stood out boldly to me as I performed this analysis.

When I began to distinguish various themes in the pre-service teachers' responses and experiences, I felt several tensions within myself and I came to a standstill wondering where to go next. I felt like my study did not correspond much with the literature. A great deal of the research I encountered which dealt with mathematics confidence either explored male and female differences or attempted to find other variables, such as success orientation or achievement, which might correlate with mathematics

confidence. Furthermore, those examining student teachers discuss negative beliefs about mathematics, which includes a lack of mathematics confidence, but is not itself mathematics confidence. When examining the origins of anxiety and negative beliefs about mathematics, the themes which are so often explored are teacher style (computation, drill and non-participatory methods) and communication of mathematics knowledge.

I began to see a parallel between myself and those I have researched. While they feel a lack of confidence when they make mathematical errors and when they do badly in a test, I felt a similar lack of confidence in myself and in the work I was producing because a part of me desired to produce a text which is "error-free" because I have been taught to follow the recommended manner in which research is done. I, too, had this desire to achieve good results. Perhaps the reasons which stood out to me for their lack of confidence were also the reasons for my lack of confidence as I did this research.

The short course on research methods which I had attended emphasised how, if I did not follow the prescribed way of doing research, my research would fall flat and would not be accepted. I began to feel more anxiety, wanting to write up my research in the prescribed way and knowing that I could achieve good results, but also wanting to state the truth.

I then also began to wonder if perhaps I had picked the wrong themes. Why had I picked these particular ones? I realised that I could easily have picked others and I would have other literature to support the themes which I had chosen, but I had picked these and this was not something which I could just ignore.

I found myself tangled in the complex web of research. I felt stuck.

I re-examined the original themes which I had observed for why these pre-service teachers lacked confidence. Why were these particular themes for the origins of a lack of confidence so strongly apparent to me? Perhaps I had chosen the wrong themes? Maybe I am biased because of my previous reading of Davis? But then the thought occurred to me that in researching mathematics confidence, there would have to be as many reasons for why people lack confidence as there are individuals. Each person who lacks confidence has his own story about why he feels he cannot do mathematics or why he feels anxious when doing it. Maturana and Varela (1987) claim that we live in a Multiverse rather than a Universe because there are endless potential experiences. When we engage and interact together, we become coupled and co-emerge, creating new worlds and new understandings. So, to try to classify all the reasons into just a few themes seemed absurd to me. It does not capture what is really taking place.

However, there was still a tension inside of me. Part of me wants to write up my research in a clean, crisp way, where the themes I choose coincide with many of the themes from the literature review and where the difficulties I have had with writing it up were not evident. Capra (1982, p. 6) states that the problem in the world is "the fact that most academics subscribe to narrow perceptions of reality which are inadequate for dealing with the major problems of our time. These problems are systemic problems which means they are closely interconnected and interdependent. They cannot be understood within the fragmented methodology characteristic of our academic disciplines.... Such an approach will never resolve any of our difficulties but will merely shift them around in a complex web of social and ecological relations." To examine mathematics confidence in the way in which it has always been explored does not enable new perceptions and new understandings to be gained. It will not enable us to resolve the anxieties and lack of confidence which so many teachers and students experience.

I also remembered that I am a structure. Due to the combined influences of my history of experiences interacting in the world and my biology, my structure is constantly undergoing change. My actions are not just manifestations of my understandings, but they are my understandings. As I have read and engaged with Davis' work, it has had an impact on my structure. Thus, I analysed the text in such a way that it reflected my past experiences: my own teaching, attending Chris Breen's class, reading Brent Davis' books, and so on. The themes I initially chose as being most prominent were the ones which resonated most with me and the experiences I have had.

Haskell, Linds and Ippolito (2002, p. 3) state, "If we take our partiality as researchers, the fact that we always influence the direction of our work, indeed, that our work is in many ways an expression of who we are and who we are becoming, we can interact with our connection to the research not as a liability to be guarded against, but as an opportunity to make the research more meaningful by more fully appreciating our part, as researchers, in it." In using Enactivism, I cannot ignore the fact that I influence the direction of my work and this research is an expression of who I am and who I am becoming. In this way, it is my hope that this research becomes more meaningful because it is a part of me and I am a part of it. Haskell, Linds and Ippolito (2002, p. 7) maintain that enactive inquiry "evolves with the coupling interactions of an unfolding world" and that experience is central to the process of research. Thus, to be true to myself, I feel the need to stick with the original themes I felt were most prominent.

In coming to terms with the themes I had chosen, I began to consider my use of Enactivism in seeking to explore further this group of pre-service teachers' understanding of mathematics confidence, their reasons for their anxiety and lack of confidence in their ability to learn and teach mathematics, as well as some ways in which they cope with their lack of

mathematics confidence. There are both strengths and weaknesses to consider when trying to map the theory of Enactivism on the research field of mathematics confidence.

One of the core strengths of Enactivism is that it argues that everything is interconnected and intertwined with everything else. First, I am a complex structure and cannot be separated from my research. Thus, my story is important in the writing up of this research. As a result, I have felt it vital to share my experience and express my voice throughout this research. Second, confidence and anxiety are seen as threads of a woven whole. Many researchers have struggled to determine the connection between these two constructs and have sought to show how the one determines the other, or how one is a subset of the other, or how there is some third variable between the two. Through Enactivism, these two constructs can be viewed as deeply interwoven with each other. It was interesting to me that when I asked one particular pre-service teacher about her current level of mathematics confidence, she began to talk about the mathematics anxiety she feels when she does not understand the mathematics being taught. This student teacher seemed unable to differentiate between the two constructs. For this reason, it has been necessary for me to discuss both mathematics confidence and anxiety and not one or the other alone. In fact, I propose that due to the entwined nature of these two constructs, a study would be incomplete if only one is addressed without the other. Third, Enactivism views learning as the process of opening up new spaces of possibility while exploring current spaces. Enactivism is thus a useful framework for exploring situations in the present with the aim of change in the future.

The main weakness for using the theory of Enactivism was its inability to be mapped directly onto the themes I had chosen. This caused continual trouble for me as I sought to produce a flawless study, where the theoretical framework perfectly explains the findings. However, as I have mentioned

previously, Enactivism was not designed to explain why teachers and learners lack mathematics confidence. Instead, Enactivism is a framework for understanding various classroom conditions. It enables one to explore new possibilities and new perspectives of teaching and learning while viewing them as complex phenomena. Thus, one can hope that change can at some point take place. Future research might investigate how a change in the way teaching and learning are currently viewed to a more Enactivist approach might increase the level of mathematics confidence of both students and teachers of mathematics.

I have now come to the end of this part of my journey. I have discussed how a group of nine pre-service teachers understand mathematics confidence as well as reasons why they experience a lack of mathematics confidence. Reasons for mathematics anxiety and strategies for coping with a lack of confidence have also been discussed. I then sought to interrupt the often unquestioned patterns of acting and present an alternative which is perhaps less damaging. While my teaching and learning have impacted on the way in which I have done and interpreted my research, my research is continuing to impact on my teaching and learning as I view myself as a teacher as well as my students through new eyes using an Enactivist lens. Now with added understanding of why learners and teachers lack mathematics confidence, I am better able to help the learners I interact with manage their lack of confidence. Indeed a new part of my journey begins.

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