INVESTIGATING HOW A PEER TEACHING PROGRAMME COULD SHAPE THE MATHEMATICAL EXPERIENCE OF THE PARTICIPATING TUTORS

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ABSTRACT

This case study, involving six Grade 10 learners, investigates how a peer tutoring programme could shape the mathematical experience and disposition of the participating tutors. The study is grounded in an interpretive paradigm and data was collected in four sequential phases. The Mathematics Dispositional Functions Inventory (MDFI) instrument was completed by the tutors prior to commencement of the tutoring programme. The tutoring sessions then took place over a three week period during which time each tutor kept a reflective journal. Semi-structured interviews were then conducted, after which each tutor completed the MDFI instrument again in order to track any potential changes in their mathematical disposition. The study found that the participating tutors showed an improved mathematics disposition after the peer tutoring experience. Not only was the peer tutoring programme an empowering experience for the tutors, it also had a positive influence on both the tutors' self-confidence as well as their perceived mathematical ability.

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DEDICATION

I dedicate this thesis to my dear wife Clare and my children Lubasi, Ntwala and Sibuku. Lubasi and Ntwala – some days I missed out on reading you bedtime stories because of my studies. I promise to do all that is humanly possible to be there for you. Clare – you gave me your support and encouragement as I went through long hours of reading and writing and stood by me throughout the process.

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CHAPTER 1

INTRODUCTION OF THE STUDY

1.1 Introduction

The focus of this study was to investigate how a peer tutoring programme could shape the mathematical disposition and experience of the participating tutors. This chapter introduces the study. The contextual background is first described, after which are brief descriptions of the research goals, research design and the research process. The chapter ends with a brief overview of the structure of the thesis.

1.2 Context of the research

In 2012 I was instrumental in instigating a Grade 10 peer tutoring programme in the school where I worked as a mathematics teacher. Ten learners whose mathematical performance was better than their peers were chosen to act as peer tutors. Each peer tutor was assigned between twelve and fifteen tutees. I would meet with tutors once a week on the day prior to the weekly tutoring session in order to help them prepare for the upcoming session. The weekly tutoring sessions were held in the school hall, each session being two hours long. Each tutor was responsible for his or her tutees, and it was the role of the tutor to assist their tutees with the particular topic chosen for the week. The programme ran from February to October 2012 and was successful not only in terms of improved Mathematics marks of the tutees, but also with respect to the tutors. I was particularly struck by the change in the tutors over the course of the tutoring programme. There seemed to be a general improvement not only in their Mathematics, but in their schoolwork and general behaviour and conduct as well.

In 2013 I was transferred to a new school where the Grade 10 marks were particularly poor. Having settled into the school, and motivated by my past experiences at my previous school, I was very much interested in establishing a similar Grade 10 peer tutoring programme. More specifically, I was particularly interested in how such a peer tutoring programme could shape the mathematical experience of the participating tutors.

Walker (2007) asks a critical question: “How can schools – even those schools where the average mathematics performance of students is poor – build on the experiences and behaviors of successful students to spur improved mathematics outcomes?” (p. 58). One possible approach could be to engage better performing students to help their peers in a peer-tutoring environment. An interesting aspect of such peer tutoring programmes is the potential influence on not only the tutees, but the participating tutors as well.

Topping (2005) reports that there is evidence to suggest that peer tutoring can yield significant gains in learners’ academic achievement. Furthermore, in peer tutoring, both tutees as well as tutors can have academic gains if the peer tutoring programmes are well organised. With this in mind, and faced with the challenge of poor mathematics results in many Namibian schools, the potential inherent in formal peer tutoring programmes is certainly worth exploring.

1.3 Research goals

This study investigates how a peer teaching programme could shape the mathematical experience of the participating tutors. The study is framed by the following research questions:

1. How does peer tutoring shape the mathematical experience of the participating tutors?
2. How does peer tutoring shape the mathematical disposition of the participating tutors?

1.4 Research design

This study is orientated in the interpretative paradigm (Leedy & Ormrod, 2005). The research took the form of a case study, the case under scrutiny being a group of six peer tutors, while the unit of analysis was the experiences of the tutors, with specific focus on their mathematical disposition. Three methods of data collection were used, namely the Mathematics Dispositional Functions Inventory (Beyers, 2011), reflective journals and semi-structured interviews.

1.5 Research process

The study was conducted in four phases.

Phase 1

Before commencement of the peer tutoring programme itself, tutors first completed the Mathematics Dispositional Functions Inventory (MDFI). This data provided insight into the initial mathematical disposition of each tutor.

Phase 2

The second phase comprised the peer tutoring programme itself. In addition to the tutoring and preparation sessions, tutors were required to complete a reflective journal throughout the process in order to capture their personal experiences and reflections.

Phase 3

At the end of the three weeks of peer tutoring, a semi-structured interview was conducted with each peer tutor.

Phase 4

Finally, each tutor was required to complete the MDFI in order to track any potential changes in their mathematical disposition.

1.6 Overview of the thesis

This section provides a brief overview of the following chapters in the thesis.

Chapter two examines literature relevant to the study, starting with the rationale for using peer tutoring at secondary school level. This is followed by a review of literature on past and current research on peer tutoring with a particular emphasis on the mathematical experience of the participating tutors. The theoretical rationale for how peer tutoring relates to the notion of mathematical disposition is then discussed. Finally, the notion of peer tutoring is linked to the epistemology of social constructivism.

Chapter 3 provides an outline and description of the methodology used in carrying out this study. Specifically, this chapter describes the goals of the study, the research orientation, the research methodology and design, the data collection techniques, the research site and participants, data analysis, validity, ethical considerations as well as the limitations of the study.

Chapter 4 deals with the presentation, analysis and discussion of the data collected during the study. The study took place in four successive phases, and the data from each of these phases is discussed in turn.

Chapter 5 is the final chapter of the thesis and provides a summary of the research findings in relation to the original research questions The chapter also includes brief discussions of the limitations as well as the significance of the study, and concludes with recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide a theoretical and contextual backdrop to the study. Firstly, the rationale of using peer tutoring in Mathematics is discussed with specific reference to secondary school. This leads to a review of past and current research on peer tutoring with a particular emphasis on the mathematical experience of the participating tutors. In the second part of this chapter the theoretical rationale for how peer tutoring relates to the notion of mathematical disposition is discussed. In addition, the conceptual framework of mathematical proficiency as advocated by Kilpatrick, Swafford and Findell (2001) is critically engaged with, particularly with regard to the strand of productive disposition. Finally, the notion of peer tutoring is linked to the epistemology of social constructivism.

2.2 The rationale for using peer tutoring at secondary school level

Topping (2005) observes that peer learning is a practice that has a long history. With this in mind it could be expected that peer teaching/tutoring should be widely incorporated into classroom practice. However, this is not the case. In my experience as a teacher of mathematics at the secondary school level I have seen very little peer tutoring being used in the classroom despite numerous studies that reveal its potential for improving the academic performance of learners – see for example Fantuzzo, King and Heller (1992) and Fox, Vos and Geldenhuys (2007).

In order for us to meaningfully explore the idea of peer tutoring it is important firstly to understand how different academics have defined peer teaching/tutoring. Bowman-Perrot et al. (2013) define peer tutoring as “a class of practices and strategies that employ peers as one-on-one teachers to provide individualised instruction, practice, repetition, and clarification of concepts” (p. 39). Roscoe and Chi (2007) define peer tutoring as the “recruitment of one-on-one instruction for another student, accompanied by explicit assignment of participants to "tutor" and "tutee" roles" (p. 535). Fox et al. define peer tutoring simply as "learners teaching other learners" (p. 45).

Peer tutoring has the potential to facilitate peer learning, thereby providing a platform to help both the peer tutor and tutees in their learning. Topping (2005) defines peer learning as "the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions" (p. 631), these being the tutors and tutees. The 'status equals' in this study will be Grade 10 learners – i.e. both the tutors and tutees will be in the same grade, an important aspect of the peer tutoring process (Robinson, Schofield & Steers-Wentzell, 2005). Although the study involves both tutors and tutees, the focus of the study is on how peer tutoring impacts on the *peer tutors* in terms of their mathematical experience.

Gordon (2009) states that there is evidence that shows that peer tutoring may not only help students to master subject knowledge and general learning skills, but also help to increase the motivation of students by providing a sense of empowerment to learners. Peer tutoring can have positive effects on the general achievement of learners in the subjects they are studying because peer tutoring can reinforce concepts, help tutees practice their skills, support problem solving, and challenge tutees' thinking. Peer tutoring can also have positive effects on the tutors by deepening their understanding of concepts and sharpening their skills, engaging them in creative thinking and problem solving as they look for ways and strategies to help tutees, and enhancing their self-image. This can help students in building their critical thinking skills. These views are also supported by a study carried out by Grubbs and Boes (2009) in which peer tutoring showed positive effects on the self-esteem of the tutors.

Gordon (2009) suggests that peer tutoring can be organised in ways that optimise opportunities to learn in many meaningful ways. Some of these suggestions may help to improve the benefits of a peer tutoring programme, and these include:

I. Peer tutors can elicit their tutees' ideas and experiences in relation to key topics and then fashion learning situations that help them elaborate on or restructure their current knowledge.
II. Tutors and tutees can be assigned complex, meaningful, problem-based activities.

III. Tutors and tutees can be encouraged to work collaboratively and be supported to engage in task-oriented dialogue with one another.
IV. Tutors can make their thinking processes explicit to tutees in their own language and encourage tutees to do the same through dialogue, writing, drawings, or other representations.
V. Tutors can employ a variety of assessment strategies to understand how their tutees' ideas are evolving and to give feedback on the processes, as well as the products, of their thinking. (p. 444)

Topping (2005) states that there has been a great deal of interest in deploying helpers whose capabilities and age are nearer to those of the helped, the idea being that both the helper and the helped will find some cognitive advantage in the activities they do. In addition to the tutee or 'helped' being assisted, the helper, or tutor in this case, will also be "learning by teaching". Both parties involved thus benefit from the experience. This makes peer tutoring ideal for students studying mathematics because the tutor, who happens to know more than the tutee, will still learn a great deal of mathematics as they prepare for and engage with the process of peer tutoring. Topping (2005) remarks that "peer tutoring is characterised by specific role-taking as tutor or tutee, with high focus on curriculum content and usually also on clear procedures for interaction" (p. 632). Such focus on curriculum content may lead both tutor and tutee to a deeper understanding of the content they are interacting with.

Peer tutoring takes place within a social setting where human interactions become a key factor in facilitating learning (Chapman, 2004) and where there is high interaction between tutors and tutees. Mesler (2009) remarks that students who act as tutors could experience improved socio-emotional and attitudinal outcomes. Not only could participating tutors improve their content knowledge through taking part in a peer tutoring programme, but the experience of being a tutor also has the potential to boost self-confidence and provide a sense of being responsible for and useful to others. Through these types of interactions where tutors and tutees engage in mathematical content, it is believed that learning will take place. Ifamuyiwa and Akinsola (2008) remark that children learn independently as well as through peer collaboration. This suggests that in learning mathematics an environment should be created during the teaching-learning process to accommodate active student interaction.

Walker (2007) asks a critical question: “How can schools - even those schools where the average mathematics performance of students is poor – build on the experiences and behaviors of successful students to spur improved mathematics outcomes?” (p. 58). One possible approach could be to engage better performing students to help their peers in a peer tutoring environment. An interesting aspect of such peer tutoring programmes is the potential influence on not only the tutees, but the participating tutors as well. Roswai et al. (1995) state that strategies using peer collaborative learning and peer tutoring show promise for reducing school dropout rates and increasing academic achievement. They further state that “peer tutoring is an effective strategy fostering academic achievement of students” (p. 276). Karsenty (2010) makes an important observation that those students who come to secondary school with a history of having struggled with mathematics often withdraw from any further efforts in trying to understand the subject content. Peer tutoring is a possible route to assisting such ‘at risk’ students.

Roscoe and Chi (2007) observe that the benefits of peer tutoring are highly inclusive, and that peer tutoring has the potential to support the learning of diverse samples of students, i.e. both academically strong and weak learners. Roscoe and Chi (2007) further observe that it is likely that tutors will always learn regardless of the subject matter they are teaching, but tutoring programmes in mathematics and science seem to show higher gains compared with other subjects.

Robinson, Schofield and Steers-Wentzell (2005) found that when a student takes on the role of tutor they often start to feel and behave differently. Students who take up the role of tutor often begin to mirror the role of the teacher and start developing confidence in that specific subject area. This goes some way to explaining why students who act as tutors in tutoring programmes often show positive attitudes toward school, increased academic achievement in the specific subject they are tutoring as well in other school subjects more generally. Robinson et al. (2005) also indicate that students in tutoring programs often display improved classroom behaviour. Robinson et al.’s (2005) role theory suggests that when tutors become involved in helping tutees, this impacts on their behaviour in positive ways. Tutors become aware that they are role models to their peers. This encourages tutors to emulate good behaviour, and to expect similar behaviour from their tutees

Mesler (2009) argues that a child who does not have self-esteem is not likely to be successful in school. In the studies she conducted she found that peer tutoring had many positive effects for both the tutor and tutees in the peer tutoring programme. Mesler's (2009) study revealed that for the tutor, the experience of being valued and respected by tutees and the teacher had a positive outcome on the attitude and socio-emotions of the tutor. Other researchers also found that learners acting as tutors developed better self-concept, showed improved classroom behaviour, both toward the specific subject being tutored as well as more generally. These findings resonate with the studies carried out by Robinson et al. (2005) where tutors were seen as role models by their peers and which in turn encouraged tutors to behave well not only inside but also outside the classroom, what Robinson et al. (2005) refer to as the spill-over effect.

Topping (2005) reports that there is evidence to suggest that peer tutoring can yield significant gains in learners' academic achievement. Furthermore, in peer tutoring, both tutees as well as tutors can have academic gains if the peer tutoring programmes are well organised. With this in mind, and faced with the challenge of poor mathematics results in many Namibian schools, the introduction of formal peer tutoring programmes is certainly something to be considered.

2.3 Effective peer tutoring programme design

Gordon (2009) suggests that peer tutoring programmes require careful planning and should be well thought through and well grounded in the appropriate training of tutors. According to research by Gordon (2009), effective peer tutoring programmes do not result from a process of haphazard volunteering. Rather, peer tutoring requires a purposeful programme with clearly defined learning objectives, activities, and assessments in order for it to be effective. Both tutors and tutees need to know how to interact with each other in the learning environment. The roles of tutors should be made clear and should be well structured. In addition, tutors need to understand the relevant curricular goals and be trained in the appropriate use of tutoring activities and materials if the programme is to be effective and successful. Grubbs and Roscoe (2009) also state that peer tutoring programmes need well defined goals and objectives, and it is crucial that tutors understand these goals.

Gordon (2009) further suggests that in terms of organisational support it is important that parents and/or legal guardians be well informed about the peer tutoring programme and the potential benefits to the tutors and tutees. This is particularly important where a peer tutoring programme is implemented as an after-school programme since parents would need to give their consent for their children to be part of the programme.

Roscoe and Chi (2007) put emphasis on programme design and implantation as important aspects that are likely to contribute to the success or failure of a peer tutoring programme. Peer tutoring programmes need to be carefully designed in order for them to have maximum benefit for the participants. Grubbs and Boes (2009) suggest that adult supervision is important in all tutoring sessions to answer questions which may arise from tutors, to monitor behaviour, and also to provide feedback to tutors on their performance. Topping (2001) suggests that when planning peer learning, the following aspects of organisation need to be considered:

1. Context – there will be problems and opportunities specific to the local context.
2. Objectives – consider what you hope to achieve, in what domains.
3. Curriculum area.
4. Participants – who will be the helpers, who will be helped, and how will you match them? There will also have to be trainers and quality assurers.
5. Helping technique – will the method used be packed or newly designed?
6. Contact – how frequently, for how long and where will the contact occur?
7. Materials – what resources will be required, and how will they need to be differentiated?
8. Training – this will be needed for staff first, then for helpers and helped.
9. Process monitoring – the quality assurance of the process must be considered.
10. Assessment of students – the product and the process should be assessed; consider whether any of this should be self and/or peer assessment.
11. Evaluation – you need to find out whether it worked.
12. Feedback – this should be provided to all participants, to improve future effort. (p. 40)

Gordon (2009) suggests that in designing and administering a tutoring programme, these components seem to show considerable promise for quality improvement:

1. Tutors can be effective regardless of their training and education by just giving students more personal attention.
2. Tutors must be able to track the session-to-session progress of each student in order to modify tutoring content and use student academic strengths to overcome weakness.

3. Tutors need to use continuous feedback to help students develop positive self-images as learners.
4. Formal/informal assessment needs to be used throughout the tutoring process.
5. Mentoring/coaching each student on learning how to learn by providing guidance on study habits, taking tests, attention to school, and learning in general is a significant, informal part of effective tutoring. (p. 443)

2.4 Conceptual and theoretical framework

2.4.1 Mathematical disposition

The notion of *mathematical disposition* forms the conceptual backdrop to this study. Kilpatrick et al. (2001) characterise a productive disposition as a "habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (p. 116) as well as a tendency "to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics" (p. 131). Kilpatrick et al. (2001) further remark that the development of productive disposition requires "frequent opportunities to make sense of mathematics, to recognise the benefits of perseverance, and to experience the rewards of sense making in mathematics" (p. 131).

Kilpatrick et al. (2001) identifies the five strands of mathematics proficiency as:

- Conceptual understanding – comprehension of mathematical concepts, operations, and relations
- Procedural fluency – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- Strategic competence – ability for logical thought, reflection, explanation, and justification
- Productive disposition – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with the belief in diligence and one's own efficacy. (p. 116)

Kilpatrick et al. (2001) argue that productive disposition develops only if the other strands do, and in turn helps each of them further develop. It is for this reason why a general understanding of these five strands is import, since they are interwoven and interdependent. Thus, when students solve routine mathematical problems they improve their strategic competence which in turn helps them develop a positive attitude and belief about themselves. When students develop conceptual understanding, mathematics becomes more sensible. In the same way, when students see themselves as capable of learning mathematics and using it in solving problems, they develop their procedural fluency or their adaptive reasoning abilities.

Student' disposition toward mathematics is seen as a major factor in determining their educational success. Students who have a high degree of productive disposition are confident in their knowledge and ability. Mathematics is seen by these types of students as reasonable and intelligible and such students tend to believe that with sufficient effort and experience they can be successful (Kilpatrick et al., 2001).

Within this study, mathematical disposition is investigated within the context of a peer tutoring programme. As tutors engage in solving mathematical problems there is the potential that they will develop a sense of mathematics being doable and sensible, and this is likely to impact positively on their mathematical disposition. Kilpatrick et al. (2001) state that people who do well in mathematics tend to believe that mathematics should make sense, they believe that they can do it, figure it out, that they can solve mathematical problems by working hard on them, and that being able to do mathematics is worth the effort.

Studies carried out by Robinson et al. (2005) reveal that tutors sometimes show academic improvement in non-tutored subjects as well, and it is hypothesized that something other than extra instruction or practice may actually be influencing tutor outcomes. These findings are supported by a study by Mesler (2009) in which students involved in mathematical peer tutoring programmes experienced benefits in other school subjects other than mathematics, the influence being attributed to higher levels of self-esteem.

As part of the peer tutoring process, tutors will need to be adequately prepared for the tutoring sessions. As such, by taking part in the peer tutoring process, tutors spend time doing mathematics both before and during the tutoring sessions. The peer tutoring process thus provides opportunities for tutors to make sense of mathematics as well as "to experience the rewards of sense making in mathematics" (Kilpatrick et al., 2001, p. 131). The aspect of making sense of mathematics is crucial for tutors as they need to be able to explain concepts and processes to the tutees and answer their questions. Mesler (2009) affirms that peer tutoring has the potential to help peer tutors find success as it offers opportunities to both assist others and strengthen their own academic skills.

Kilpatrick et al. (2001) argue that for students to make progress in mathematics, motivation plays an important role. Margolis and McCabe (2004) state that one motivational factor is for the teacher to "engage students in collaborative learning activities, such as cooperative learning and peer tutoring" (p. 247). The establishment of a peer tutoring programme has the potential to provide peer tutors with opportunities to feel useful and diligent in doing mathematics. Lehr (1984) remarks that peer tutoring programmes also provide the potential for tutors to develop their leadership skills. Leadership skills may be developed through the interaction of tutors and tutees where tutors take responsibility for ensuring that tutees are guided through the sessions and also for maintaining order in their group. It is thus possible that the experience of being a peer tutor can play a role in the development of self-esteem which will serve as motivation to peer tutors. Lehr (1984) remarks that "peer teaching has also been shown to improve attitudes toward school and learning, to improve self-esteem, and increase motivation for both tutor and tutee" (p. 636). This view is supported by research carried out by Mesler (2009) in which peer tutors' academic performance, attitude and self-concept improved as a result of having taken in peer-tutoring process.

Broadly speaking, mathematical dispositions can be seen to include learners' views and perceptions of both mathematics and self in relation to how learners engage with mathematical tasks. Mathematical dispositions "...relate to learner ways of participating in mathematical learning situations" (Graven, Hewana & Stott, 2013, p. 29). To the extent that learners are social beings and that learning and knowing are intrinsically social processes (Wenger, 1998), it seems reasonable to locate the notion of mathematical disposition within a socio-cultural theoretical framework (Carr & Claxton, 2002). Within this study, mathematical disposition will thus be situated within a socio-cultural framing. Indeed, as Sadler (2002) remarks, dispositions in practice are inevitably situational.

The word 'disposition' is somewhat imprecise, but as Carr and Claxton (2002) comment it is a useful descriptor of those human attributes that are distinct from knowledge and skill. Katz (1987) describes dispositions as "habits of mind or tendencies to respond to certain situations in certain ways" (p. 2). There is, for example, a critical distinction between having mathematical skills and having the disposition to be a mathematician. Beyers (2011) remarks that the notion of mathematical disposition has been variously, and often inconsistently, conceptualised in the research literature. Consequently, operationalizations of the disposition construct have also been varied in terms of examining learner dispositions with respect to mathematics (Beyers, 2011). Carr and Claxton (2002) for example conceptualise disposition in terms of aspects they refer to as resilience, playfulness and reciprocity. Resilience is characterised by the inclination to take on challenges despite uncertainty of the outcome. Playfulness incorporates aspects such as mindfulness, imagination and experimentation, while reciprocity relates to the facility to interact with others productively (Allal, 2002; Carr & Claxton, 2002). Snow (1996) makes use of a ‘conative’ dimension which incorporates aspects of motivation and volition, while Hartman and Sternberg (1993) consider affective aspects such as motivation, attitude and affective self-regulation.

In view of the varied interpretations and operationalizations of the notion of disposition, Beyers (2011, 2012) has attempted to create a comprehensive conceptual framework for mathematical disposition, drawing from a literature review of learners’ dispositions with respect to mathematics, composed of three modes of dispositional functioning, namely *cognitive*, *affective* and *conative.*

The *cognitive* mode relates to connections and argumentation dispositional functions. For Beyers (2011), a cognitive mental function is considered dispositional with respect to mathematics “if a person has a tendency or inclination to engage (or not) in a particular cognitive mental process associated with perceiving, recognizing, conceiving, judging, reasoning, and the like in mathematics” (p. 23). Hartman and Sternberg (1993) have attempted to look at the two primary jobs of the cognitive mode as acquiring and processing information. Information processing skills are dependent on the information acquired and include inferring, analysing, synthesizing and connecting. Reasoning thus forms the basis of the cognitive mode.

The *affective* mode incorporates aspects related to the nature of mathematics (e.g. its usefulness and sensibleness), mathematics self-concept, and attitude. Hartman and Sternberg (1993) mention that there are three components which make up the affective mode – those of motivation, self-regulation and attitudes. This is reflected in the belief system of the mathematics student. Does the student believe that he or she can do mathematics? If the student believes that they cannot, this is likely to be reflected in the development of anxiety and other negative feelings towards mathematics.

The *conative* mode relates to aspects such as effort and persistence. This can be seen in a student's tendency to strive for diligence in doing mathematical tasks (Beyers, 2011). Students may show high or low levels of persistence in the face of challenging mathematical tasks. This study draws on these three categories as framed by Beyers (2011, 2012).

Beyers (2011, 2012) developed a Mathematical Dispositional Functions Inventory (MDFI) to assess mathematical disposition with respect to these three modes or categories. The category of *Cognitiv*e is designed to assess connections and argumentation dispositional functions. The category of *Affective* is meant to assess the nature of mathematics, its usefulness, worthwhileness, sensibleness, as well as mathematics self-concept, attitude, and mathematics anxiety. The category of *Conative* assess effort/persistence dispositional functions (Beyers, 2011)

Although the MDFI instrument was developed to measure prospective teachers' dispositions with respect to mathematics, it can readily be adapted to assess mathematical disposition of school learners. The following table provides descriptions of the categories (and subcategories) of the dispositional functions along with a sample item as framed by Beyers (2011).

Table 2.1 Dispositional functions based on Beyers (2011)

Scale	**Subcategory of Dispositional Function**	**Description of Subcategory**	**Sample Item**
Cognitive	Connections	A tendency to try and connect with or cross mathematical topics.	In general, I try to see how mathematical ideas in different maths classes are connected to each other.
	Argumentations	A tendency to evaluate the mathematical correctness of statements, make mathematical arguments, justify mathematical statements, etc.	Even if I' m not asked to, I try to develop and evaluate mathematical arguments to explain things in maths classes.

Affective	Nature of Mathematics	A belief about mathematics being more procedural or conceptual in nature.	In general, mathematics is made up of procedures and algorithms.
	Usefulness	A belief about the usefulness of mathematics for meeting current or future needs in or out of school.	I need to learn maths because, if I want to be a teacher, I need maths.
	Worthwhileness	A value judgement that the work put into learning mathematics has been worth it to the student.	All the work I have had to put into learning maths has been worth it to me.
	Sensibleness	A belief that mathematics is composed of ideas that can be made sense of.	In general, maths is a connected system that can be made sense of.
	Mathematics Self-Concept	What the student believes about him or herself as a learner of mathematics	In general, maths is too challenging for me to really understand it well.
	Attitude	The respondent's emotional reactions to mathematical activity in or out of school.	I like doing maths in school.
	Maths Anxiety	Whether or not the student experiences anxiety in relation to mathematics.	In general, I get stressed out when I have to take a maths test.
Conative	Effort/Persistence	A tendency to persist or exert effort if necessary.	If someone is having difficulties in maths, they can eventually do well if they persist.

2.4.2 Social constructivism

From a social constructivist perspective, knowledge is established as a human product, and is constructed socially and culturally. Social constructivists view learning as an inherently social process, and this speaks well to the notion of peer tutoring. Simon (1995) reminds us that constructivism derives from a philosophical view that as human beings we have no access to an objective reality and that our constructed reality is based on the way we engage with our experiences and perceptions, i.e. the way we adapt to our experiential world. An important aspect of this engagement is the unique prior knowledge and predispositions that individual students have (Ndlovu, 2013).

McMahon (1997) remarks that learning does not take place only within an individual but rather that learning occurs when individuals are engaged in social activities, with a dynamic role being played between one learner and another, between a learner and the instructor and the assigned learning task. McMahon (1997) further states that this interaction between individuals and the learning environment in which the individual is located grants an opportunity for individuals to construct personal understanding.

Cobb, Yackel and Wood (1992) look at learning as a process in which students actively construct mathematical knowledge as they strive to make sense of their worlds. Learning in mathematics becomes a process of recognising mathematical relationships presented in instructional representations. Students learn as they interact with one another and they make meaning of the world through this interaction. Palincsar (1998) remarks that “social interactions lead to higher levels of reasoning and learning” (p. 350). Walker (2007) suggests that making mathematics a collaborative activity rather than an individual activity can be useful as individuals are able to communicate individual insight to peers when solving mathematical problems.

Ndlovu (2013) makes the important remark that for learning to be seen to have taken place, personal constructions of knowledge must be communicated, justified and accepted by the group. This notion resonates well with a peer tutoring programme as Fox et al. (2007) comment that one of the greatest advantages of peer tutoring is that learners feel comfortable asking questions of learners of their own age.

2.5 Conclusion

The purpose of this chapter was to provide a theoretical and contextual backdrop to the study. The theoretical rationale for how peer tutoring relates to mathematical disposition was discussed, as was the link between peer tutoring, productive disposition and social constructivism. The following chapter draws these elements together to inform the design of the study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The focus of this study was to investigate how a peer tutoring programme could shape the mathematical experience of the participating tutors. This chapter outlines and articulates the methodology used in carrying out the study. Specifically, this chapter describes the goals of the study, the research orientation, the research methodology and design, the data collection techniques, the research site and participants, data analysis, validity, ethical considerations as well as the limitations of the study.

3.2 Research goals

The study investigated how a peer tutoring programme could shape the mathematical experience and mathematical disposition of the participating tutors. This was done by seeking answers to the following questions:

1. How does peer tutoring shape the mathematical experience of the participating tutors?
2. How does peer tutoring shape the mathematical disposition of the participating tutors?

3.3 Research orientation

This study is anchored in the interpretative paradigm (Leedy & Ormrod, 2005). Cohen, Manion and Morrison (2001) state that in the interpretative paradigm the researcher begins with individuals and seeks to understand their interpretations of the world around them. This study seeks to understand the mathematical experiences of the research participants through their involvement as tutors in a peer tutoring programme. The three different data collection methods used, namely the Dispositional Functions Inventory (Beyers, 2011), reflective journals and semi-structured interviews, are all firmly rooted in the interpretive paradigm.

3.4 Research methodology

A case study methodology was adopted for this study. The case under scrutiny was a group of six peer tutors, while the unit of analysis was the experiences of the tutors, with specific focus on their mathematical disposition.

The purpose of a case study is for the researcher to investigate a person, group of people or situation in great depth within their/its natural setting – in this instance a group of peer tutors within a peer tutoring environment. The study seeks to investigate how these tutors' experience as peer tutors could shape their mathematical disposition by taking an in-depth look at the experience of each tutor.

3.5 Research design

The research process was conducted in four phases:

Phase 1

In the first phase learners completed the Mathematics Dispositional Functions Inventory (MDFI) (Beyers, 2011). This was carried out before commencement of the peer tutoring programme in order to assess the mathematical disposition of the participating tutors before their experience of being part of a peer tutoring programme. The MDFI instrument was completed individually by each tutor. I was available while the MDFI was completed in case tutors needed help understanding certain questions.

Phase 2

This phase comprised the peer tutoring programme itself. There were six peer tutors in total and eighteen tutees altogether, divided randomly into six groups of three. Each of these groups was assigned a tutor. All the tutees and tutors were grade 10 learners in the same school. Each tutoring sessions was officially two hours long, although each session extended beyond the allocated 2-hour slot as learners would spend additional time doing mathematics after the official session was over. The peer tutoring programme took place over a period of three weeks. Two tutoring sessions were held each week – one on Tuesday and one on Thursday. The tutoring took place in a single classroom with each tutor and their tutees placed in a separate group. During the tutoring sessions tutors were allowed to share information and also get assistance from one another. I was present at each tutoring session in a non-participant capacity.

On the day before each tutoring session (i.e. Monday and Wednesday respectively) the tutors met to prepare for the upcoming tutoring session. The preparation sessions were each scheduled to last for two hours, but on many occasions went beyond the allocated time due to the interest of the learners. During these sessions the tutors, with my direction, discussed possible ways to explain the given topics to the tutees. Peer tutors were given the opportunity to share with the other peer tutors possible ways they would teach the topic to the tutees. The content chosen for the tutoring sessions was guided by the Grade 10 Mathematics syllabus and scheme of work. The content focused on Numbers and Operations (squares and square roots, cubes and cube roots, reverse operations, fractions and percentages, ratio, rate and proportion) as well as Money and Finance (utility bills, exchange rates, interest, tax, and personal finance). During the preparation sessions the tutors worked through and discussed the worksheets that their tutees would complete during the upcoming tutoring session. The tutors took turns in explaining their solution to their peers in a manner similar to what they would be doing in the actual tutoring sessions.

At the end of each tutoring session the peer tutors were required to complete a reflective journal in order to capture their personal experiences and reflections.

Phase 3

At the end of the three weeks of peer tutoring, a semi-structured interview was conducted with each peer tutor. The questions to the individual peer tutors were specifically developed based on the responses of that specific peer tutor in their reflective journal. The questions thus varied from one individual to another. The interviews were recorded and then transcribed.

Phase 4

Once each peer tutor had had a personal experience of peer tutoring, they were each required to complete the MDFI in order to track any potential changes in their mathematical disposition.

3.6 Data collecting techniques

Three different methods were used to collect data from each peer tutor: the MDFI (Beyers, 2011), reflective journals, and semi-structured interviews.

3.6.1 Mathematics Dispositional Functions Inventory (MDFI)

The MDFI instrument was used to asses each peer tutor's mathematical disposition. The MDFI instrument comprises 60 forced-response items formatted on a 5-point Likert scale. These items are structured around the defining characteristics of productive disposition as conceptualised by Beyers (2011) and are summarised in Table 3.1. The MDFI instrument was completed by each peer tutor both before commencement of the peer tutoring programme as well as on its completion. This was used to assess possible changes in the mathematical disposition of each research participant.

Table 3.1 Primary modes and subcategories of the MDFI instrument

MODE	SUBCATEGORY	DESCRIPTION
Cognitive	Connections	A tendency to try and connect ideas with or across mathematical topics.
	Argumentation	A tendency to evaluate the mathematical correctness of statements and to make mathematical arguments and justifications.
Affective	Nature of mathematics	A belief about mathematics being more procedural or conceptual in nature.
	Usefulness	A belief about the usefulness of mathematics for meeting current or future needs.
	Worthwhileness	A value judgement that the work put into learning mathematics is worth it.
	Sensibleness	A belief that mathematics is composed of ideas that can be made sense of.
	Mathematics self-concept	What the learner believes about themselves as a learner of mathematics.
	Attitude	The learner's emotional reactions to mathematical activity.
	Maths anxiety	Whether or not a learner expresses anxiety in relation to mathematics.
Conative	Diligence, effort, persistence	A tendency to persist or exert effort if necessary

(Adapted from Beyers, 2011, p. 30)

The MDFI instrument was originally designed to assess prospective teachers' mathematical dispositions, so the wording of some of the items had to be slightly altered. Use of the MDFI instrument was granted by its developer.

3.6.2 Tutor reflective journals

All peer tutors were asked to keep a reflective journal for the 3-week duration of the tutoring process. Peer tutors were required to record an entry after every tutor session (including the preparation sessions). The nature of the journal was anecdotal, and tutors were encouraged to reflect informally on the ups and downs of their mathematical experience as peer-tutors.

The journal entries were structured around the following five questions:

- What were your general feelings about today's session?
- What were some of your strong/weak points during the session?
- Can you describe how you felt about mathematics during the session?
- How did it make you feel to teach or prepare to teach your fellow learners mathematics?
- Describe one event in the session that particularly stood out for you.

3.6.3 Semi-structured interviews

Semi-structured interviews (Cohen et al., 2011) were used to obtain a deep understanding of the individual experiences of each peer tutor, specifically in terms of how the peer tutoring experience shaped the mathematical experience and disposition of the participating tutors. The interviews were informed by data emanating from the MDFI instrument as well as the tutor reflective journals, the purpose of the interviews being to delve deeper into the personal experiences of each tutor.

3.7 Research site and participants

The study was conducted in a school located in Otjiwarongo which is in the Otjozondjupa region of Namibia. The school was chosen for convenience since the researcher worked there as a Grade 10 Mathematics teacher. The research participants, who acted as peer tutors, comprised six Grade 10 learners selected on the basis of their mathematical proficiency. Continuous assessment marks and final examinations results were used to guide the selection of potential peer tutors. The tutees were also Grade 10 learners whose mathematical proficiency was low compared to those of peer tutors. The selection of the six participants was thus based on purposive sampling (Patton, 1990), the six peer tutors being high performers in relation to their peers.

3.8 Data analysis

3.8.1 Mathematics Dispositional Functions Inventory (MDFI)

Likert scale responses were tallied for each of the three primary modes (cognitive, affective and conative), as well as the various sub-categories, for each tutor. This data was then analysed using descriptive statistics in order to form rich profiles of each individual tutor (as well as the group of six tutors as a cohort) both prior to commencement and after completion of the peer tutoring programme. Graphs and tables were used to analyse the data.

3.8.2 Tutor reflective journals & semi-structured interviews

Data from the reflective journals and semi-structured interviews was coded and categorised into themes aligned with the primary modes and sub-categories of the MDFI instrument as outlined in Table 3.1. Since this study seeks to investigate how tutors' mathematical experience and mathematical disposition can be shaped by a peer tutoring process, this qualitative data was important in providing a rich account of each tutor's personal journey over the course of peer-tutoring programme. Themes and categories that emerged from this data were gradually grouped to provide a rich and deep characterisation of peer tutors' mathematical experience and mathematical disposition during the tutoring processes.

Table 3.2 Summary of the Research Process

Phase	Method/ Techniques	Aim	Data	Analysis
1	MDFI instrument	To assess each peer tutor's mathematical disposition before commencement of the tutoring programme.	Likert scale numeric data	Descriptive statistics.

2	Tutor reflective journal	To capture each tutor's lived experience of the tutoring process.	Qualitative data	Coding/ Themes
3	Semi-Structured Interviews	To delve deeper into each tutor's experience and to allow them to reflect on the process as a whole.	Qualitative data	Coding/Themes
4	MDFI instrument	To assess each peer tutor's mathematical disposition at the end of the tutoring programme	Likert scale numeric data	Descriptive statistics.

3.9 Validity

The MDFI instrument that was used in this study has been tested by its developer for internal consistency for each of the three modes (cognitive, affective and conative) as well as for the instrument as a whole (Beyers, 2011). Since the MDFI instrument was originally designed to assess prospective teachers' mathematical dispositions, the wording of some of the items had to be slightly altered, but these modifications were of such a nature that they would not affect the validity of the instrument in any way.

The semi-structured interviews were informed by the tutor reflective journals. This allowed the researcher to delve more deeply into issues arising from the reflective journals. During these interviews I allowed the research participants the opportunity to expand on or clarify specific journal entries where further explication was necessary. These interviews in part thus formed a process of member checking and thus constituted a form of external validation (Lewis & Ritchie, 2003).

3.10 Ethical considerations

In terms of ethical considerations I followed the principles provided by Cohen et al. (2011):

- I fully revealed my identity and background as a researcher to the participants.
- The purpose of the research was made known to the participants and their parents or legal guardians, and written informed consent from all participants and their parents or legal guardians was obtained.

- The participants participated on a voluntary basis and they retained the right to withdraw from the processes at any point.
- Participants' identities were kept anonymous.
- I obtained permission to conduct research from the Regional Education Director for the Otjozondjupa region in which Otjiwarongo is located. Permission was also obtained from the principal of the school where the research was carried out.
- I strove to be objective and honest, and to report on the research process with accuracy and integrity.

3.11 Limitations

The research investigated how a peer tutoring programme could shape the mathematical experience of the participating tutors. Given that the peer tutoring process was carried out over a relatively short time frame (3 weeks), it is likely that richer data could have been elicited if the peer tutoring process had been carried out for a longer duration. The programme was originally planned to take place over a 4-week period, but unavoidable circumstances resulted in the programme being cut short by one week.

Given that this study is a case study, it should be borne in mind that the findings can not be generalised to other situations. Nonetheless, the study adds to the growing body of research on peer tutoring.

3.12 Conclusion

This chapter provided a description of the research design as well as the instruments and techniques used. The next chapter analyses and discusses the data collected through this process.

CHAPTER 4

RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results of the study. The central focus of the study was to investigate how a peer tutoring programme could shape the mathematical experience and disposition of the participating tutors. The study took place in four successive phases, and the data from each of these phases is discussed in turn.

4.2 Phase 1 – MDFI (before commencement of peer tutoring programme)

The MDFI instrument was used to create a rich profile of each tutor prior to commencement of the peer tutoring programme. The overall results are first presented and then each of the six tutors is discussed in turn.

Table 4.1 MDFI results prior to commencement of the peer tutoring programme

	Tutor 1	Tutor 2	Tutor 3	Tutor 4	Tutor 5	Tutor 6	MIN possible	MAX possible
COGNITIVE	**0.62**	**0.48**	**0.66**	**0.80**	**0.64**	**0.62**	**0.2**	**1**
Connections	0.68	0.52	0.68	0.72	0.68	0.64	0.2	1
Argumentation	0.56	0.44	0.64	0.88	0.60	0.60	0.2	1
AFFECTIVE	**0.69**	**0.69**	**0.67**	**0.79**	**0.65**	**0.70**	**0.2**	**1**
Nature of Mathematics	0.58	0.56	0.48	0.66	0.56	0.60	0.2	1
Usefulness	0.67	0.62	0.60	0.84	0.60	0.65	0.2	1
Worthwhileness	0.80	0.93	0.93	0.87	0.33	0.67	0.2	1
Sensibleness	0.60	0.70	0.75	0.70	0.60	0.55	0.2	1
Mathematics Self-concept	0.73	0.70	0.80	0.73	0.83	0.77	0.2	1
Attitude	0.80	0.75	0.95	0.90	0.90	0.90	0.2	1
Maths Anxiety	0.80	0.92	0.60	0.96	0.76	0.92	0.2	1
CONATIVE	**0.84**	**0.76**	**0.76**	**0.96**	**0.64**	**0.56**	**0.2**	**1**

Table 4.1 provides a summary of the MDFI results for the participating tutors prior to commencement of the peer tutoring programme. Results are shown for each of the three primary scales of *cognitive*, *affective* and *conative*, as well as the various subcategories.

There are a number of interesting anomalies that are worth noting. In the cognitive mode, tutors 1, 3, 5 and 6 are within the same range whereas tutor 2 scored significantly lower (0.48) and tutor 4 scored significantly higher (0.80). In the affective mode, tutors 1, 2, 3, 5, and 6 all have scores between 0.65 and 0.70, whereas tutor 4 scored somewhat higher at 0.79. In the sub-domains under the affective mode there are a number of interesting anomalies. In relation to worthwhileness, tutor 5 scored 0.33 which is far lower than the other tutors. This tutor doesn't see the effort he has put into his mathematics as having been worthwhile. In terms of usefulness subcategory, all the tutors, with the exception of tutor 4, had scored close to neutral. Tutor 4 scored 0.84 which indicates that this tutor sees the usefulness of mathematics outside of the school context.

Each tutor is now profiled individually. Given that the lowest and highest obtainable scores per MDFI primary scale or subcategory are 0.2 and 1 respectively, only responses that are reasonably removed from a median (neutral) score of 0.6 are highlighted at this point.

4.2.1 Tutor 1

With respect to the cognitive mode, this tutor scored 0.62 which represents a neutral value. The subcategories of connections and argumentations are similarly neutral. In the affective mode this tutor scored 0.69. The most noteworthy subcategories that resulted in this somewhat higher score were those of worthwhileness, attitude and maths anxiety, each of which had a score of 0.8. This tutor not only enjoys doing mathematics (attitude), but sees the effort and work he has put into his mathematics as being worthwhile (worthwhileness). In addition, this outlook is manifested in an inner confidence that sees this tutor not becoming stressed when working on mathematical tasks in class or when writing maths tests[1]. With respect to the conative mode, this tutor scored a high 0.84. This high value indicates that the tutor possesses qualities such as diligence and determination with regard to persisting with difficult or confusing mathematical questions/tasks.

[1] It is important to remember that the MDFI scores relate to a *positive* disposition with respect to the domain or subcategory. A high score for the subcategory *Maths Anxiety* thus means the student has a *positive* disposition with regard to anxiety – i.e. that they *aren't* anxious and *don't* get stressed.

4.2.2 Tutor 2

With regard to the cognitive mode, this tutor scored a low 0.48 with the subcategories of connections and argumentation both being low – 0.52 and 0.44 respectively. Tutor 2 is not able to connect ideas across mathematical topics, and tends to shy away from mathematical investigation and justification. In the affective mode this tutor scored 0.69 which is slightly above a neutral score. The most noteworthy subcategories that resulted in this elevated score were those of worthwhileness and maths anxiety where this tutor scored 0.93 and 0.92 respectively. The high score for worthwhileness shows that this tutor finds all the hard work she has invested in her mathematics has been worth the effort. In addition to this positive outlook the high score for the maths anxiety subcategory indicates that feeling stressed because of mathematics is not an issue for this tutor. With respect to the conative mode, this tutor scored a high 0.76. This reflects that this tutor believes that qualities such as persistence and diligence eventually pay off.

4.2.3 Tutor 3

With respect to the cognitive mode, this tutor scored 0.66 which represents a neutral value. The overall score for the affective mode is 0.67. Although this is only slightly higher than neutral, there are particular subcategories that were either particularly high or particularly low. The most noteworthy high scoring subcategories are worthwhileness and attitude where the tutor scored 0.93 and 0.95 respectively. This tutor not only really enjoys doing mathematics (attitude), but also finds the work she puts into the subject of value (worthwhileness). Interestingly though, her score for the nature of mathematics subcategory was a low 0.48. This indicates that she sees mathematics as a highly rule-based, algorithmic and procedural subject. With respect to the conative mode, this tutor scored a reasonably high value of 0.76 which reflects a high level of diligence, persistence and determination in her mathematics, and that such attributes are related to success in mathematics.

4.2.4 Tutor 4

With respect to the cognitive mode, this tutor scored 0.80 which represents a high value. The subcategories of connections and argumentation are both high. This shows that this tutor tries to connect ideas across mathematical topics and tries to articulate her mathematical reasoning processes. In the affective mode this tutor scored 0.79. The most noteworthy subcategories that resulted in this high score were those of usefulness (0.84), worthwhileness (0.87), attitude (0.95) and maths anxiety (0.96). This tutor sees the practical value and relevance of mathematics as a school subject. She enjoys mathematics, believes that hard work pays off, and is confident when engaged in mathematical tasks and tests. With respect to the conative mode, this tutor scored a high 0.96. This very high score is an indicator that the tutor possesses qualities such as diligence and determination with regard to solving difficult mathematical problems. The tutor believes that in general if one persists with a difficult task, one will ultimately make progress.

4.2.5 Tutor 5

With reference to the cognitive mode, this tutor scored 0.64 which is only slightly higher than a neutral value. In the affective mode this tutor scored 0.65. Although this overall score is only slightly higher than neutral, the picture becomes more interesting when one looks at the subcategories. The most noteworthy subcategories with high scores are mathematical self-concept (0.83) and attitude (0.90). This tutor is confident in his mathematical ability (self-concept) and enjoys doing mathematics (attitude), both of which are mirrored in the relatively high score of 0.76 for the maths anxiety subcategory. Interestingly, the low score of 0.33 for the worthwhileness subcategory indicates that even though the tutor enjoys mathematics and is confident in his ability he nonetheless doesn’t see the effort he has put into his mathematics as being worthwhile.

4.2.6 Tutor 6

With reference to the cognitive mode, this tutor scored 0.62 which represents a neutral value. In the affective mode this tutor scored 0.70. The most noteworthy subcategories that resulted in this somewhat above neutral score were those of attitude and maths anxiety, with scores of 0.90 and 0.92 respectively. This tutor enjoys doing mathematics and does not easily get stressed when doing mathematics in class or when writing tests. With respect to the conative mode this tutor scored 0.56. This score is only slightly below neutral, but responses to specific questions indicate that she sometimes lacks the determination to persist with difficult or confusing mathematical tasks.

4.3 Phase 2 – Peer tutoring programme

This phase of the data analysis process involved repeatedly reading through the reflective journals that the tutors kept during the course of the peer tutoring programme. A number of common themes gradually emerged from the journal entries, and the various entries were coded accordingly.

The themes that emerged relate to: self-confidence, better understanding of mathematics, prospects of improving mathematics examination results, and feeling good/happy and appreciated by peers. Although these themes are presented separately it is important to acknowledge that they are nonetheless interrelated.

4.3.1 Self-confidence

A strong theme running through the journal entries related to self-confidence. The peer tutors who participated in this study reflected in their journals that the peer tutoring programme had a positive influence on their self-confidence.

Tutor 1 for example commented that the positive emotion generated during the tutoring programme resulted in him feeling "*even more confident to aim high in mathematics … and help other learners do the same"* (lines 95-96). Significantly, as revealed in this particular journal entry, the self-confidence generated through the tutoring programme also manifested in a desire to help others achieve well in mathematics. Tutor 1 also reports that the tutoring sessions "*made me to think outside the box and helped me to start believe that I can be good at mathematics*" (lines 115-116). Although the tutoring sessions challenged this tutor to think "outside the box", the mutually supportive environment of the tutoring and preparation sessions ensured that this was a positive and reinforcing experience. Tutor 1 also reflects that his increased self-confidence resulted in an improved sense of personal autonomy: "*I realised that I can now solve mathematical problems alone without any problems*" (lines 115-116).

Tutor 3 remarked that the peer tutoring programme impacted positively on her self-confidence, commenting that "*every day when I come to the mathematics classes I always get confidence that is why my day was so good"* (lines 316-317). Here we see that the self-confidence generated through the peer tutoring programme impacting on the tutors' affective wellbeing beyond the confines of the tutoring programme itself. Tutor 3 reveals that complements from tutees helped her to build her confidence: *"during this session my fellow learners told me that I am the best and that gave me confidence"* (lines 337-338). In addition to affective aspects, the tutor found the tutoring programme very helpful in terms of building her mathematical understanding and reinforcing her mathematical confidence.

Tutor 4 indicated that the peer tutoring programme improved her general confidence and courage, remarking that "it was good because I gained confidence in myself and my work, I also gained courage" (lines 461-462). For tutor 5 it was the process of teaching others that helped in building his confidence: "*…my confidence in mathematics keeps on building because of teaching other learners*" (lines 607-608). The tutor suggests in his journal that tutoring other learners impacted positively his self-image, remarking that *"just for me to be able to teach other learners made me feel strong and I am now confident that I can help other learners and in the process I am also learning"* (lines 677-678). The tutor suggests that by teaching other learners, not only has his self-confidence improved, he has also improved his own mathematical understanding.

4.3.2 Better understanding of mathematics

All the peer tutors who participated in this programme indicated that the peer-tutoring process helped them to understand mathematics better. Tutor 2 commented that "*It was very great … I understand some new things that I never understood before"* (lines 163-164). With respect to the specific topic of fractions, Tutor 2 remarked that *"I can now do fractions I never understood before in my life but now I understand the topic very well and I can explain to others well"* (lines 156-157).

Tutor 3 makes an important point that it was the process of teaching others, and the preparation that went into it, that had the positive effect of building her own mathematical understanding: "*it feels good to teach others because it helps me understand mathematics better"* (lines 431-432). Tutor 5 remarks that "*I felt so excellent when I was doing mathematics during the session because I know some things I did not know [previously]"* (lines 584-585). What the peer tutors are advocating is that the peer tutoring process was successful in terms of improving their own mathematical understanding.

4.3.3 Prospects of improving mathematics examination results

All six tutors shared the sentiment that peer tutoring afforded them an opportunity to potentially improve their examination results. Tutor 1 wrote that "*if one want to pass one have just to work hard and it can be done"* (lines 172-173). The peer tutoring process developed in this tutor a belief that if one works hard there is a good chance of improving one's results. The tutor also sees the peer tutoring programme as an opportunity for doing just this. Tutor 4 expressed the following feelings: "*I felt great knowing that this session will help me a lot to improve my results and [those of] my fellow learners"* (line 467). The tutor acknowledges that the programme presented an opportunity not only for the tutees to improve their results but for her as a tutor to improve her results as well. Tutor 5 sees improved results as becoming a reality: *"I see that this will improve my mathematics skills very well and it will also help me in my examination. I now feel so confident in Mathematics and I feel I can get an A symbol if I work hard"* (lines 602-604). Furthermore, tutor 5 commits himself to improving his mathematics, remarking that "*I am willing to do my best to improve in mathematics results"* (lines 632-633). Tutor 6 remarks that *"this year my aim is to get high marks in mathematics"* (lines 708-709). These tutors see their participation in the peer tutoring programme as having a positive impact on their drive to succeed and thus ultimately on their mathematics examination marks.

4.3.4 Feeling good, happy and appreciated by peers

All six peer tutors indicated that being a peer tutor made them feel happy and appreciated by their peers. Tutor 2 wrote in her journal that through this programme her inner feelings changed as she now feels happy and hopeful to pass mathematics. She wrote that "*I am now a very happy person, I have improved in my mathematics as I passed the test we wrote and learners in my group did well also"* (lines 279-280). The tutor expressed happiness to see changes in her peers "*I was so happy to see how learners in my group are getting interested in mathematics"* (lines 282-283)

Tutor 3 remarked that "*to teach others makes me feel good because my fellow learners try their best to do well and understand mathematics"* (lines 345-346). Tutor 4 shared the following insight: "teaching *my fellow learners mathematics was really great, that feeling of* *knowing you are sharing your knowledge with others is a most wonderful feeling"* (lines 530-531).

For Tutor 5, the experience of having been a peer tutor has inspired him to consider teaching a future career: "*I have now decided to be a teacher for mathematics, I realised that helping others makes you feel good"* (lines 670-671). It seems that for all tutors involved, helping other learners was a positive personal experience.

4.5 Phase 3 – Semi-structured interviews

The purpose of the semi-structured interviews was to probe deeper into each tutor's personal experience of the tutoring process. Qualitative data from these interviews was transcribed and categorised in terms of the modes and subcategories of the MDFI instrument.

4.5.1 Tutor 1

Tutor 1 commented that taking part in the peer-tutoring programme had strengthened his understanding of fractions, and that this in turn had positively influenced his understanding of other mathematical domains. In his own words, his improved conceptual grasp of fractions "*makes me to understand more about mathematics"* (lines 27-28). This suggests that the tutor was able to link the topic of fractions to other mathematical topics across the curriculum.

An important aspect of the tutoring experience for Tutor 1 was that the process of helping others had the reciprocal effect of improving his own mathematics – "*teaching other learners helped me to develop a deeper understanding of mathematics*" (lines 5-7). There were two levels to this interaction. The first involved the mutual support and assistance of the tutors amongst one another, while the second revolved around the interaction between each tutor and his or her group of tutees. For Tutor 1, both of these interactions had a positive effect in terms of deepening his own mathematical understanding. With reference to the tutor-tutee interaction, Tutor 1 mentioned that having to respond to questions asked by the tutees helped his own conceptual understanding of the topic being discussed. Responding to tutees questions requires a certain degree of critical reflection on the topic being discussed, and this process seems to have been useful for Tutor 1 in terms of his own mathematical understanding: "*As I was teaching some learners in my group it really helped me to understand better by the questions they asked*" (lines 7-8).

The peer tutoring process also resulted in a change in Tutor 1's view of mathematics. Although his own Mathematics marks were not particularly good, he commented that "*when I became a peer tutor I see that mathematics makes a lot of sense and I can do it*" (lines 11-12). This reflects an important change in outlook. This is echoed in his remark that although he initially regarded Mathematics as a difficult subject, the peer-tutoring process "*gave me confidence and courage that I can be good"* (lines 14-15). Mathematical self-concept has to do what a learner believes about themselves as a learner of mathematics. The peer-tutoring programme was meaningful for this tutor as it allowed him to experience a sense-making process which in turn resulted in improved learner confidence and courage.

4.5.2 Tutor 2

Tutor 2 sees mathematics as being a part of her future career. Her view of mathematics is shaped by this outlook and she remarked that "*whenever I am doing anything I am always thinking of my future career"* (lines 54-56). Furthermore, this tutor found the peer tutoring programme helpful with respect to her projected future: "*being a peer tutor myself it helped me a lot because I know that mathematics is part of my future career*" (lines 47-48). This suggests that the tutor is able to see the usefulness of mathematics in her future life.

In addition to the mathematical usefulness of the peer tutoring experience, the tutor also appreciated the worthwhileness of the peer tutoring programme in terms of the affective domain: *"for the first time in my life I felt like doing something useful to other people"* (line 62). This generated emotions of happiness in this particular tutor as she states that *"I felt happy because I can teach someone and I was helpful to others that made me feel very happy"* (lines 75-76). Tutor 2 found it rewarding to help other people, in this case teaching other learners mathematics.

The peer tutoring programme was not only worthwhile for Tutor 2 because it brought feelings of happiness, but also because it helped her to improve in other subjects. Tutor 2 remarked that "*It had been worth it for me because it is helping me with other subjects which uses numbers likes physical science and entrepreneurship."* (lines 79-80).

Tutor 2 comments that her attitude towards mathematics also changed through the peer tutoring process: "*I changed a lot because before I became a tutor I used to see mathematics as a difficult subject, when I started teaching other learners I realised mathematics was simple"* (lines 127-128). Tutor 2 further remarks that *"I changed my attitude; I now concentrate on my school work and mathematics. I told myself that I will pass mathematics and I can do it"* (lines 58-59). The peer tutoring process has had an important positive effect on the general attitude of this particular tutor towards school. In her own words, "*being a tutor motivated me to work hard"* (lines 49-50).

4.5.3 Tutor 3

Tutor 3 stated that "I *felt great because when I teach other learners I also teach myself and I just understand better"* (lines 104-105). This remark highlights an important aspect of mathematics, namely that by teaching someone else one develops a better understanding of the subject content oneself.

The peer tutoring experience had a positive motivating influence on Tutor 3: *"I now believe that I will pass mathematics with an A symbol because I will put more effort in mathematics. Now I know mathematics is not that difficult if you put more effort mathematics can be easy"* (lines 99-102). Through participating in the tutoring programme, the tutor's perception of mathematics has changed and she now considers it within her ability to improve her mathematics.

4.5.4 Tutor 4

Tutor 4 finds mathematics useful, and remarks that "*…mathematics is something that is enjoyable and it happens in everyday life and everyone actually needs the knowledge of mathematics"* (lines 154-156). Tutor 4 found the peer tutoring programme not only useful but also rewarding and worthwhile: *"teaching mathematics, I know that doing it I am helping other learners in mathematics and I will improve in my own mathematics"* (lines 143-144)

Tutor 4 acknowledges that the peer tutoring programme changed her outlook on her own mathematical ability: "*before I became a tutor I used to see mathematics as a difficult subject [but] when I started teaching other learners I realised that it was simple*" (lines 127-

128). The peer tutoring experience resulted in this tutor developing a positive mathematical disposition: "*I was paying more attention than I was before and putting more effort in my work"* (lines 128-130). The tutor's perception changed and she now sees mathematics as being far more accessible and doable. When the tutor experienced the joy of being able to do mathematics it had a profound influence on her view of the subject and her overall mathematical disposition: *"I started giving a lot of attention to mathematics on my own and doing a lot of mathematics activities from the textbook. I started spending more time doing mathematics and I fell in love with mathematics"* (lines 136-139). The tutor also now has the confidence to tackle mathematics with conviction and determination. Importantly, the tutor remarked that "*My confidence I believe started when I became a tutor*" (line 150).

4.5.5 Tutor 5

Tutor 5 sees mathematics as being useful outside the school situation, particularly with respect to his future career: *"I enjoy doing mathematics, even in my future career I am looking forward to work in the bank; I believe mathematics will help me a lot"* (lines 195-196). The tutor further comments that "*mathematics is the subject that you can do not only at school even at home it can help in some activities"* (lines 191-192). This tutor sees the usefulness of mathematics beyond the classroom and that it can be used in one's daily life.

Tutor 5 saw value in the peer tutoring experience and remarked that *"the more you are teaching others the more you learn and make them understand what you are teaching helps you understand mathematics better and it really made me proud"* (lines 182-184). The peer tutoring experience was not only useful for this tutor in terms of his own mathematical understanding, but also in terms of important affective aspects. The anxiety levels experienced by this tutor also seem to have improved: "*now I find mathematics very easy and writing a test would not stress me up"* (line 199).

4.5.6 Tutor 6

Tutor 6 found the peer tutoring programme very helpful and comments that *"it helped me a lot because some things that I did not understand I was taught by my fellow peer tutors, I was even empowered to teach other learners even my understanding of mathematics improved"* (lines 207-209). The tutor found his participation in the peer tutoring process not only of mathematical benefit, but also an empowering and enjoyable experience. The tutor also reports increased levels of mathematical confidence: *"I can now understand some topics and I am now more confident in mathematics"* (213-214). This increased confidence is also manifested in a more positive view of mathematics as a subject: *"I now believe that this is the subject I can do"* (line 232).

4.6 Phase 4 – MDFI (after conclusion of peer tutoring programme)

The MDFI instrument was used to create a rich profile of each tutor after concluding the peer-tutoring programme. The overall results of the MDFI instrument are shown in Table 4.2

Table 4.2 MDFI results after conclusion of the peer tutoring programme

	Tutor 1	**Tutor 2**	**Tutor 3**	**Tutor 4**	**Tutor 5**	**Tutor 6**		
	POST	**POST**	**POST**	**POST**	**POST**	**POST**	**MIN Possible**	**MAX possible**
COGNITIVE	**0.72**	**0.86**	**0.78**	**0.90**	**0.74**	**0.82**	**0.2**	**1**
Connections	0.80	0.84	0.84	0.92	0.64	0.80	0.2	1
Argumentation	0.64	0.88	0.72	0.88	0.84	0.84	0.2	1
AFFECTIVE	**0.73**	**0.68**	**0.72**	**0.84**	**0.73**	**0.68**	**0.2**	**1**
Nature of Mathematics	0.68	0.60	0.62	0.70	0.64	0.60	0.2	1
Usefulness	0.71	0.64	0.67	0.78	0.62	0.64	0.2	1
Worthwhileness	0.80	0.93	0.93	1.00	0.87	0.87	0.2	1
Sensibleness	0.65	0.60	0.70	0.85	0.70	0.70	0.2	1
Mathematics Self-concept	0.70	0.70	0.77	0.87	0.80	0.63	0.2	1
Attitude	0.85	0.90	0.95	0.95	0.80	0.90	0.2	1
Maths Anxiety	0.80	0.68	0.68	1.00	0.96	0.68	0.2	1
CONATIVE	**0.96**	**0.60**	**0.72**	**0.96**	**0.64**	**0.72**	**0.2**	**1**

Table 4.2 provides a summary of the MDFI results for the participating tutors after conclusion of the peer tutoring programme. As with Table 4.1, results are shown for each of the three primary scales of *cognitive*, *affective* and *conative*, as well as the various subcategories. Compared with the MDFI results prior to commencement of the peer tutoring programme, all six tutors saw an increase in their cognitive mode scores, the biggest increases being those of tutor 2, whose score increased from 0.48 to 0.86, and tutor 6 who increased from 0.62 to 0.82. In the affective mode the overall scores suggest little

change, but the subcategories show some interesting shifts. In the subcategory of worthwhileness, for example, Tutor 5 increased dramatically from 0.33 to 0.87. The conative mode saw an increase for Tutors 1 and 6, a slight decrease for Tutor 2, while the scores for Tutors 3, 4 and 5 remained relatively constant.

4.7 Discussion

In this section the two sets of MDFI results, i.e. before and after the peer-tutoring programme, are compared. This is done with supporting data obtained from the tutor reflective journals as well as the semi-structured interviews.

4.7.1 Tutor 1

4.7.1.1 Cognitive

The overall cognitive mode of Tutor 1 increased slightly from 0.62 to 0.72 Figure 4.1 shows the two subcategories for the cognitive mode both before and after the peer tutoring programme.

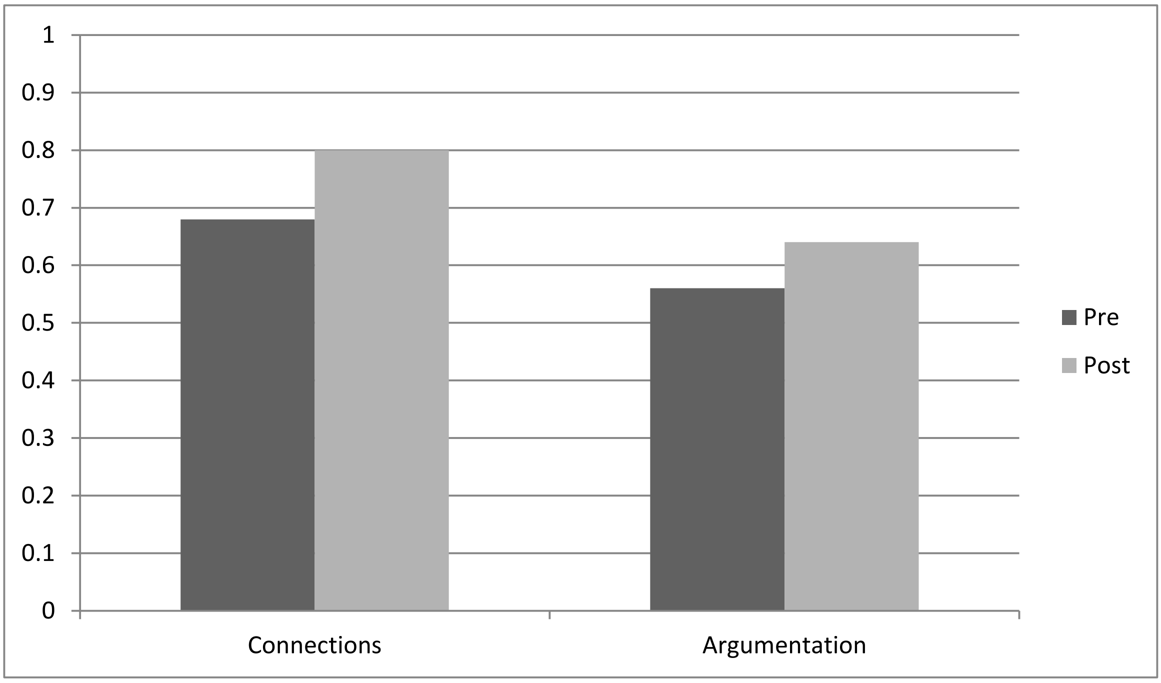

Figure 4.1 Cognitive subcategories for Tutor 1

Both subcategories increased slightly. The tutor's response to Q12 (Even if I'm not asked to, I try to use various methods of reasoning in mathematics) changed from being 'neutral' to 'agree'. The tutor now seems to be more open to exploring different reasoning approaches when trying to make sense of mathematics: *"my strong points were changing teaching methods* [i.e. different methods of explanation] *that made it easy for everyone to understand"* (line 105). The tutor's response to Q53 (In general, I try to see how mathematical ideas in maths classes are connected to things outside of school) changed from 'agree' to 'strongly agree'. The tutor suggests that he is now more sensitive to seeing the connections between mathematics in the classroom and mathematics outside of the classroom context.

4.7.1.2 Affective

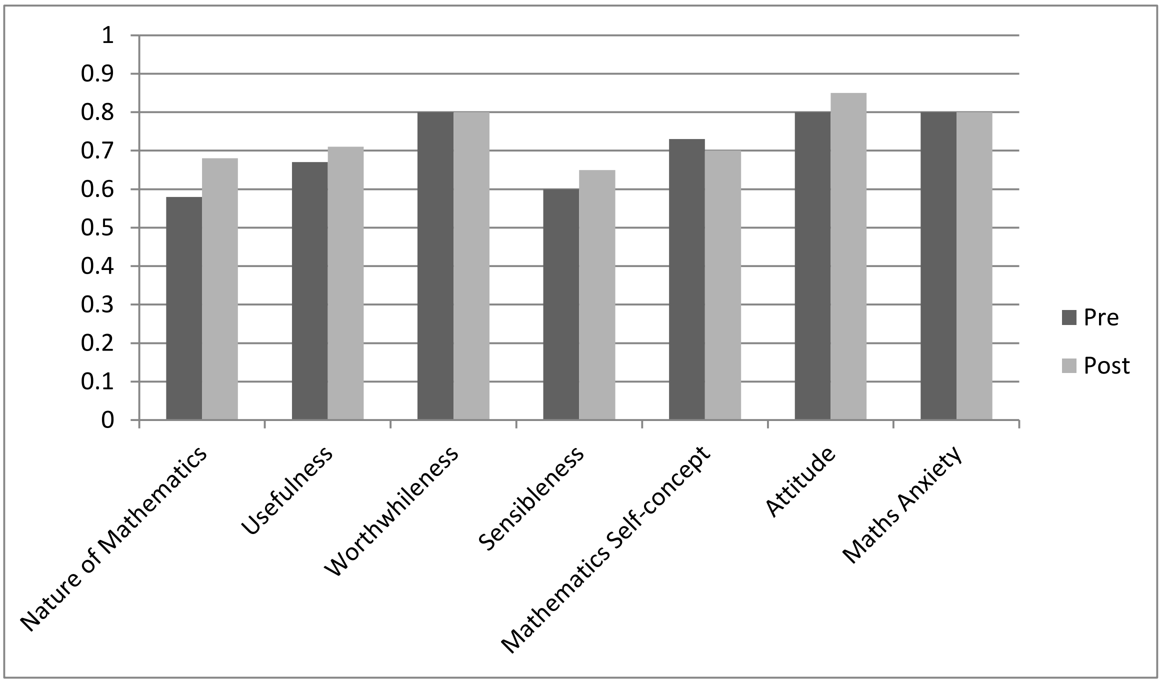

Figure 4.2 Affective subcategories for Tutor 1

Overall the affective mode increased marginally from 0.69 to 0.73. Although overall there seems to be little change, the change in response to specific questions is revealing. The tutor's response to Q28 (In general, maths is too challenging for me to really understand it well) changed from 'disagree' to 'strongly disagree'. In other words, after the tutoring programme this tutor seems to be more confident that he can tackle the challenges of maths. This change by the tutor is supported by the sentiments he shared in the reflective journal that *"I felt that now I can do maths and I am good at it"* (line 121). Q35 (Ideas learned in one maths class can help you learn ideas in other maths classes) changed from 'neither agree nor disagree' to 'strongly agree' while Q45 (most mathematical ideas are related to one another) changed from 'neither agree nor disagree' to 'agree'. This is a clear indication that there has been a general increase in the sense that maths is inter-related and inter-connected rather than being composed of discrete sections.

4.7.1.3 Conative

The conative mode increased from 0.84 to 0.96. Q8 (No matter how much effort some people put into learning maths, they just won't understand it) changed from 'neither agree nor disagree' to 'strongly disagree' while Q36 (If someone is having difficulties in maths, they can eventually do well if they persist) changed from 'agree' to 'strongly agree'. This suggests that this tutor experienced an increased sense of the importance of resilience with regard to engaging with mathematical problems.

4.7.2 Tutor 2

4.7.2.1 Cognitive

This tutor showed a high increase in the cognitive mode, from 0.48 to 0.86. Figure 4.3 shows the two subcategories for the cognitive mode both before and after the peer tutoring programme.

The connections subcategory increased from 0.52 to 0.84. The biggest change per item response was in Q19 (When I think about mathematical ideas, I try to think about how they connect to other ideas in maths) which changed from 'strongly disagree' to 'agree'. The tutor seems to be much more open to exploring and thinking about the connections in mathematics. This is corroborated by her responses to Q27 (In general, I try to see how mathematical ideas in different maths classes are connected to each other) which changed from 'neither agree nor disagree' to 'agree'.

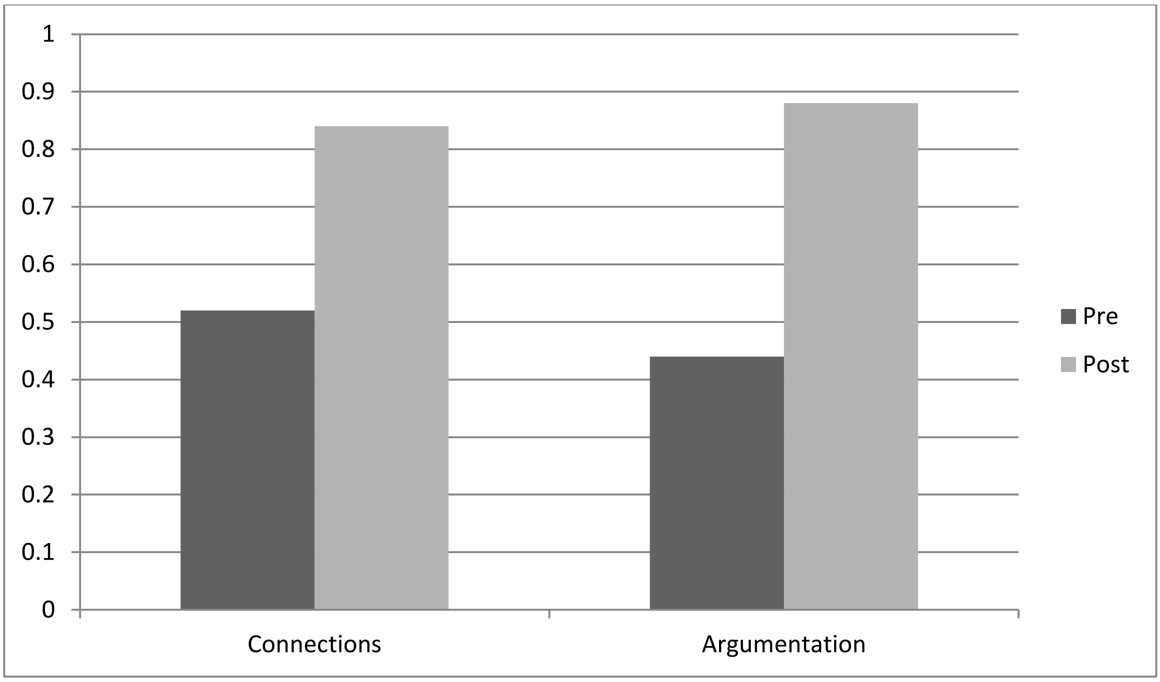

Figure 4.3 Cognitive subcategories for Tutor 2

The argumentations subcategory increased from 0.44 to 0.88. The tutor's response to Q12 (Even if I'm not asked to, I try to use various methods of reasoning in mathematics) changed from 'disagree' to 'strongly agree'. The tutor would now seem to be more open to exploring alternative solution paths when engaging with mathematical tasks. There was also a change in response to Q48 (Even if I'm not asked to, I try to develop and evaluate mathematical arguments to explain things in maths classes), which changed from 'disagree' to 'agree'. This change may well have been a result of the experience of trying to explain mathematical ideas and processes to tutees.

4.7.2.2 Affective

The overall score for the affective mode remained essentially constant, from 0.69 to 0.68. Changes in the various subcategories for the affective domain are shown in Figure 4.4.

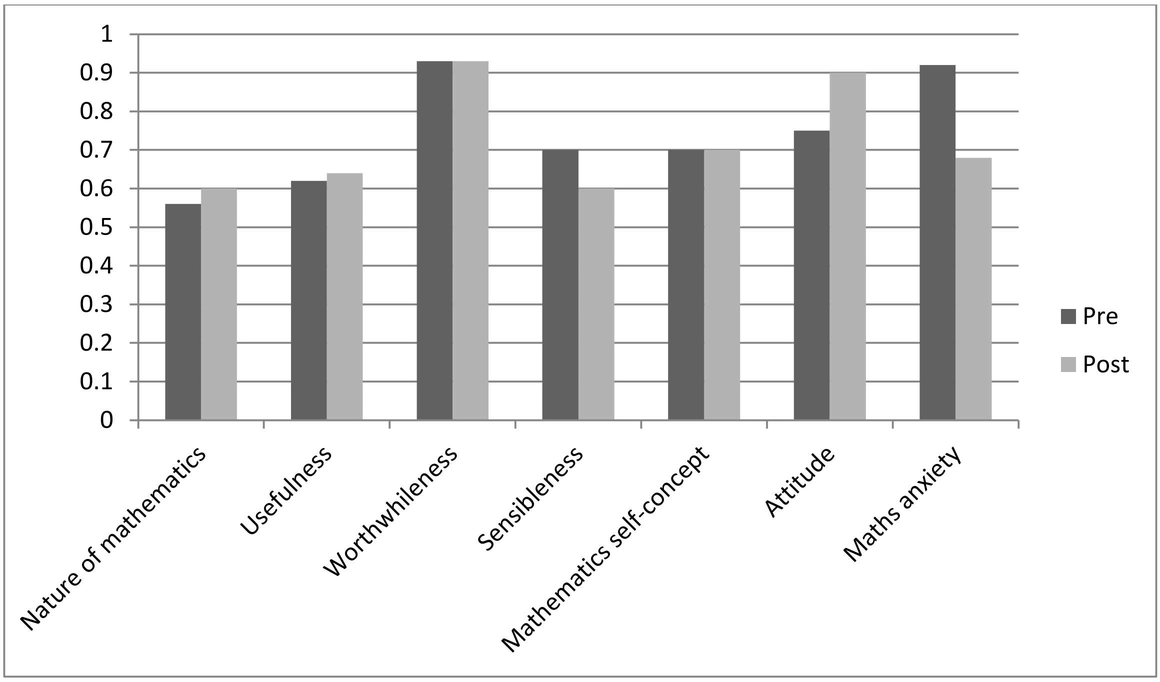

Figure 4.4 Affective subcategories for Tutor 2

Scores for three of the subcategories increased, two decreased, and two remained the same. Interestingly though, her response to Q1 (In general, I don't get stressed when I am doing maths in non-school situations) changed from 'agree' to 'disagree'. Responses to three other questions showed an increase in perceived levels of maths anxiety, although there is no evidence from the tutor's reflective journal that supports this change. The tutor did however occasionally express that she found some of the maths topics difficult for her. Q11 (I like doing maths in situations outside of school) changed from 'disagree' to 'agree' while Q52 (I like doing maths in school) changed from 'neither agree nor disagree' to 'strongly agree'. Despite possible maths anxiety, this tutor's responses nonetheless suggest an increased enjoyment of mathematics.

4.7.2.3 Conative

The score for the conative mode decreased from 0.76 to 0.60. Of particular interest is the change in response to Q8 (No matter how much effort some people put into learning maths, they just won't understand it) changed from 'strongly disagree' to 'agree' as well as Q22 (If I don't figure out something in maths pretty quickly, then I probably won't even if I keep trying) which changed from 'disagree' to 'strongly agree'. These responses resonate with the tutor's increased levels of maths anxiety, and there may well have been incidents in the tutoring process that sparked this change, although there is no evidence of this in her reflective journal.

4.7.3 Tutor 3

4.7.3.1 Cognitive

In the cognitive mode this tutor increased from 0.66 to 0.78. Figure 4.5 shows the two subcategories for the cognitive mode both before and after the peer tutoring programme.

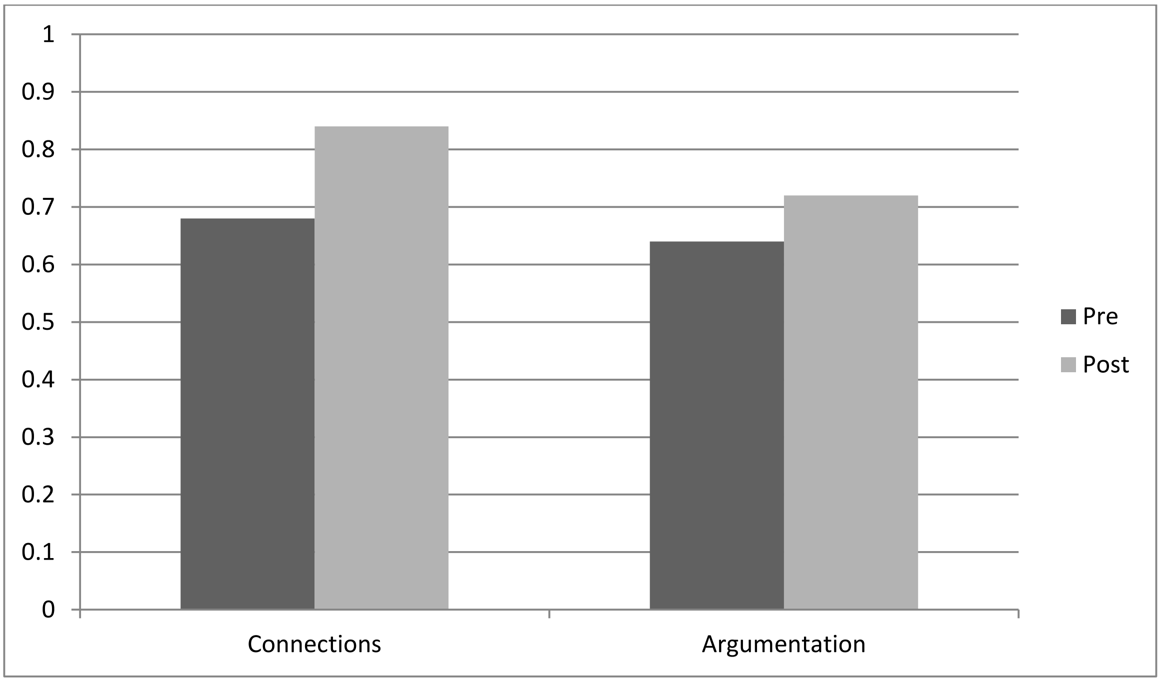

Figure 4.5 Cognitive subcategories for Tutor 3

In terms of the individual item responses, the two biggest changes were in Q51 and Q26. The response to Q51 (In general, I try to see how mathematics ideas within a single class are connected to each other) changed from ‘strongly disagree’ to ‘agree’. This represents a significant shift and indicates that the tutor is now much more appreciative of the interconnectedness of mathematical ideas.

4.7.3.2 Affective

The score for the affective mode of the tutor increased marginally from 0.67 to 0.72. Figure 4.6 shows the various subcategories for this mode.

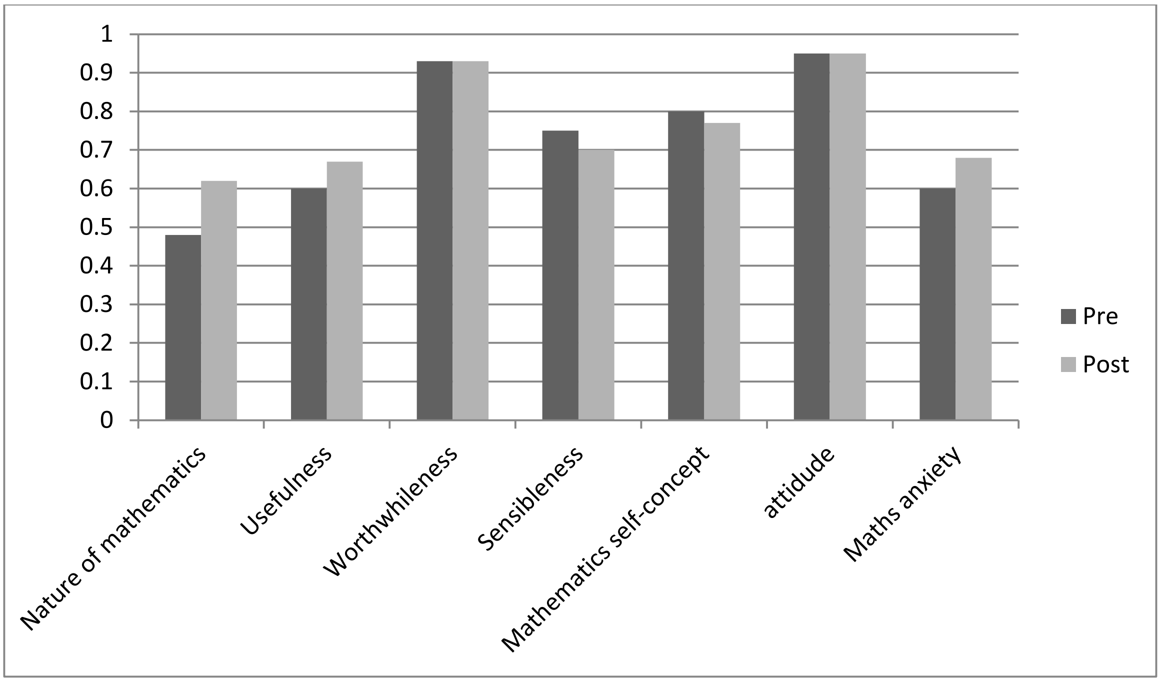

Figure 4.6 Affective subcategories for Tutor 3

Within the affective mode, three items increased in score, two items remained the same and two items decreased. A notable change is seen Q35 (Ideas learned in one maths class can help you learn ideas in other maths classes) which changed from 'neither agree nor disagree' to 'strongly agree'. This resonates with the response to Q13 (Different areas in maths that you have studied, like fractions and geometry, are not related very much) which changed from 'agree' to 'disagree'. There has been a clear shift in this tutor's view of the interconnectedness of mathematical ideas.

4.7.3.3 Conative

The conative mode decreased marginally from 0.76 to 0.72. There were no significant changes to individual item responses.

4.7.4 Tutor 4

4.7.4.1 Cognitive

The cognitive mode of the tutor increased from 0.80 to 0.90. Figure 4.7 shows the two subcategories for the cognitive mode both before and after the peer tutoring programme.

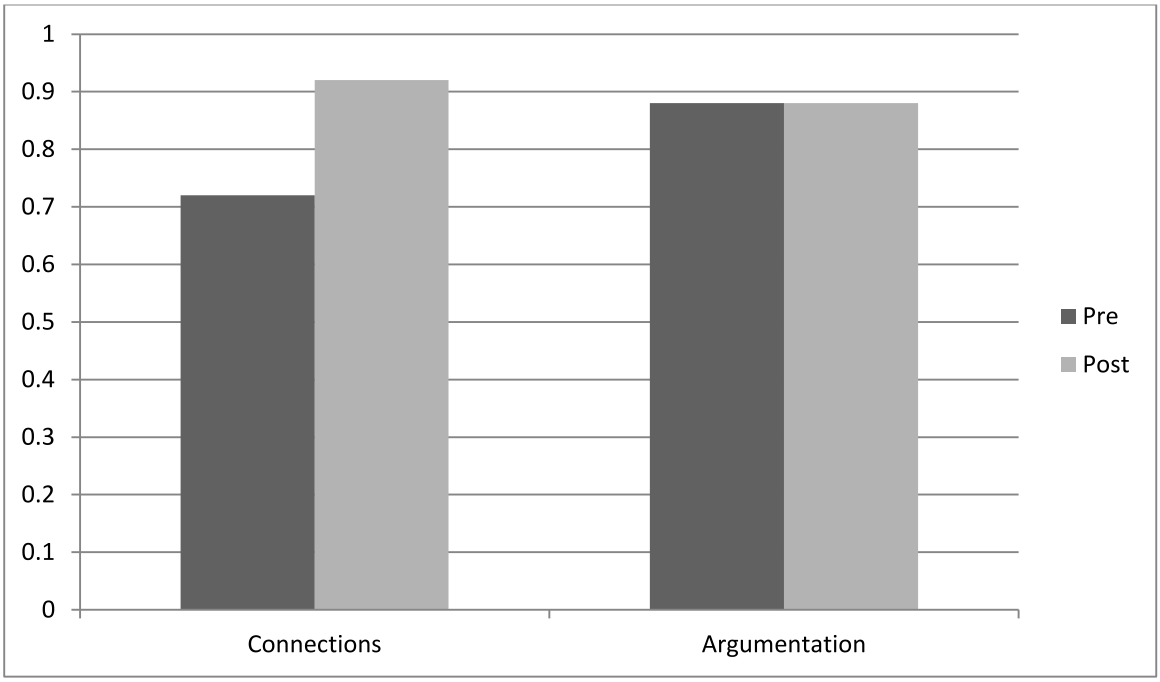

Figure 4.7 Cognitive subcategories for Tutor 4

Under the connections subcategory, each of the five individual item responses improved – either changing from ‘neither agree nor disagree’ to ‘agree’ or from ‘agree’ to ‘strongly agree’. This suggests an improved sense of the connectedness of mathematics and mathematical ideas. Under the argumentation subcategory, individual responses to all five questions remained the same.

4.7.4.2 Affective

Overall the affective mode increased marginally from 0.79 to 0.84. Figure 4.8 shows the various subcategories for the affective mode.

There was an increase in all subcategories with the exception of usefulness which decreased slightly from 0.84 to 0.78. In those subcategories that showed increases there were no individual item responses that increased by more than a single unit, but the overall increase in the affective mode is an important indicator that the tutoring experience was beneficial for this tutor.

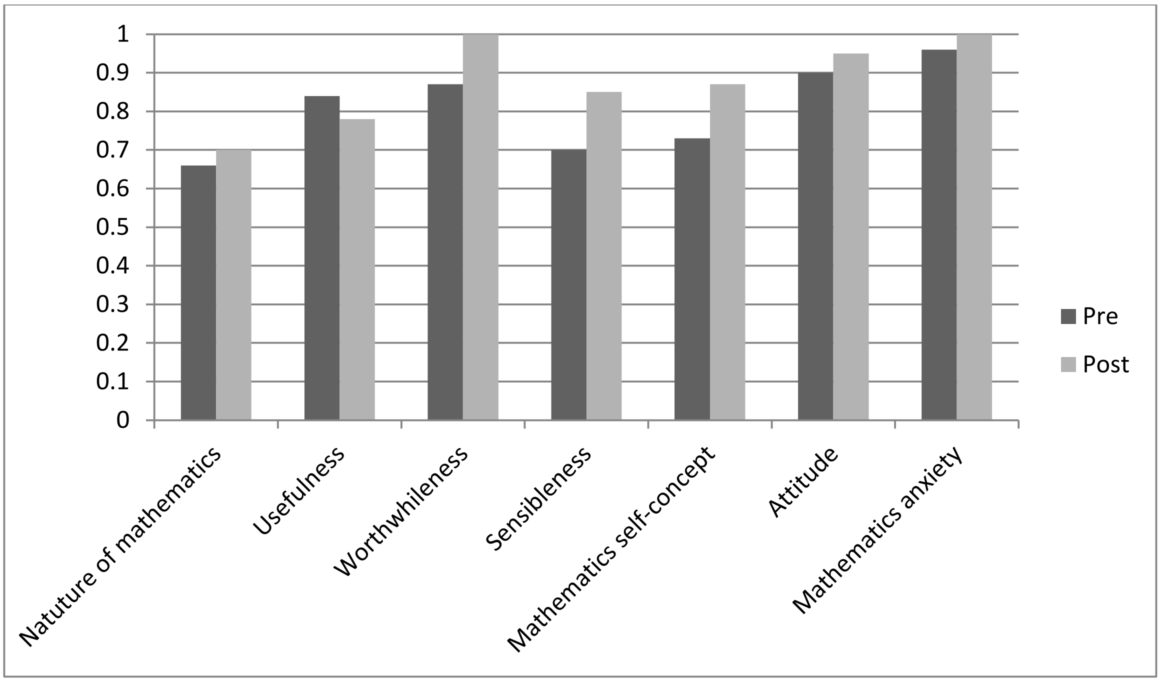

Figure 4.8 Affective subcategories for Tutor 4

4.7.4.3 Conative

The conative mode for this tutor remained constant at 0.96. There were no changes in any responses to individual items on the MDFI instrument.

4.7.5 Tutor 5

4.7.5.1 Cognitive

The cognitive mode for this tutor increased from 0.64 to 0.74. Figure 4.9 shows the two subcategories for the cognitive mode both before and after the peer tutoring programme.

Within the cognitive mode the subcategory of connections dropped marginally from 0.68 to 0.64 whereas the argumentation subcategory increased from 0.60 to 0.84. The most significant change in single item responses was that to Q12 (Even if I'm not asked to, I try to use various methods of reasoning in mathematics) which changed from 'strongly disagree' to 'strongly agree'. The process of peer tutoring seems to have opened this tutor's eyes to the importance of being able to reason and make sense of mathematics in different ways.

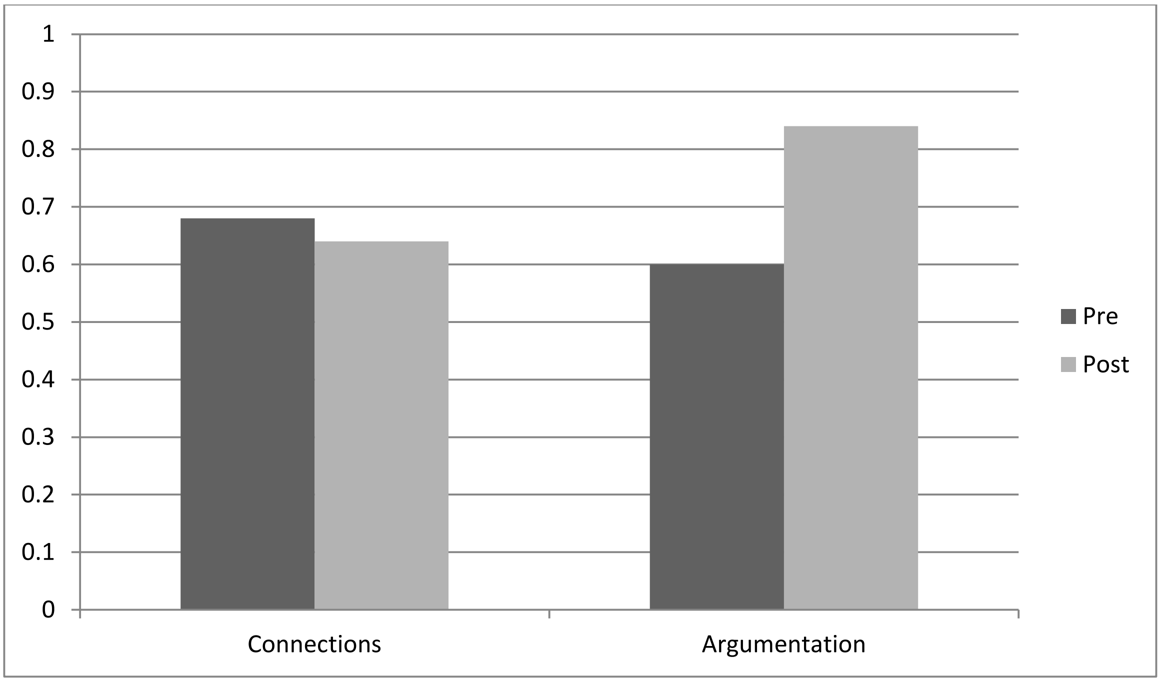

Figure 4.9 Cognitive subcategories for Tutor 5

4.7.5.2 Affective

Overall the affective mode increased from 0.65 to 0.73. Figure 4.10 shows the various subcategories for the affective mode.

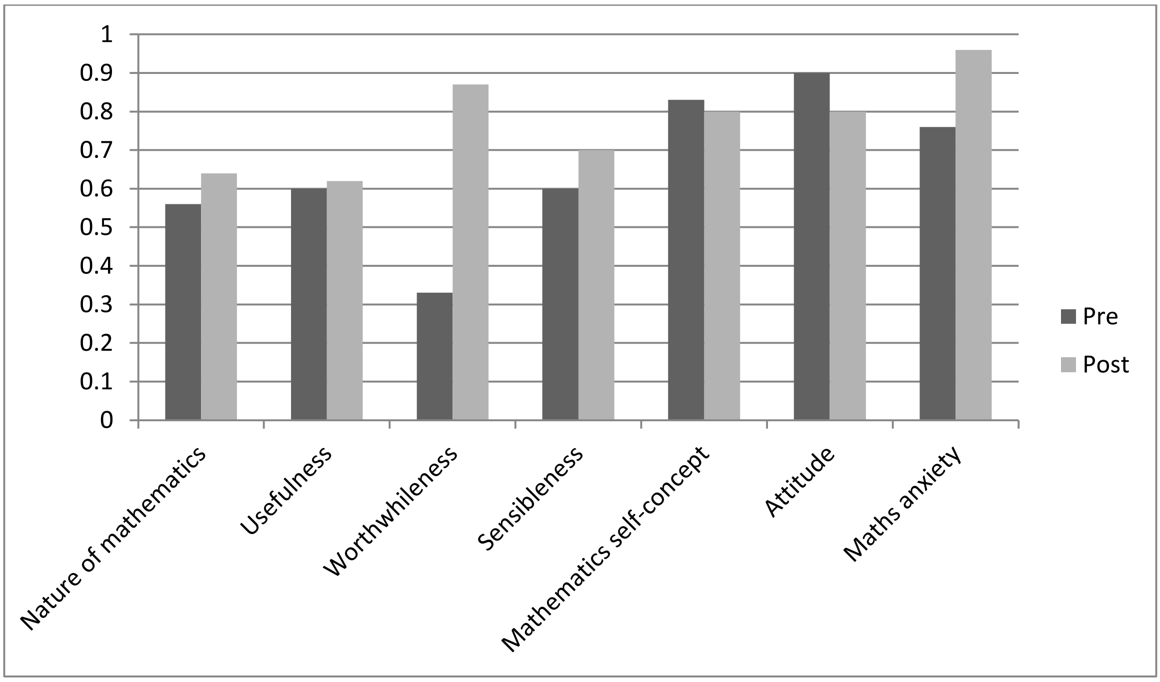

Figure 4.10 Affective subcategories for Tutor 5

The tutor showed substantially improved dispositions with respect to worthwhileness and maths anxiety. The tutor's response to Q4 (All the work I have had to put into learning maths has been worth it to me) changed from 'disagree' to 'strongly agree'. The peer tutoring process was clearly an empowering and motivating experience for this tutor.

4.7.5.3 Conative

The conative mode for this tutor remained constant at 0.64.

4.7.6 Tutor 6

4.7.6.1 Cognitive

Overall the cognitive mode increased from 0.62 to 0.82. Figure 4.11 shows the various subcategories for this mode.

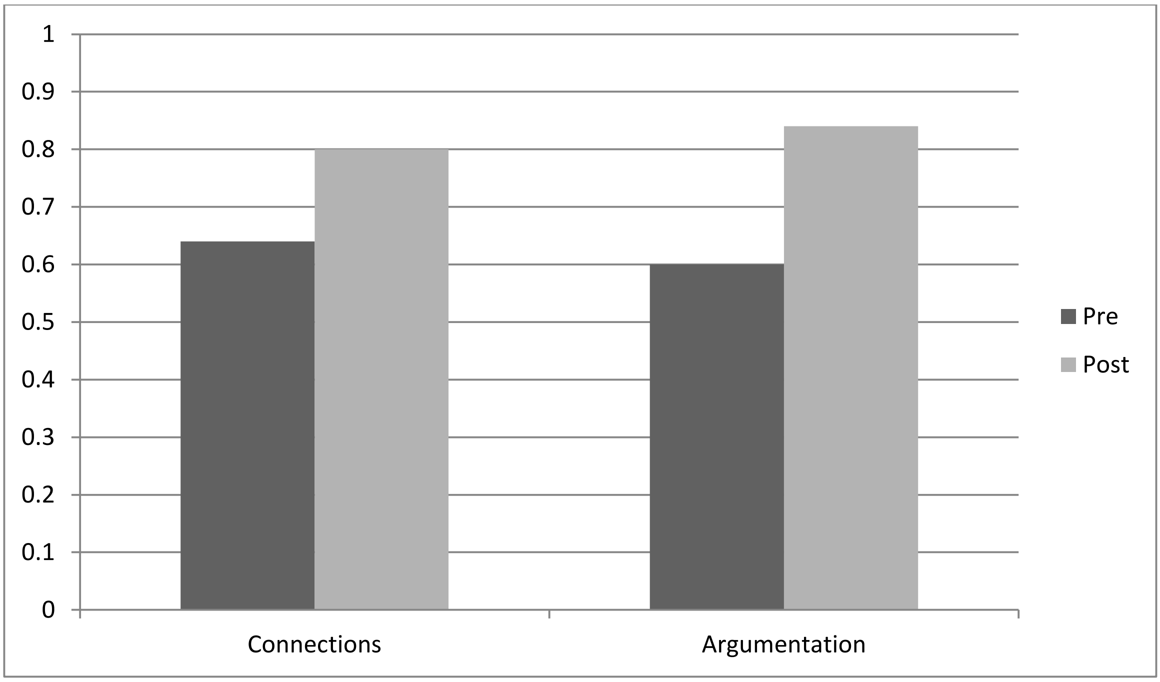

Figure 4.11 Cognitive subcategories for Tutor 6

Both subcategories showed improved dispositional levels. The subcategory of connections increased from 0.65 to 0.80 while that of argumentation increased from 0.60 to 0.84. The most notable changes occurred in the argumentation subcategory. The response to Q48 (Even if I'm not asked to, I try to develop and evaluate mathematics arguments to explain things in maths classes) changed from 'disagree' to 'strongly agree'. The tutoring experience has had a positive effect on the degree to which this tutor tries to make use of logical reasoning and argumentation while engaging with mathematical tasks with others.

4.7.6.2 Affective

Overall the affective mode remained constant, dropping marginally from 0.70 to 0.68. Figure 4.12 shows the subcategories of the affective mode both before and after the peer tutoring process.

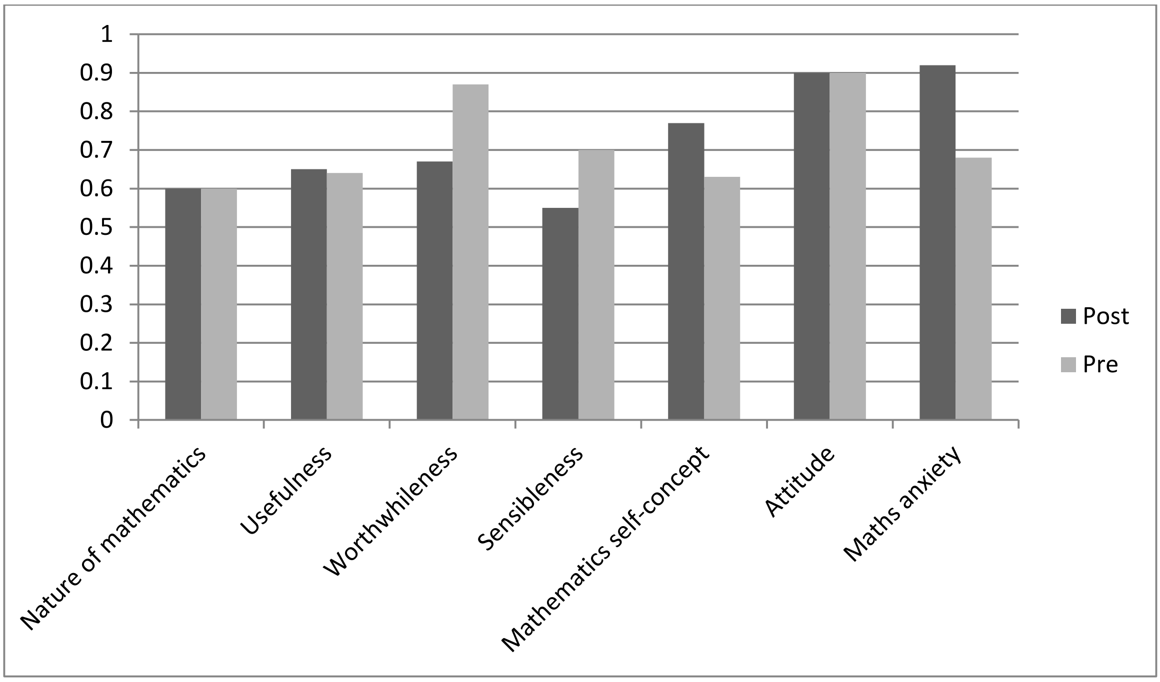

Figure 4.12 Affective subcategories for tutor 6

Although overall there was little change to the affective mode, there were nonetheless changes in the various subcategories. The most notable changes were increases to the subcategories of worthwhileness and sensibleness, and decreases to mathematics self-concept and maths anxiety. In terms of individual item responses to those subcategories that improved, Q25 (In general, mathematics is a connected system that can be made sense of and consequently learned) changed from 'disagree' to 'agree' while Q50 (All the work I had to put into learning mathematics in primary school was worth it to me) changed from 'neither agree nor disagree' to 'strongly agree'. The tutor seems to have made important connections between primary school mathematics and that of secondary school. Nonetheless, the experience of peer tutoring seems to have negatively affected the tutor's mathematical self-concept as well as mathematical anxiety.

4.7.6.3 Conative

The conative mode increased from 0.56 to 0.82. In Q43 (In general, if I don't give up right away, I will eventually figure out the mathematics) changed from 'strongly disagree' to 'agree'. This suggests that the tutor now sees the value of persistence and resilience in relation to tackling mathematical problems. This view is supported by the sentiments the tutor shared in his reflective journal: *"I now believe that if you work hard you can understand even those difficult things"* (lines 774-775).

4.8 Conclusion

This chapter presented the results of how a peer tutoring programme shaped the mathematical experience of the participating tutors. The following chapter summarises the findings of the study in relation to the original research questions.

CHAPTER 5

FINDINGS & CONCLUSION

5.1 Introduction

This chapter provides a summary of the main ideas of the study and presents the research findings. It presents a brief review of the research questions, the contextual backdrop to the study as well as the research process. It then summarises the findings of the study in relation to the original research questions and comments on the limitations and significance of the study. The chapter concludes with recommendations for future research.

5.2 Review of the objectives

This study focused on investigating how a peer tutoring programme could shape the mathematical experience and mathematical disposition of the participating tutors. The study was guided by the following research questions:

1. How does peer tutoring shape the mathematical experience of the participating tutors?
2. How does peer tutoring shape the mathematical disposition of the participating tutors?

5.3 Overview of the context

In 2012 I was instrumental in setting up a Grade 10 peer tutoring programme in my previous school as a potential means to motivate and help develop learners' interest in doing mathematics. The aim was to ensure the participation of everyone and have those learners who were more able in mathematics to help their peers. The programme met with great success, not only in terms of improved Mathematics marks of the tutees, but also with respect to the tutors. Of particular interest was the impact of peer tutoring on the mathematical disposition of the tutors since there seemed to be a general improvement not only in their Mathematics, but in their schoolwork and general behaviour and conduct as well. This experience formed the backdrop to my interest in investigating more formally the peer tutoring experience from the perspective of the tutors.

Topping (2005) observes that peer learning is a practice that has a long history. With this in mind it could be expected that peer teaching/tutoring should be widely incorporated into classroom practice. However, this is not the case. In my experience as a teacher of mathematics at the secondary school level I have seen very little peer tutoring being used in the classroom despite numerous studies that reveal its potential for improving the academic performance of learners

Gordon (2009) for example states that there is evidence that shows that peer tutoring may not only help students to master subject knowledge and general learning skills, but also help to increase the motivation of students by providing a sense of empowerment to learners. Peer tutoring can have positive effects on the general achievement of learners in the subjects they are studying because peer tutoring can reinforce concepts, help tutees practice their skills, support problem solving, and challenge tutees' thinking. Peer tutoring can also have positive effects on the tutors by deepening their understanding of concepts and sharpening their skills, engaging them in creative thinking and problem solving as they look for ways and strategies to help tutees, and enhancing their self-image. This can help students in building their critical thinking skills.

5.4 Overview of the research process

This case study was anchored in the interpretative paradigm, the case under scrutiny being a group of six peer tutors. The unit of analysis was the experiences of the tutors, with specific focus on their mathematical disposition. Three methods of data collection were used – the Mathematics Dispositional Functions Inventory (Beyers, 2011), reflective journals and semi-structured interviews.

The study was conducted in four phases. Before commencement of the peer tutoring programme, tutors first completed the Mathematics Dispositional Functions Inventory (MDFI). This data provided insight into the initial mathematical disposition of each tutor. The second phase comprised the peer tutoring programme itself. In addition to the tutoring and preparation sessions, tutors were required to complete a reflective journal throughout the process in order to capture their personal experiences and reflections. At the end of the three weeks of peer tutoring, a semi-structured interview was conducted with each peer tutor. Finally, each tutor was required to complete the MDFI in order to track any potential changes in their mathematical disposition.

5.5 Findings of the study

The findings of this are summarised here in response to the two guiding research questions.

5.5.1 How does peer tutoring shape the mathematical experience of the participating tutors?

The mathematical experiences of participating tutors are summarised here in relation to emerging themes.

Self-confidence: The peer tutors who participated in this study reflected in their responses that the peer tutoring programme had a positive influence on their self-confidence. This improved self-confidence was manifested in different forms for different tutors. For one tutor the self-confidence generated through the tutoring programme manifested in a desire to help others achieve well in mathematics. For another tutor, increased self-confidence resulted in an improved sense of personal autonomy. For most tutors, the tutoring programme was very helpful in terms of building their own mathematical understanding and reinforcing their mathematical confidence, while at the same time impacting on their affective wellbeing beyond the confines of the tutoring programme itself.

Better understanding of mathematics: The peer tutors who participated in this programme indicated that the peer tutoring process helped them improve their own mathematical understanding, highlighting that it was the process of teaching others, and the preparation that went into it, that had the positive effect of building their mathematical understanding

Prospects of improving mathematics examination results: All six tutors shared the sentiment that peer tutoring afforded them an opportunity to potentially improve their examination results. For some tutors there was a development in the belief that if one works hard there is a good chance of improving one’s results. The tutors saw their participation in the peer tutoring programme as having a positive impact on their drive to succeed and thus ultimately on their mathematics examination marks.

Feeling good, happy and appreciated by peer: All six peer tutors indicated that being a peer tutor made them feel happy and appreciated by their peers. For all six tutors, helping other learners was a positive personal experience. Tutor 4 summed up her feelings as follows: "teaching *my fellow learners mathematics was really great, that feeling of knowing you are sharing your knowledge with others is a most wonderful feeling"* (lines 530-531).

5.5.2 How does peer tutoring shape the mathematical disposition of the participating tutors?

The following table provides descriptions of the categories (and subcategories) of the various dispositional functions (Beyers, 2011) along with observed changes in the mathematical disposition of the group of tutors taken as a whole, as tracked by the MDFI instrument. Taking the six tutors as a group, the cognitive mode increased from 0.64 to 0.80. The affective mode increased marginally from 0.70 to 0.73, while the conative mode also showed only a marginal improvement, from 0.75 to 0.77.

Table 5.1 Dispositional functions based on Beyers (2011)

Scale	Subcategory of Dispositional Function	Description of Subcategory	Observed change
Cognitive	Connections	A tendency to try and connect with or cross mathematical topics.	The average score for this subcategory increased from 0.65 to 0.81. Specifically, tutors were able to connect their understanding of fractions to ratio and proportion.
	Argumentations	A tendency to evaluate the mathematical correctness of statements, make mathematical arguments, justify mathematical statements, etc.	The average score increased from 0.62 to 0.80. This indicates an increase in critical reasoning.
Affective	Nature of Mathematics	A belief about mathematics being more procedural or conceptual in nature.	The average score increased from 0.57 to 0.64, indicating a slight increase in an appreciation for the

			conceptual aspects of mathematics.
	Usefulness	A belief about the usefulness of mathematics for meeting current or future needs in or out of school.	The average score increased marginally from 0.66 to 0.68.
	Worthwhileness	A value judgement that the work put into learning mathematics has been worth it to the student.	The average score increased from 0.72 to 0.90. This represents an increased appreciation for the value of time and effort put into learning mathematics.
	Sensibleness	A belief that mathematics is composed of ideas that can be made sense of.	The average score increased from 0.65 to 0.70, indicating a slight increase in the belief that mathematics as a subject can be made sense of.
	Mathematics Self-Concept	What the student believes about him or herself as a learner of mathematics	The average score decreased marginally from 0.76 to 0.74.
	Attitude	The respondent's emotional reactions to mathematical activity in or out of school.	The average score increased marginally from 0.87 to 0.89.
	Maths Anxiety	Whether or not the student experiences anxiety in relation to mathematics.	The average score decreased marginally from 0.83 to 0.80.
Conative	Effort/Persistence	A tendency to persist or exert effort if necessary.	The average score increased marginally from 0.75 to 0.77.

In terms of the individual tutors, all six tutors saw an improvement in the cognitive mode – the biggest increase being that of Tutor 2 from 0.48 to 0.86. In the affective mode the overall scores suggested little change, but the subcategories showed some interesting shifts. The conative mode saw an increase for Tutor 1 and 6, a slight decrease for Tutor 2, while the scores for Tutors 3, 4 and 5 remained essentially constant.

Tutor 1 saw a change in his view of mathematics through his participation as a peer tutor. Although his own Mathematics marks were not particularly good, he commented that "*when I became a peer tutor I see that mathematics makes a lot of sense and I can do it*" (lines 11-12). This reflects an important change in outlook. Mathematical self-concept has to do what a learner believes about themselves as a learner of mathematics. The peer-tutoring programme was meaningful for this tutor as it allowed him to experience a sense-making process which in turn resulted in improved learner confidence and courage.

Tutor 2 sees mathematics as being a part of her future career, and found the peer tutoring programme helpful with respect to her projected future: "*being a peer tutor myself it helped me a lot because I know that mathematics is part of my future career*" (lines 47-48). This suggests that the tutor is able to see the usefulness of mathematics in her future life. In addition to the mathematical usefulness of the peer tutoring experience, the tutor also appreciated the worthwhileness of the peer tutoring programme in terms of the affective domain: *"for the first time in my life I felt like doing something useful to other people"* (line 62). The peer tutoring process also had an important positive effect on the general attitude of this particular tutor towards school. In her own words, "*being a tutor motivated me to work hard"* (lines 49-50). Interestingly, though, this particular tutor showed an increase in Maths Anxiety. This may well have been brought about by a feeling of being 'put on the spot' during the tutoring session itself.

Tutor 3 found that by teaching someone else one develops a better understanding of the subject content oneself. Through participating in the programme, this tutor's perception of mathematics has changed and she now considers it within her ability to improve her mathematics.

Tutor 4 acknowledged that the peer tutoring programme changed her outlook on her own mathematical ability: "*before I became a tutor I used to see mathematics as a difficult subject [but] when I started teaching other learners I realised that it was simple*" (lines 127-128). When the tutor experienced the joy of being able to do mathematics it had a profound influence on her view of the subject and her overall mathematical disposition: *"I started giving a lot of attention to mathematics on my own and doing a lot of mathematics activities from the textbook. I started spending more time doing mathematics and I fell in love with mathematics"* (lines 136-139).

Tutor 5 saw value in the peer tutoring experience and remarked that *"the more you are teaching others the more you learn and make them understand what you are teaching helps you understand mathematics better and it really made me proud"* (lines 182-184). The peer tutoring experience was not only useful for this tutor in terms of his own mathematical understanding, but also in terms of important affective aspects. The anxiety levels experienced by this tutor also seem to have improved: "*now I find mathematics very easy and writing a test would not stress me up*" (line 199).

Tutor 6 found his participation in the peer tutoring process not only of mathematical benefit, but also an empowering and enjoyable experience. The tutor also reports increased levels of mathematical confidence: *"I can now understand some topics and I am now more confident in mathematics"* (213-214). This increased confidence is also manifested in a more positive view of mathematics as a subject: *"I now believe that this is the subject I can do"* (line 232). Interestingly, as with Tutor 2, this particular tutor also showed an increase in Maths Anxiety. This may well have been brought about by the added pressure of having to make sense of the mathematical content in a limited time frame prior to the tutoring sessions.

5.6 Limitations of the study

The research investigated how a peer tutoring programme could shape the mathematical experience of the participating tutors. The greatest limitation of this study is the short duration over which it was carried out. Since the study was only carried out over a period of three weeks, which nonetheless incorporated six tutor sessions and six preparation sessions, it is likely that richer data could have emerged if the period had been longer.

Given that the study took the form of a case study, the findings cannot be generalised beyond the case investigated. Nonetheless, the study adds value to the growing body of research on peer tutoring.

5.7 Significance of the study

This study provides findings which can help mathematics teachers with potential ways of developing important aspects of mathematical disposition in their learners. An important finding of this study is that participation in a peer tutoring programme is likely to have a positive effect on the participating tutors with respect to their own mathematical confidence and understanding. The study is also important to teacher educators in the field of mathematics in relation to training student teachers on how to design peer tutoring programmes and to implement such programmes in their schools.

5.8 Recommendations and suggestions for further study

Based on the results of this study, the following recommendations are put forward:

- Schools that are struggling with poor results in Mathematics should consider peer tutoring as a potential means of improving learner performance.
- Institutions of higher learning tasked to train teachers should include peer tutoring in their course content.
- The Ministry of Education should be encouraged to ensure that those involved in the support of mathematics teachers are aware of the potential benefits of peer tutoring programmes.

In addition, the following suggestions are put forward as possible future research avenues to explore:

- Given the short duration of this study, it would be interesting to repeat the study over a much longer period.
- Since this study made use of tutors whose mathematical proficiency was better than their peers, it would be interesting to repeat the study with tutors who, although struggling in some areas, could tutor in areas of their strength.
- It would also be interesting to study teachers’ views on the use of peer teaching programmes in schools.

5.9 Conclusion

Motivating learners to develop positive mathematics dispositions requires innovative methods. The use of peer tutoring programmes represents one such approach, and the results of this study suggest that the potential benefits of a peer tutoring programme extend positively to the peer tutors themselves.

REFERENCES

Allal, L. (2002). The assessment of learning dispositions in the classroom. *Assessment in Education, 9*(1), 55-58.

Beyers, J. (2011). Development and evaluation of an instrument to assess prospective teachers' dispositions with respect to mathematics. *International Journal of Business and Social Science, 2*(16), 20-32.

Beyers, J. E. R. (2012). An examination of the relationship between prospective teachers' dispositions and achievement in a mathematics content course for elementary education majors. *SAGE Open, 2*(4), 1-15. Retrieved 14 November, 2013, from http://sgo.sagepub.com/content/2/4/2158244012462589.full.pdf+html

Bowman-Perrot, L., Davis, H., Vannest, K., Williams, L., Greenwood, C., & Parker, R. (2013). Academic benefits of peer tutoring: A meta-analytic review of single-case research. *School Psychology Review. 42*(1), 39-55.

Carr, M., & Claxton, G. (2002). Tracking the development of learning dispositions. *Assessment in Education, 9*(1), 9-37

Chapman, O. (2004). Facilitating peer interactions in learning mathematics: Teachers' practical knowledge. *Psychology of Mathematics Education, 2*(28), 191-198.

Cohen, I., Manion, L., & Morrison, K. (2001). *Research in education (7th ed.).* London: Routledge

Cobb, P., Yackel, E., & Wood, T. (1992). A Constructivist Alternative to the representational View of Mind in Mathematics Education. Journal for Research in Mathematics Education, 23(1) 2-33

Dhlamini, J., & Mogari, D. (2013). The effect of a group approach of the performance of high school mathematics learners. *Pythagoras, 34*(2), Art, #198, 9 pages.

Fantuzzo, J. W., King, J. A., & Heller, L. R. (1992). Effects of reciprocal peer tutoring on mathematics and school adjustment: A component analysis. *Journal of Education Psychology, 84*(3), 331-339.

Fox, T. D., Vos, N. B., & Geldenhys, J. L. (2007). The experience of cross-cultural peer teaching for a group of mathematics learners. *Pythagoras, 65*, 45-52.

Gordon, E. E. (2009). 5 ways to improve tutoring programs. *Phi Delta Kappan, 90*(6) 440-445.

Graven, M., Hewana, D., & Stott, D. (2013). The evolution of an instrument for researching young mathematical dispositions. *African Journal of Research in Mathematics, Science and Technology Education, 17*(1-2), 26-37.

Grubbs, N., & Boes, S. R. (2009). The effects of the peer tutoring program. *GSCA Journal, 16*(1), 20-30

Hartman, H., & Sternberg, R. J. (1993). A broad BACEIS for improving thinking. *Instructional Science, 21*(5), 401-425.

Ifamuyiwa, A. S., & Akinsola, K. M. (2008). Improving senior secondary school students' attitude towards mathematics through self and cooperative-instructional strategies. *International Journal of Mathematical Education in Science and Technology*, *39*(5), 569-585.

Karsenty, R. (2010). Nonprofessional mathematics tutoring for low-achieving students in secondary schools: A case study. *Educational Studies in Mathematics, 74*, 1-21.

Katz, L. G. (1987). *What should young children be learning? ERIC Digest ED290554*. Urbana, IL: ERIC Clearinghouse on Elementary and Early Childhood Education. Retrieved 14 November, 2013, from http://eric.ed.gov/?q=Katz&ft=on&ff1=autKatz%2c+Lilian+G.&pg=3&id=ED290554

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.) (2001). *Adding it up: Helping children learn mathematics*. Washington DC: National Academy Press.

Leedy, P.D., & Ormrod , J.E. (2005). *Practical Research (8th ed.).* Upper Saddle River, NJ: Prentice Hall.

Lehr, F. (1984). Peer teaching. *The Reading Teacher, 37*(7), 636-639.

Lewis, J., & Ritchie, J. (2003). Generalisation from qualitative research. In J. Ritchie & J. Lewis (Eds.*), Qualitative research practice: A guide for social science students and researchers* (pp. 263-286). London: Sage

Margolis, H., & McCabe, P. P. (2004). Self-efficacy: A key to improving the motivation of struggling learners, *The Clearing House*, *77*(6), 241-249.

McMahon, M. (1997). *Social constructivism and the World Wide Web – A Paradigm for Learning.* Paper presented at the ASCILITE conference. Perth, Australia

McNall, S.G. (1975). Peer teaching: A description and evaluation. *Teaching Sociology, 2*(2), 133-146.

Mesler, L. (2009). Making retention count: The power of becoming a peer tutor. *Teachers College Record*, *111*(8), 1894-1915.

Ndlovu, M. (2013). Revisiting the efficicacy of contructivism in mathematics education. *Philosophy of Mathematics Education Journal, 27. 1-13*

Palincsar, S.A. (1998). Social constructivist perspective on teaching and learning. *Annual Revue of Psychology, 49, 345-375*.

Patton, M.Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage.

Robinson, R. D., Schofield, W. J., & Steers-Wentzell, L. K. (2005). Peer and cross-age tutoring in Math: Outcomes and their design implications. *Educational Psychology Review*, *17*(4), 327-362.

Roscoe, R. D., & Chi, M. T. H. (2007). Understanding tutor learning: Knowledge-building and knowledge-telling in peer tutors' explanations and questions. *Review of Educational Research*, *77*(4), 534-574.

Roswai, G. M., Mims, A. A., Evan, D. M., Smith, B., Burch, M., Croce, R., Horvat, M. A., & Block, M. (1995). Effects of collaborative peer tutoring on urban seventh graders. *The Journal of Educational Research, 88*(5) 275-279.

Sadler, D. R. (2002). Learning dispositions: Can we really assess them? *Assessment in Education, 9*(1), 45-51.

Simon, M.A. (1995). Reconstructing mathematics pedagogy from a constructivisit perspective. *Journal for Research in Mathematics Education, 26(2) 114-145*

Snow, R. E. (1996). Self-regulation as meta-conation? *Learning & Individual Differences, 8*(3), 261-267.

Topping, J. K. (2005). Trends in peer learning*. Educational Psychology*, *25*(6), 631-645.

Topping, K. J. (2001*). Peer assisted learning: A practical guide for teachers*. Cambrige, MA: Brookline Books.

Vygotsky, L.S. (1978*). Mind in society. The development of higher psychology processes.* Cambrige: Harvard University Press.

Walker, E.N. (2007). The structure and culture of developing a mathematics tutoring collaborative in an urban high school. *The High School Journal*, *91*(1), 57-67.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York, NY: Cambridge University Press.

Appendix A – Mathematics Dispositional Functions Inventory

Mathematics Dispositional Functions Inventory

The purpose of this questionnaire is to collect information about prospective peer tutors' dispositions with respect to mathematics. The survey contains 60 questions. You will be asked about your dispositions in the context of mathematics.

Your responses are confidential. In any reports I prepare, you will not be referenced in any way that will allow someone to know your identity. Your participation is appreciated.

Name: ____

Grade 10 …….

Date: ………………………………………………….

Section I

SA = Strongly Agree **A** = Agree **N** = Neither Agree nor Disagree **D** = Disagree **SD** = Strongly Disagree

Please use the scale above to indicate the extent to which you agree or disagree with each of the following statements:

1)	In general, I don't get stressed when I am doing maths in non-school situations.	SA	A	N	D	SD
2)	Even if I didn't have to take any maths courses at university, I still would take some because the mathematics I could learn in university would be useful to me for some reason.	SA	A	N	D	SD
3)	In general, learning computational skills, like addition and multiplication, is more useful to me than learning to solve maths problems.	SA	A	N	D	SD
4)	All the work I have had to put into learning maths has been worth it to me.	SA	A	N	D	SD
5)	If I weren't going into a profession that required training in mathematics, I would have little use for taking mathematics in secondary school.	SA	A	N	D	SD
6)	When I'm doing a maths problem, I look for solutions to similar problems and follow the steps from those solutions to find an answer to my problem.	SA	A	N	D	SD
7)	In primary school, I was really good at maths.	SA	A	N	D	SD
8)	No matter how much effort some people put into learning maths, they just won't understand it.	SA	A	N	D	SD
9)	In general, I get stressed out when I have to take a maths test.	SA	A	N	D	SD
10)	The main reason I am studying mathematics in school is because I have to for my future career.	SA	A	N	D	SD
11)	I like doing maths in situations outside of school.	SA	A	N	D	SD

Section I, cont.

SA = Strongly Agree **A** = Agree **N** = Neither Agree nor Disagree **D** = Disagree **SD** = Strongly Disagree

12) Even if I'm not asked to, I try to use various methods of reasoning in mathematics.	SA	A	N	D	SD
13) Different areas in maths that you have studied, like fractions and geometry, are not related very much.	SA	A	N	D	SD
14) In general, I try to justify the statements I make in maths classes.	SA	A	N	D	SD
15) In general, I don't like doing maths in school.	SA	A	N	D	SD
16) All the work I have (or will) put into learning mathematics here at school will be worth it to me.	SA	A	N	D	SD
17) I use maths outside of school to do many things that do not involve money.	SA	A	N	D	SD
18) Even if I'm not asked to justify something, I still try to use mathematical reasoning and justification to explain how I did something in maths classes.	SA	A	N	D	SD
19) When I think about mathematical ideas, I try to think about how they connect to other ideas in maths.	SA	A	N	D	SD
20) I need to learn maths because, if I want to pursue my desired career, I need to know maths.	SA	A	N	D	SD
21) In general, mathematics is made up of related concepts.	SA	A	N	D	SD
22) If I don't figure out something in maths pretty quickly, then I probably won't even if I keep trying.	SA	A	N	D	SD

Section I, cont.

SA = Strongly Agree **A** = Agree **N** = Neither Agree nor Disagree **D** = Disagree **SD** = Strongly Disagree

23) There were some things in primary school maths that I just couldn't get, so I stopped trying.	SA	A	N	D	SD
24) In general, the maths that I do outside of school has to do with money, for example figuring out how much I can spend on something.	SA	A	N	D	SD
25) In general, mathematics is a connected system that can be made sense of and consequently learned.	SA	A	N	D	SD
26) Even if I'm not asked to, I try to make and investigate mathematical conjectures in maths classes.	SA	A	N	D	SD
27) In general, I try to see how mathematical ideas in different *maths* classes are connected to each other.	SA	A	N	D	SD
28) In general, maths is too challenging for me to really understand it well.	SA	A	N	D	SD
29) In general, I try to see how mathematical ideas are connected to ideas in other *non*-maths classes.	SA	A	N	D	SD
30) In general, I have no problems understanding concepts in mathematics.	SA	A	N	D	SD
31) In general, there is a specific rule to follow when solving a problem in mathematics.	SA	A	N	D	SD
32) I don't really use a lot of the maths I learned in school for anything outside of school.	SA	A	N	D	SD
33) Mathematics has more to do with thinking about how things like numerals, place value, and base-ten structure are related, than working with separate ideas.	SA	A	N	D	SD

Section I, cont.

SA = Strongly Agree **A** = Agree **N** = Neither Agree nor Disagree **D** = Disagree **SD** = Strongly Disagree

34) I don't really use a lot of the maths I learned in primary school for anything outside of school.	SA	A	N	D	SD
35) Ideas learned in one maths class can help you learn ideas in other maths classes.	SA	A	N	D	SD
36) If someone is having difficulties in maths, they can eventually do well if they persist.	SA	A	N	D	SD
37) In general, I get stressed when I have to take any kind of test.	SA	A	N	D	SD
38) In general, mathematics is made up of procedures and algorithms.	SA	A	N	D	SD
39) In general, I only use maths to figure out calculations.	SA	A	N	D	SD
40) In general, it is really easy for me to learn step-by-step ways to do maths problems.	SA	A	N	D	SD
41) For me, maths mostly involves using algorithms and following steps.	SA	A	N	D	SD
42) In general, I get more stressed when I have to take a maths test than any other kind of test.	SA	A	N	D	SD
43) In general, if I don't give up right away, I will eventually figure out the mathematics.	SA	A	N	D	SD
44) A lot of times, topics in mathematics can be so disconnected from each other that it is next to impossible to make sense of the 'big picture'.	SA	A	N	D	SD

Section I, cont.

SA = Strongly Agree **A** = Agree **N** = Neither Agree nor Disagree **D** = Disagree **SD** = Strongly Disagree

45) Most mathematical ideas are related to one another.	SA	A	N	D	SD
46) There is a ‘maths talent’ that makes some people better at maths than others.	SA	A	N	D	SD
47) In general, maths is a connected system that can be made sense of.	SA	A	N	D	SD
48) Even if I’m not asked to, I try to develop and evaluate mathematical arguments to explain things in maths classes.	SA	A	N	D	SD
49) In general, I don’t like maths.	SA	A	N	D	SD
50) All the work I had to put into learning maths in primary school was worth it to me.	SA	A	N	D	SD
51) In general, I try to see how mathematical ideas within a single class are connected to each other.	SA	A	N	D	SD
52) I like doing maths in school.	SA	A	N	D	SD
53) In general, I try to see how mathematical ideas in maths classes are connected to things outside of school.	SA	A	N	D	SD
54) In general, people don’t need to learn mathematics beyond basic arithmetic.	SA	A	N	D	SD
55) I need to learn maths because, if I want to pursue my desired career, I need to know maths.	SA	A	N	D	SD

Section I, cont.

SA = Strongly Agree **A** = Agree **N** = Neither Agree nor Disagree **D** = Disagree **SD** = Strongly Disagree

Please use the scale above to indicate the extent to which you agree or disagree with each of the following statements:

56) Most of the maths I do in school is boring to me.	SA	A	N	D	SD
57) In general, I get stressed out when I have to do maths in maths classes.	SA	A	N	D	SD
58) Mathematics consists of many unrelated topics.	SA	A	N	D	SD
59) I've always been pretty good at maths.	SA	A	N	D	SD
60) Mathematics is mostly a disconnected system of information that should just be memorized.	SA	A	N	D	SD

Appendix B – Request to Regional Director to conduct research

P.O. Box 1924
Otjiwarongo
Namibia
9 January 2014

The Otjondjupa Regional Education Director
Ministry of Education
P/Bag 2618
Otjiwarongo

Dear Madam,

Re: Request for permission to conduct educational research in your region.

I am presently in the process of starting my research project for an MEd degree in Mathematics Education through the Education Department of Rhodes University. Dr Duncan Samson, a lecturer from the same university, will be my supervisor.

The proposed research focuses on pupils taking the role of tutors. The central goal of the research is to investigate how a peer teaching programme could shape the mathematical experience of the participating tutors.

My aim is to use six grade 10 pupils whose mathematical performance is better than their peers to be tutors. Each of tutors will be responsible of three tutees. Peer tutoring sessions will be carried out twice per week, on Tuesdays and Thursdays, for a period of four weeks. I will meet with the six peer tutors on Mondays and Wednesdays to prepare them for the upcoming peer tutoring session.

The process of data collection involves the six learners to complete a Mathematics Disposition Functions Inventory, reflective journals, and semi-structured interviews.

I am aware of the various ethical considerations pertinent to research in social sciences. Anonymity of both the school as well as the research participants will be assured at all times, as well as in the final thesis. Secondly, only those learners who agree to participate in the study through voluntary informed consent will form part of the research sample, and participants will have the freedom to withdraw from the study at any stage. In terms of learner participation, consent will be obtained from each participant's parents or legal guardians.

This letter serves as a formal request that I be allowed to conduct the proposed research at ...xxx... Combined school.

Sincerely

Justin Lubasi (Mr)

0812496961

Appendix C – Regional Director's permission to conduct research

REPUBLIC OF NAMIBIA
OTJOZONDJUPA
REGIONAL COUNCIL

DIRECTORATE OF EDUCATION

Tel no: 264 67 308000/04
Fax no: 264 67 304871
Enq: Ms. F.N. Caley

Private Bag 2618
Otjiwarongo
NAMIBIA

4 February 2014

To: Mr. Justin Lubasi
P.O.Box 1924
Otjiwarongo

Dear Sir

PERMISSION TO CONDUCT RESEARCH AT [redacted] IN OTJIWARONGO CIRCUIT, OTJOZONDJUPA REGION, NAMIBIA

Permission is hereby granted to you, Mr. Justin Lubasi to conduct research at the [redacted] Combined School in the Otjozondjupa Region. The Regional Director does not have any objection for you to conduct research at the aforesaid school in the Otjiwarongo Circuit.

It is our hope that your research will benefit our office in the near future. We believe that the outcome of your research will contribute towards the provision of quality education in our schools.

Thank you very much and wish you well in your studies.

Yours sincerely

OTJOZONDJUPA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
2014 -02- 04
OFFICE OF DIRECTOR
TEL 067-308000 PRIVATE BAG 2618
FAX 067-304871 OTJIWARONGO
OTJOZONDJUPA REGION

Ms. Faustina N. Caley
Director

Appendix D – Request to principal to conduct research at her school

P.O. Box 1924
Otjiwarongo
22 January 2014

The Principal
...xxx... Combined School
Otjiwarongo

Dear Madam

Re: Request for permission to conduct educational research in your school,

I am presently in the process of starting my research project for an MEd degree in Mathematics Education through the Education Department of Rhodes University. Dr Duncan Samson, a lecturer from the same university, will be my supervisor.

The proposed research focuses on pupils taking the role of tutors. The central goal of the research is to investigate how a peer teaching programme could shape the mathematical experience of the participating tutors.

My aim is to use six grade 10 pupils whose mathematical performance is better than their peers to be tutors. Each of the tutors will be responsible for three tutees. Peer tutoring sessions will be carried out twice per week, on Tuesdays and Thursdays, for a period of four weeks. I will meet with the six peer tutors on Mondays and Wednesdays to prepare them for the upcoming peer tutoring session.

The process of data collection involves the six learners to complete a Mathematics Dispositional Functions Inventory, reflective journals, and semi-structured interviews.

I am aware of the various ethical considerations pertinent to research in social sciences. Anonymity of both the school as well as the research participants will be assured at all times, as well as in the final thesis. Secondly, only those learners who agree to participate in the study through voluntary informed consent will take part in the study, and participants will have the freedom to withdraw from the study at any stage. In terms of learner participation, consent will be obtained from each participant's parents or legal guardians.

This letter service as a formal request that I be allowed to conduct the proposed research at ...xxx... Combined school.

Sincerely

Justin Lubasi (Mr)

0812496961

Appendix E – Parent permission letter

P.O. Box 1924

Otjiwarongo

10 January 2014

Dear Parent/Guardian

I am a part-time MEd student in the Education Department of Rhodes University. My research focus is on peer tutoring. The principal of ...xxx... Combined School has granted permission for me to conduct the proposed research in this school and your child has been selected as a potential research participant. This letter provides important information regarding the study, and formally requests your consent for your child to take part in the study.

There are no foreseeable risks involved in participating in the study. Your child will be required to be at school during the month of February from Monday to Thursday in order to be part of this study. Your child's participation will deepen his or her understanding of grade 10 mathematics.

Your child's participation in this study is entirely voluntary. Should you agree for your child to take part in the study your child retains the right to withdraw, without explanation, at any point. Anonymity and confidentiality are guaranteed at all times, both during the research process itself and in the final written thesis.

After you have read and understood this letter, and made any necessary clarifications about your child's involvement in the research process, please complete and sign the attached form.

Sincerely

Justin Lubasi (Mr)