Overcoming Math Anxiety: How Does Teaching Math Conceptually Impact Students Learning Math?

By

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Abstract
Mathematics anxiety (MA) is a major issue in education today that affects young students, with residual effects in adulthood (Geist, 2010). To end this destructive cycle the leading causes of MA must be determined in order to mitigate their outcomes. Extensive research has focused on various causes and contributions of MA and its negative effects, such as the correlation between peers’, parents’ and teachers’ negative attitudes towards mathematics and students’ attitudes, motivation and level of confidence surrounding their mathematics education (Jackson & Leffingwell, 1999; Malinsky et al., 2006; Scarpello, 2007; Stuart, 2000) physiological reasons (Cavanagh, 2007), and the negative implications of teaching mathematics in a procedural, rule-based fashion on MA (Finlayson, 2014; Geist, 2010). Derived from the latter cause, this phenomenological study sought to answer: What are teachers’ perceptions of the connection between the use of a conceptual methodology for mathematics teaching and the level of MA among elementary school students? Semi-structured interviews were conducted with three experienced teachers who use a conceptual methodology for teaching mathematics. Rich data were gathered, coded and analyzed. Various themes emerged. For example, Effective Teaching Strategies was a predominant theme, such as using the 3-part lesson, cooperative learning, etc. Overcoming Math Anxiety was another major theme, which included the adoption of a conceptual methodology. This study reveals the importance of teaching mathematics conceptually, which has important implications for teaching practice as many teachers do not implement this teaching methodology (Van de Walle et al., 2011).

Keywords: math anxiety, procedure, conceptual, methodology, understanding, strategies
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Overcoming Math Anxiety: How Does Teaching Math Conceptually Impact Students Learning Math?

Chapter 1: Introduction

Introduction to the Research Study

Although not a new phenomenon, there has been an increasing focus on math anxiety over the past couple of decades. Each researcher looks at different aspects of this phenomenon and defines it accordingly. For the purpose of this paper, math anxiety will be defined as “anxiety that is present or produced surrounding mathematical content eliciting an emotion that blocks a person’s reasoning ability when confronted with a mathematical situation” (Spicer, 2004, p. 1). From this definition we can see that math anxiety interferes with mathematics education and prevents students from learning, grasping and applying the knowledge.

This phenomenon affects a wide range of people including K-12 and post-secondary students, adults in the workplace and teachers. Research demonstrates varied reasons why math anxiety occurs and many factors that contribute to its negative impacts. Negative attitudes surrounding math (Jackson & Leffingwell, 1999; Scarpello, 2007), gender biases (Fennema, Peterson, Carpenter & Lubinski, 1990; Goetz, Bieg, Lutke, Pekrun & Hall, 2013; Gunderson, Ramirez, Levine & Beilock, 2012), capacity of working memory (Beilock & Carr, 2005; Cavanagh, 2007), teacher anxiety (Geist, 2010), teacher methodology (Finlayson, 2014; Geist, 2010) or even just a bad experience that the child had in a math setting are all factors that can contribute to the development of math anxiety. Thus it becomes a cyclical problem: students who grow up with math anxiety and then become teachers or parents with math anxiety can unwittingly pass their anxiety on to a new generation. It is not always easy to determine the trigger for math anxiety, nor is it easy to “cure” math anxiety. By examining the different reasons
for the onset of math anxiety and the possible solutions for it, we can reach a better understanding of this phenomenon and work to end the cycle.

**Purpose of the Study**

Fear of math and/or the lack of math achievement prevent millions of adults from pursuing professional and technical careers (Tobias, 1991), but to what can we attribute the onset of such fear and anxiety of math? Adult math anxiety stems from childhood experiences (Geist, 2010). Recent research on teaching methodologies shows that the practice of teaching math in a procedural fashion has a negative impact on the development of math anxiety (Finlayson, 2014; Geist, 2010). My project explored the perceptions of elementary school teachers on the relationship between teaching math conceptually and math anxiety. I sought to answer the question: What are teachers’ perceptions of the connection between the use of a conceptual methodology for math teaching and the level of math anxiety among elementary school students?

Hiebert and Lindquist (1990) discuss the differences between conceptual and procedural knowledge. According to Hiebert and Lindquist (1990) “conceptual knowledge is knowledge that is rich in relationships” while “procedural knowledge, in contrast, is made up mostly of rules, procedures, or algorithms for performing mathematical tasks” (p. 19). In this current study, my goal was to discover teachers’ perceptions regarding the effect of teaching mathematics with conceptual knowledge as the goal, rather than procedural, on the math anxiety of elementary students. The data revealed how and why participants adopted various strategies and philosophies in order to teach math conceptually as well as the positive effects these had on students. The experiences and perceptions of teachers in this study may help other math teachers to consider implementing similar practices in order to effectively educate students thus mitigating the cycle of math anxiety.
Research Topic/Questions

The goal of this research project was to gain a better understanding of math anxiety and how it is affected by the conceptual teaching of math. By interviewing math teachers who had experience teaching junior grades (grades four to six), I hoped to gain insight into how teaching math conceptually might help to prevent the onset and/or reduce the prevalence of math anxiety in elementary students, from the teacher’s perspective.

My main question was:
What are teachers’ perceptions of the connection between the use of a conceptual methodology for math teaching and the level of math anxiety among elementary school students?

My sub-questions were:
1. How do elementary teachers describe students with math anxiety? What are elementary teachers’ experiences in learning math? Have they experienced math anxiety?
2. How do elementary teachers describe their math teaching practices? Are their practices procedural or conceptual?
3. What are elementary teachers’ preferred strategies for working with children who have math anxiety?

In order to select appropriate participants for the purposes of this study, it was imperative to determine criteria for teaching math conceptually in order to guide the recruitment process. I specifically looked for participants who included hands-on activities in their instructional practices, taught using various strategies such as group work, focused on making math meaningful to students and avoided the reliance on formulas, memorization and textbook work. Understanding the math background of teachers and how it is related to their teaching of math in a conceptual versus procedural way helped me, as a researcher, to gain insight into this cyclical
phenomenon. Discerning the teacher’s role in the cycle made the picture more complete. Additionally, knowing these teachers’ experiences with math anxiety, whether themselves or their students, gave credibility to their suggested interventions. It was also important to identify the conceptual math strategies used by these teachers for practical application.

**Background of the Researcher**

As a student growing up, math was a subject that I always enjoyed. I am more drawn to concepts that are objective, formulaic and inarguable. I struggle more with content that is subjective and up to the teacher or the reader to interpret. I tend to like rules and formulas and find it enjoyable to manipulate formulas, solve mathematical problems and play around with numbers.

While I was pursuing my undergraduate degree, I took some elective math courses. In my final year, I decided I wanted to take enough math courses to have a math teachable when I went to teachers’ college. Math was going very smoothly for me, I was getting straight A’s and A+’s. I really enjoyed my math classes until my final semester, when I took two math courses: discrete math for counting and linear algebra. Both of these courses required the students to have a deep conceptual understanding of math and to possess a conceptual knowledge of various mathematical principles such as the dimensions of vectors, logical mathematical reasoning to deduce proofs and more basic general understandings of numeracy. It was then that I realized I did not actually have a conceptual understanding of math; I was just very good at manipulating formulas.

I struggled through those courses and was able to finish with A’s in both classes, but I still didn’t feel confident in my understanding of complex math concepts. I also forgot most of the things that I learned because it was attained by rote memorization. The instruction I received
in those classes lacked conceptual explanation, therefore I failed to learn conceptually. During these classes, I not only struggled to understand the concepts, I also struggled severely with math anxiety. Memorizing and manipulating formulas worked fine for me until I was met with challenging concepts that I couldn’t grasp. It was then that I started suffering from math anxiety. I spent hours in my professor’s office weekly and spent additional hours at home, practicing math to better my understanding. I even went as far as to get a tutor. My anxiety was so high that I would dread class, I would break down emotionally while doing homework and I would get so overwhelmed when I failed to understand something. It consumed my life.

I did make it through those math classes eventually, and math is my teachable. (In order to attain a teachable in math at the University of Toronto, students must have taken three full math courses or six half math courses during their undergraduate degree program). As a math teacher, I want to provide my students with an education that will mean something to them and not just be an exercise in memorization. I want to equip my students with an understanding that will be applicable to their studies so they can learn to think and reason for themselves. Lastly, I want to teach them in a way that will not only be useful and enjoyable, but in a way that will limit, as much as possible, the anxiety they could possibly experience while learning and applying the math concepts.

In addition to my personal experience as a student of math, I have some practical experience in math education. For the past four years I have worked as a classroom tutor to help prepare grades three and six students for the EQAO assessment. This involves working with small groups of students who are struggling and helping them better grasp the concepts. In addition to tutoring children in a classroom setting, I have also privately tutored math students. As a classroom and private tutor, I spent time supporting students who experience difficulty with
grasping math conceptually. I have witnessed firsthand, the frustration, distress, worry and sometimes anger associated with the failure to understand the math. In many cases, students are unable to simply memorize and manipulate formulas when it lacks connection to their previous knowledge. It is also very common for students to refer to a concept based on the formula rather than the actual meaning of the concept, illustrating a superficial and procedural understanding.

Due to my experiences with math anxiety, both from a student’s and a teacher’s perspective, I am passionate about this topic. I want to teach my future students using instructional methods that will prevent anxiety and facilitate true understanding. Through this study, I also hope to contribute to the teaching profession by demonstrating the importance of teaching math conceptually, thereby reducing the math anxiety that plagues classrooms throughout.

**Overview**

Chapter one of this research paper is the introduction. It includes an introduction to the concept being researched, the purpose of this study, research questions guiding this paper and the background of the researcher. Chapter two is the literature review. This chapter explores different themes surrounding math anxiety as well as the literature surrounding conceptual and procedural teaching methodologies. Chapter three discusses the methods taken in this study, including the instruments used, it describes the background of the participants and how they were recruited, and it also discusses the ethical review and the limitations of this study. Chapter four reveals the findings of this study categorized into meaningful themes based on the data. These themes include: Teacher Background and Development, Effective Teaching Strategies, Math Anxiety and Overcoming Math Anxiety. Finally, chapter five provides the reader with a discussion of the findings. This chapter offers practical implications and next steps to be taken,
based on the findings, in order to reduce math anxiety in elementary school students.
Chapter 2: Literature Review

What is Math Anxiety?

As stated earlier, for the purpose of this study, math anxiety will be defined as “anxiety that is present or produced surrounding mathematical content eliciting an emotion that blocks a person’s reasoning ability when confronted with a mathematical situation” (Spicer, 2004, p. 1). At a first glance, it may appear that this issue of math anxiety is nothing more than a student who simply struggles with math and therefore feels apprehension towards it. It may also seem strange “that the subject seen as the most logical and intellectual is also the one that ignites so many passionate emotions” (Stuart, 2000, p. 330). However, in reality, “it is a real affliction called ‘math anxiety’” (Tobias, 1978 as cited in Stuart, 2000, p. 330). The onset of this affliction can appear as early as grade four and rises to its highest levels in middle school and high school (Scarpello, 2007). A major implication of this affliction, other than the symptoms and effects it has on the student while activated, is the implications it has for their futures. Students with math anxiety are at risk of avoiding math-related courses and math-related careers (Scarpello, 2007). Therefore, math anxiety not only affects the students while in elementary school, but could also have lasting effects.

Math anxiety manifests itself in many different ways depending on the victim. According to Kitchens (1995), math anxiety can produce physical symptoms such as nausea, hot tingling, severe nervousness, inability to concentrate and physically hear the teacher, disturbed by noises, negative self-talk and sweating (as cited in Godbey, 1997). The effects of math anxiety are not isolated or partial to elementary students but are very prevalent in college students, pre- and in-service teachers and even other adults that have no direct contact with math. This study looked at the math anxiety of elementary school students as perceived by their math teachers.
The Onset

As stated earlier, there is no formula to determine how math anxiety begins. On the contrary, there have been many identified sources that cause math anxiety. Some researchers have revealed that the cause of math anxiety stems from negative attitudes, beliefs, and/or behaviours surrounding math. Fennema et al. (1990) discuss the effect of gender bias and how teachers will attribute boys’ math successes to effort and ability and identify them as their best students. The attributions for girls differ from that of boys and were thought to negatively affect girls’ math achievement. Girls’ lower perception of competency in math has also been identified as a possible reason for a greater number of females’ reporting math anxiety that they, in fact, don’t experience (Goetz et al., 2013). Teachers’ attitudes play a big role in the development of a student’s attitude because students will be directly affected by and will adopt the instructor’s perceived positive or negative attitude towards teaching math (Jackson & Leffingwell, 1999). Supporting this claim, Scarpello (2007) advocates that the attitudes and influences emanating from the home and the classroom have a big impact on the attitude a child will develop towards math. Teachers play a major role in creating the classroom emotional environment and their attitudes consequently have a rippling effect on students. The reason why this is such a critical issue is because the attitude that a student adopts about math will influence their confidence level (Stuart, 2000). Finally, the effectiveness of teaching may also be altered by the attitudes a teacher adopts (Teague & Austin-Martin, 1981 as cited in Malinsky, Ross, Pannels & McJunkin, 2006). If teachers’ negative attitudes influence the effectiveness of their teaching as well as their students’ attitude and confidence towards math, this leads to a negative impact on the students’ math education. These effects likely include math anxiety accompanied by many more detrimental consequences.
Besides their attitudes, teachers can contribute other ways to the development of student math anxiety. As mentioned earlier, teachers can suffer from math anxiety themselves. Many of these teachers who have math anxiety transfer it onto their students (Geist, 2010). Jackson and Leffingwell (1999) identify certain behaviours that teachers display that increase anxiety in their math students. Some of these include: statements that blame the students for their lack of understanding, lack of feedback or failure to answer questions, avoidance of eye contact, demeaning sighs, and inadequate amount of time dedicated to explanation and tutoring. Teacher mastery of the content also has an effect on the students.

‘It goes back to teacher preparation and knowledge of the subject matter,’ said Ms. Ford, a former member of the governing board that sets policy for the National Assessment of Educational Progress. ‘If the teacher’s uncomfortable with the curriculum, it will be noticeable to the students’ (Cavanagh, 2007, p. 1).

Physiological factors have been shown to impact the effects of math anxiety. According to Beilock and Carr (2005), students under pressure who possessed greater capacities for working-memory are at greater risk of struggling in math when the problems are more complex. This is because in higher-pressure situations, anxiety actually interrupts the function of the working-memory thereby inhibiting its response. This implies that, under high-pressure situations, the effects of math anxiety are worse for students who have a great capacity for working memory. This is the case especially when the situation demands a higher reliance on working memory (Beilock & Carr, 2005).

Lastly, teacher methodology has been shown to have an impact on math anxiety of the students. Geist (2010) recognizes a problem in the policies of the school system that cause students to firstly depend on rote memorization and secondly suffer more from math anxiety. He asserts that these policies make math “high risk” (p. 24). A student who perceives math as high-risk would certainly have increased anxiety surrounding it. Geist then goes on to explain that this
contributes to the outcome of more adults suffering from math anxiety. Finlayson (2014) addresses how the “traditional delivery method” (p. 100) of math increases math anxiety because it is teacher-directed and teachers use their power and authority over the students. Students do not feel free to ask teachers questions and they take in information passively. Karp (1991) discusses the reasoning behind this kind of teaching methodology, which relies on the formulas and rules of math, and explains that teachers suffering from high levels of math anxiety, who also have negative attitudes about math themselves, practice procedural methodology. This relates back to the previously discussed issue that attitudes can have a negative impact on teaching. This type of memorization-based teaching is especially dangerous as it fails to meet the learning styles of all students and, therefore, may unintentionally perpetuate math anxiety (Hodges, 1983; Zaslavsky, 1994 as cited in in Sloan, Daane & Giesen, 2002). Teachers with math anxiety or negative attitudes about math need to recognize not only the rippling effect that their attitudes have on the students, but also the impact it has on their teaching and how they present the concepts to their students. By becoming aware and critical of the impact that a teacher’s methodology has on their students, teachers can learn to adapt their teaching strategies to enrich the learning experience of their students rather than hinder such experience.

**Conceptual versus Procedural Teaching**

We have just discussed some negative effects that teaching for memorization can have on students’ math anxiety. Teaching rote memorization and the concentration on mere procedures is one teaching methodology that some math teachers use. However, other math teachers are more committed to teaching for understanding, which is a method that scaffolds students’ skills to make deeper connections and understand the math concepts rather than merely memorizing them. In this next section, conceptual versus procedural knowledge and teaching is discussed.
Hiebert and Lindquist (1990) define conceptual knowledge as “knowledge that is rich in relationships” and “can be thought of as connecting a web” as students make connections between new knowledge and previous knowledge (p. 19). In a math context, conceptual knowledge makes the procedures meaningful as it allows for an understanding of the relationships and connections behind the math (Eisenhart, Borko, Underhill, Brown, Jones et al., 1993). In addition, conceptual knowledge is flexible and can be generalized to solve different types of problems (Rittle-Johnson & Star, 2007). Conversely, procedural knowledge is defined as knowledge that “is made up mostly of rules, procedures, or algorithms for performing mathematical tasks” (Hiebert & Lindquist, 1990, pp. 19-20). Hiebert and Lindquist (1990) continue to reveal that procedural knowledge doesn’t need to be connected to previous knowledge but can be learned in independently. With the production of a correct answer as the goal, procedural knowledge dictates exact steps to be taken in order to reach that goal (Hallett, Nunes & Bryant, 2010). Hiebert and Lindquist (1990) also highlight that a certain kind of knowledge is developed based on the way we are taught and the instructional activities used to teach concepts. They also feel that it is important to have a balance of the two types of teaching, however they emphasize that the majority of students acquire procedural knowledge independent from conceptual knowledge (Hiebert & Lindquist, 1990).

Teaching procedurally focuses the instruction on the procedure itself. It involves memorization of facts, rules, formulas and step-by-step procedures. Returning to Hiebert and Lindquist’s (1990) definition of procedural knowledge, we see that in order to attain this knowledge, there need not be any links to other concepts, and the rules can be separated from the concept. Many teachers teach math in this way and emphasize that students must memorize the procedure. McNeil and Alibali (2000) discuss this method of teaching and highlight that when
students are learning these procedures they risk failing to grasp the conceptual knowledge that corresponds to that concept. In this discussion they state that children don’t have to even understand the procedure they are using, but merely apply it to the question in order to get the correct answer. While teaching the rules, procedures and facts are very important, conceptual understanding must support it in order for it to be transferable (Graffam, 2003; Shepard, Hammerness, Darling-Hammond, Rust and Baratz Snowden et al., 2005) and truly meaningful to the student (Thanheiser, 2012).

Many researchers like Hiebert have examined what it means to teach conceptually-for understanding. In order to teach math meaningfully, teachers must first define what understanding is. Perkins and Blythe (1994) define understanding as “being able to do a variety of thought-demanding things with a topic- like explaining, finding evidence and examples, generalizing, applying, analogizing and representing the topic in a new way” (pp. 5-6). In addition, students must be able to perform tasks that not only demonstrate an understanding of the material, but also enhance it simultaneously (Perkins & Blythe, 1994). Eisenhart et al. (1993) explain that teaching math conceptually refers to helping students develop an understanding of the procedures they are using. Silver, Mesa, Morris, Star and Benken (2009) highlight giving explanations, representing concepts through physical models and making real-world connections as key components to teaching students for deeper understanding.

Similar to the methodology of teaching conceptually is the theory of constructivism. There are many elements involved when teaching through a constructivist approach such as group work, interactions, use of manipulatives, pursuing student questions and interests, and assessing through student work, observation, discussion and tests (Thirteen Ed Online, 2004). The main idea of constructivism is to focus on the process rather than the outcome and allow
students to build on their prior knowledge (Pirie & Kieren, 1992; Posamentier, Smith & Stepelman, 2010 as cited in Finlayson, 2014). Many characteristics of constructivism coincide with those of the conceptual methodology. They both share the common emphasis that students should build a network of connected knowledge and not rely on rote memorization.

Conceptual knowledge is very important in the acquisition of math. However, researchers recognize that the combination of factual/procedural knowledge with this conceptual knowledge best facilitates true understanding. In fact, Hallett, Nunes and Bryant (2010) found that students who were high in conceptual knowledge and low in procedural knowledge performed better than those with high procedural knowledge and low conceptual knowledge. However, those who were both high in procedural and conceptual knowledge performed the highest. That being said, it must be reiterated that focusing on procedures and neglecting to support such procedures with concepts is common (Van de Walle, Folk, Karp & Bay-Williams, 2011). Additionally, too much emphasis is being placed on the development of procedural knowledge, creating a major lack in the development of conceptual understanding with opportunity to apply such understanding (Porter, 1989). Arslan (2010) found that while the acquisition of procedural knowledge was not sufficient to predict conceptual knowledge, the acquisition of conceptual knowledge was in fact a predictor of procedural knowledge. This one-way relationship is again support for the insufficiency of procedural teaching and suggests a need for a pedagogical focus on conceptual teaching (Arslan, 2010).

Factors Impacting Teacher Methodology

There are many factors that can and do affect a teacher’s pedagogy. We have discussed the differences between two teaching methodologies, procedural and conceptual, and now we will discuss some factors that influence the teacher’s choice of such methodologies. Philipp,
Ambrose, Lamb, Sowder, Schappelle et al. (2007) discuss these factors in light of pre-service teachers. One main factor that they identify is the individual’s educational history in math. They found that pre-service teachers were not willing to engage the math material in a new and “deeper” way than they themselves were taught during their schooling. Additionally, pre-service teachers believed that their knowledge was sufficient for their students’ level of learning and they didn’t feel the need to relearn something they already knew (Philipp et al., 2007). Two factors are at play here in influencing the teacher’s preferred methodology. Firstly, we see that many teachers were not taught math conceptually themselves as children and are therefore reluctant to relearn it conceptually in order to teach it that way. Secondly, we can identify a belief in the pre-service teachers that whatever they know is sufficient for an elementary school education. Therefore, strong influences on teacher methodology could be: a history of learning math procedurally, a reluctance to explore math conceptually and an belief of self-sufficiency.

Thompson and Thompson (1996) discuss teacher orientation as a factor influencing whether or not teachers will adopt a conceptual methodology. A teacher with a “conceptual orientation” (p. 20, italics in original) is motivated by various visions for their students’ learning. These visions for their students include: ideas and thinking strategies they want their students to have, how such ideas and thinking patterns can develop, activities that engage students and guide them toward generalizable knowledge and lastly, a vision for how students will remain engaged intellectually (Thomson, Philipp, Thompson & Boyd, 1994 as cited in in Thompson & Thompson, 1996). According to Thompson et al. (1994) conceptually-oriented teachers resist the emphasis on procedures and guide their students to focus on the conceptual understanding of ideas and the relationships amongst them (as cited in Thompson & Thompson, 1996). Thompson & Thompson (1996) also argue that a teacher must at least acquire the
schemes they want students to develop in order to effectively teach math conceptually. These ideas are further supported by Thanheiser (2012) who asserts that procedural proficiency is insufficient preparation for pre-service teachers to teach conceptually. In sum, teachers must possess conceptual knowledge of math themselves in order to implement such methodology in their teaching (Ball, 1990).

An additional factor that could influence a teacher’s methodology would be “mathematical knowledge for teaching” (Hill, Rowan & Ball, 2005, p. 373). Although being able to properly calculate mathematical problems is very important for teachers, those who possess knowledge for teaching must also be able to demonstrate the mathematical concepts and procedures using diagrams or pictures, provide explanations that allow for deeper understanding and meaning, and evaluate solutions and explanations given by the students (Ball, 1990; Hill et al., 2005). In other words, the important factor is not just that a teacher can perform math tasks themselves, but rather that they have a deeper understanding of the concepts and they are prepared to teach the knowledge in the classroom (Ball, 1990; Hill et al., 2005). Hill et al. (2005) found that the possession of the mathematical knowledge for teaching positively impacted students’ learning, however it is still uncertain how this knowledge influences teacher practice.

There exist many factors that impact a teacher’s methodology. In some cases teachers are conscious and purposeful about their teaching methods, but in other cases their methodology is a result of historical and orientation factors they may not even be aware of. The next section will examine the impact that teaching either procedurally or conceptually has on students.

**How Teaching Methodology Impacts Students**

To begin, the effects that teaching procedurally has on students and their learning is briefly discussed. We have already identified that teaching procedurally focuses on the
memorization of facts, formulas, procedures, etc. Firstly, the development of meaning suffers when the focus of teaching is on the rote practice of procedures (Thanheiser, 2012). In other words, many students have no idea why they are performing the procedures (Ball, 1990).

Unfortunately, when teachers present mathematical information in this way, students risk not being able to learn the conceptual knowledge that correlates to the procedure (McNeil & Alibali, 2000). McNeil and Alibali (2000) also add that it is often difficult for children to then transfer the use of the procedure to another question other than the particular question used during instruction. Due to the fact that meaning and understanding is often detached from procedural practice, many students fail to acquire conceptual knowledge from procedural teaching and therefore struggle to transfer it (McNeil & Alibali, 2000).

According to Van de Walle et al. (2011), teaching math procedurally, and failing to support it conceptually “leads to errors and a dislike of mathematics” (p. 22). Van de Walle et al. (2011) also discuss what understanding means in light of a continuum. Borrowed from Skemp (1978) they discuss two extremes: “relational understanding” which is a richer, more networked and connected understanding, and “instrumental understanding” which is isolated and lacks meaning (as cited in Van de Walle et al., 2011, p. 21, italics in original). According to Van de Walle et al. (2011) when math is learned by rote memorization and focuses on procedures, the understanding gained is instrumental; it is isolated and lacks connection. Lastly, returning to Geist (2010), procedural teaching and the reliance on rote memorization seem to be coupled with math anxiety, which is inevitable when math is perceived as a “high-risk activity” (p. 24) for many students. Finlayson (2014) also addresses how the “traditional delivery method” (p. 100) of math increases math anxiety because it is teacher-directed and teachers use their power and
authority over the students. Therefore, procedural teaching contributes to the experience of math anxiety as well.

Teaching math conceptually also has an impact on the students. As mentioned earlier, Hiebert and Lindquist (1990) discuss conceptual knowledge as making connections and relationships with other knowledge. Therefore, when students are taught with conceptual knowledge as the goal, it allows the connections to previous knowledge and the understanding of the topic in a new way to take place. This learning would be categorized as relational understanding on Skemp’s (1978) continuum that Van de Walle et al. (2011) discuss. Additionally, these types of connections and relationships are characteristic of the constructivist theory discussed earlier. Finlayson (2014) found that certain aspects of this constructivist model of learning helped pre-service teachers with math anxiety improve their understanding of math concepts. Eisenhart et al. (1993) credits conceptual teaching with the intention of helping students actually understand the procedures they use in solving problems. If this intent is indeed fulfilled, students, under the guidance of a teacher who teaches math conceptually, will develop a better understanding of why they are exercising the given procedures. This understanding not only makes math more meaningful, but also limits the risk of forgetting the procedure easily (Nebesniak, 2012). When the understanding is present and the deeper connections are made students are more likely to remember the mathematical concepts for future reference (Nebesniak, 2012).

Of equal importance is the ability to transfer the knowledge to multiple contexts. Shepard et al. (2005) assert that when knowledge is taught with a focus on understanding the underlying concepts, application and cause-and-effect relationships, transfer is more likely. According to Graffam (2003) the transferring of knowledge is inevitable when understanding is the focus and
the goal of teaching. However the ability to transfer knowledge is hindered by merely focusing on rote memorization (Shepard et al., 2005). In describing her teaching journey from teaching math procedurally to conceptually, Thrift (2007) summarizes her experience:

I chose to create meaningful lessons for them. And that first group of students rewarded me by becoming excited about being in charge of their learning. During this experience, my view of the role of the teacher shifted. I moved from thinking that I had to be the dispenser of knowledge to understanding that my students needed me to *guide* them as they found solutions to the problems they faced. From procedural teaching to conceptual teaching- what an eye-opening journey (p. 60, italics in original)).

From Thrift’s experience, conceptual teaching encourages students to take responsibility for their learning, ignites excitement and meaning that relates to the concepts and allows students to figure out the solutions to their mathematical problems more independently.

Teaching conceptually adds significantly more meaning and usefulness to a student’s mathematical education. It allows students to make connections and deeply understand what they are learning. Given that this teaching methodology benefits a child’s education significantly, this requires an examination as to whether or not this teaching methodology has an impact on math anxiety. Research tells us that teaching math procedurally does indeed play a role in the onset of math anxiety (Geist, 2010; Finlayson, 2014). Therefore, this current study sought to reveal what teachers’ perceptions are of the connection between the use of a conceptual methodology for math teaching and the level of math anxiety among elementary school students.
Chapter 3: Methods

Procedure

This research paper, focusing on teachers’ perceptions of the relationship between teaching math in a conceptual way and math anxiety, is qualitative in nature. More specifically, the nature of this research is phenomenological, which Creswell (2013) defines as a study that “describes the common meaning for several individuals of their lived experiences of a concept or a phenomenon” (p. 76), in this case being math anxiety. The literature review began with a review of the research focusing on concepts surrounding the purpose of this study. It first gave some background knowledge about what math anxiety is and defined it for the reader. Afterwards, it discussed what the literature demonstrates about the onset of math anxiety. It then proceeded with a discussion about the difference between conceptual and procedural knowledge and teaching, and certain factors that influence what methodology a teacher chooses to implement. Lastly, the review discussed how such methodologies impact the learner.

Following the literature review, I conducted face-to-face interviews with three in-service teachers who implement a conceptual methodology in their math teaching. These semi-structured interviews were guided by a list of interview questions (see appendix B). These interviews were recorded and then transcribed and analyzed for common themes and participant experiences (Creswell, 2013).

Instruments

The informal interviews were guided by a set of interview questions. The questions focused on the teachers’ backgrounds, their conceptual approach to teaching math, how math anxiety manifests in their classroom and how their teaching methods affect that anxiety. Some of these questions included:
1. What are some effective teaching methods and strategies you implement in your math teaching?

2. What are your thoughts about procedural versus conceptual teaching strategies?

3. In your opinion and personal experience, what contributes to the cause of math anxiety in your students?

4. What are your thoughts on teaching mathematics conceptually and math anxiety?

5. How would you advise teachers of math to best prevent and/or reduce math anxiety in their students?

The interview questions were comprised of a combination of open and closed-response questions. I conducted semi-structured interviews that were guided by a specific set of questions yet allowed for flexibility and probing to best reach the participants and extract thorough and useful information (Rowley, 2012). This gave ample opportunity for the participants to answer openly, in a conversation style, and discuss things that may not have been answered using the specific questions (O’Leary, 2004). The goal of the interviews was to gather as much information as I could about math anxiety in relation to teaching math conceptually (Gill, Steward, Treasure & Chadwick, 2008). The interviews took place in an environment of the participants’ choice that ensured confidentiality, focus and comfort at the participants’ convenience (Gill et al., 2008). I began with an explanation of the purpose of the interview, reminded the participants of their rights according to the ethical review process and an outline of the format the interview would take (McNamara, 2009). I then proceeded with the interview questions.
Participants

There were three participants in this study. The participants were elementary school teachers who all had experience teaching math to junior students (grades four to six) as well as other grades. All participants had been teachers for at least five years. They had ample experience teaching math to notice how certain teaching strategies have changed over time, implement different teaching strategies and develop observation skills in order to analyze their students’ emotions and behaviours in the classroom.

Of utmost importance, the teachers being interviewed understood and practiced a conceptual teaching methodology while teaching math. This was particularly important because only teachers who implement this teaching methodology would have been able to richly comment on its effect on the students. In order to ensure my participants met these criteria, I sought them out by methods such as job description, reputation and observation. One participant, I was able to personally observe in order to verify their experience and teaching methodologies. A math coach within the Toronto District School Board (TDSB) whose mandate is to support other teachers to implement a conceptual framework for math education was another participant. Lastly, my third participant was recommended due to his reputable math program with an emphasis on conceptual teaching. I sought out and selected elementary school teachers who actively valued a rich education and implemented teaching practices that facilitated students’ conceptual understanding. I ensured that the participant teachers met the above criteria throughout the interview process with specific questions about their teaching methods, strategies and philosophies. Through the guidance of and discussion with professionals in this field, I selected teachers who were reputable for implementing conceptual teaching methodologies in their math classrooms.
Data Collection and Analysis

After the interviews took place, I transcribed them, then coded and analyzed them. Researchers who carry out phenomenological studies look for common experiences of the participants surrounding the phenomenon (Creswell, 2013). Therefore, I analyzed the data to find common experiences these teachers had surrounding math anxiety of their students. I also looked for common themes amongst the three teachers’ answers and analyzed their perceptions of teaching math conceptually and its effects on student math anxiety.

Ethical Review Procedures

Each voluntary participant in this study was given ample information about this study before they were asked to commit to participate. Prior to the interview, participants received a consent letter (see Appendix A) to sign thereby giving them time to make an informed decision whether or not to participate. Participants were given time and opportunity to ask questions of clarification and/or withdraw from the study at any time.

Participants were informed of the topic and purpose of this study. Each participant was guaranteed anonymity by the use of pseudonyms throughout the report. Participants had full knowledge of the interview process and were aware that it would be recorded. Interviews took place in a location of the participants’ choice in order to ensure their comfort. After the transcribing of the interviews took place, participants received a copy of their signed consent form along with a transcribed copy of the interview. Participants had the opportunity to review the paper prior to submission in order to correct/clarify any conclusions drawn based on their information given. Lastly, without reservation, participants were given my contact information, and were permitted to review the final research paper.
Having had this openness and prudence with each participant, it helped to increase their comfort level (Gill et al., 2008). Clear expectations and procedures built trust, thereby increasing honest participation. Each participant willingly and excitedly agreed to participate in this study and offered up rich and conclusive data that contributed to the value and success of this study.

**Limitations**

Limitations are variables in a study that may prevent the findings from being reliable and/or generalizable. The limitations of this study predominantly stem from the time allotted for this research study as well as the breadth of the research. The purpose of this study was to investigate a topic in teaching that would inform my future practice as an elementary teacher. My choice of interviewing three teachers limits the ability to generalize the results to the entire population. Having only interviewed the teachers each once also limits the generalizability of this study. That being said, the information collected from the experienced teachers was sufficient to fulfill the purpose of this study.

Evidently, there is bias present in the collection and interpretation of the data. I recognize that by specifically choosing teachers who implement conceptual teaching strategies, they likely presented their bias towards this teaching style as they advocated for their practice. Additionally, as a Master’s student in education, I too may have had bias while collecting and analyzing the data as I viewed the data through the lens of my own personal experiences and assumptions. These biases may have effected my analysis as I looked for responses and/or trends that either complimented or contradicted my training and professional experience.

Lastly, this study is limited in its spectrum of data collection. I would have liked to spend more time in the classroom observing the students over a longer period of time to get a sense myself of their reaction to conceptual teaching of math. I would have also liked the opportunity
to interview and speak with students to get their interpretation of the topic, thereby expanding the picture of math anxiety relating to the conceptual teaching of math.
Chapter 4: Findings

The findings extracted from the interviews with each teacher are very enlightening for all involved in the math education of elementary school students. Due to the variety of participants and their individual backgrounds, experiences, qualifications and even teaching positions, the data collected was rich in insight, personal stories, teaching strategies and implications for math educators. All participants spoke to their experiences with various teaching methodologies and strategies within the math classroom as well as their personal experiences with math anxiety. The names being used are pseudonyms for anonymity. Each participant was eager and passionate to share his or her expertise and therefore provided plentiful and rich data to work with.

In this chapter I present the findings from the interviews that took place with the three teachers. I have organized the data into four major themes with subthemes for each as follows (refer to Figure 1):

1) Teacher Background and Development
   a. Achieving high qualifications
   b. Teaching with passion and motivation
   c. Moving away from procedural dependency
   d. Adopting a positive attitude

2) Effective Teaching Strategies
   a. Teaching to the student
   b. Utilizing the three-part lesson
   c. Learning cooperatively
   d. Nurturing math success
3) Math Anxiety
   a. Teaching students with math anxiety
   b. Decoding possible causes of math anxiety

4) Overcoming Math Anxiety
   a. Nurturing math success
   b. Creating a learning environment
   c. Exposing students to math
   d. Defusing math anxiety
   e. Teaching conceptually
Each participant provided ample data within each theme. I will discuss each theme by breaking them down into subthemes for better understanding. These themes were chosen and are presented in the order of the flow of conversation with each participant therefore the order in which they will be presented in this chapter does not represent their importance.

**Theme 1: Teacher Background and Development**

**Achieving high qualifications.** The first subtheme that arose from the interviews was the finding that each participant was highly qualified in their field. All three took additional qualification (AQ) courses after the completion of their teacher-training program and had lots of experience teaching math. Abby took multiple AQ courses including mathematics part one, tutored math, taught booster programs for math and engaged in unique mathematics education experiences. She described one unique experience:

> I did home instruction and it was with a student who had a tumor in his brain so there was some severe developmental delays there so I delivered his math program . . . he was non-verbal and couldn’t talk at all. So there are lots of different facets that I’ve done the math in.

Lila had many qualifications as well and was in a leadership position of a math coach. The role of a math coach is a teacher who is mandated and committed to math education improvement through co-planning, co-teaching, observation and helping other teachers grow and develop (Toronto District School Board, 2009). Aside from all of her courses and workshops that she engaged in, Lila attributed much of her growth and development as a math teacher to a mentorship relationship with another teacher. Lila described this relationship in the following way:

> She [Lila’s mentor] was taking her AQ courses and she had a great professor who was teaching her and then she was passing that kind of down to me. And so many times she went for professional development she would bring me so my math skills improved but also my interest in teaching and my relationship with her. We . . . became good friends through this process.
Lastly, Jake not only had a high level of qualification and experience teaching math, he also had a strong background in math himself. He shared, “I have a strong math background of various degrees, I’ve always enjoyed . . . teaching, I think quite a bit. . . . I’ve done various workshops and done a lot of reading on my own.”

All participants were highly qualified and competent in math but also had different and unique work experiences and/or mandates that influenced the way they approached math education.

**Teaching with passion and motivation.** Each teacher loved his/her job and viewed teaching math as a calling rather than a paycheck. The findings demonstrated that every participant put in efforts daily to strive for the greatest success of their students. Abby described her efforts to support math students and resolved:

> It does take more time at the end of the day to actually sit and reflect on what the students have learned and to figure out where you’re going to take each student the next day but I think in the long run it pays off because then you’re making more progress.

Lila, as a math coach, had great vision and hope for students of an entire school body as a whole and explained that “it’s a slow process, but once you see a school transformed, it’s amazing how everyone starts to move.” Lastly, Jake acknowledged the value in taking extra time with students when he stated that it “takes a lot of time to prepare. I spend a lot of time preparing my units, my year plan, my unit plans, a lot of time reading and understanding.”

It was evident that all participants were passionate about their job and motivated to ensure that all students were truly learning the math. Whether they were spending extra time, expanding their experience through unique job opportunities or making sacrifices for student success, each teacher truly dedicated him or herself to the mission of student success in math.
Moving away from procedural dependency. It was very interesting to hear what each teacher had to say about teaching math procedurally. There was a general theme amongst all participants that math educators need to move away from the sole dependency on the procedural methodology. Abby had many concerns about how teaching math procedurally would have a negative impact of students. She highlighted, “There are tons of students who have poor memory so . . . if there’s no meaningful context to the steps it’s very easy for all that to become lost.” Interestingly, Abby’s concern about the linkage from procedural teaching to the difficulty with memory connects to Beilock and Carr’s (2005) research discussion about students who rely on working memory. Students with a greater capacity for working-memory are affected in high-pressure situations because of the impact that anxiety has on the working memory (Beilock & Carr, 2005). Because memory is limited in some students, and strongly affected by high-pressure situations in other students, perhaps a teaching methodology that does not require such a heavy reliance on memory is needed so that it won’t be a hindrance to student success. Returning to the literature, Nebesniak (2012) discusses how the presence of understanding and deeper connections makes it more likely that students will remember the mathematical concepts for future reference.

Lila was of the strong belief that there needs to be a balance of procedural and conceptual teaching, however she recognized that procedural capabilities are not sufficient. She asserted, “You can memorize it all you want, but [students] physically can’t explain it so you don’t know that they have that conceptual understanding. . . . they’re still in that procedure of just the memorization, the low-level learning.”

In alignment with Abby’s beliefs, Jake also believed that “if you’re just teaching surface algorithm and kids encounter difficulties you have no idea how to help them.” He stated that he
thinks “procedural is kind of a waste of time.” He continued, “You’re wasting your time, you’re wasting the students’ time. I think it’s what’s done when you as the teacher don’t really understand the concept. It’s easy to default to the procedure.”

There was a general consensus among the teacher participants that it is not sufficient to rely solely on procedural methodologies and educators must move away from the reliance on this teaching style. All participants were consistent in stating that there is room in an effective program for standard algorithms, however if teachers do teach the procedures, a conceptual understanding must support them. The literature review discussed how Eisenhart et al. (1993) define teaching math conceptually as helping students develop an understanding of the procedures they are using. When math is taught in this way, with a focus on understanding, the ability to transfer knowledge is more likely (Graffam, 2003; Shepard et al., 2005). Abby’s ideas aligned with those of Eisenhart et al. (1993) and Shepard et al. (2005) when she summarized:

I think the rote procedures help to a certain degree but if they’re taught in isolation and the kids don’t understand why we’re doing this, it’s not going to stick. . . . That’s not to say that standard algorithms aren’t good but if they’re taught without an understanding of why you’re doing this then students get lost.

**Adopting a positive attitude.** The last common attribute amongst these teachers was their positive attitude. Looking back to the literature review, the research showed that teacher attitude plays a very significant role in the attitudes that students adopt towards math (Jackson & Leffingwell, 1999; Scarpello, 2007). This attitude can also affect students’ confidence level (Stuart, 2000) and therefore potentially play a role in math anxiety. So also the research shows that “these attitudes may affect the effectiveness of the teaching itself” (Teague & Austin-Martin, 1981 as cited in Malinsky et al., 2006, pp. 275-276). Abby demonstrated an open and optimistic attitude. She explicated her efforts to see math through her students’ eyes in order to help them succeed. She stated, “Just to see confidence grow in students is a huge thing.”
Lila also showed a willingness to keep an open and flexible attitude in her classroom and chose to strive for student and teacher growth throughout the process of learning math. She explained:

And so now I love math . . . and so now I realize that I’m . . . at least open to the new styles and I try things out and so by no means do I think I’ve hit the end point. Every day I think I learn something new from a student.

The findings indicated that Jake maintained the philosophy that “all kids can learn math. There’s nobody who is ‘bad’ at math” and he demonstrated his love for teaching math when he stated, “I’ve always enjoyed it, teaching I think quite a bit. I really, I enjoy it.” The data showed that Jake loved math and believed all his students could learn, but he also had an attitude towards struggling students that gave them the best chance to succeed. He mentioned that at his school there was a large immigrant population and therefore many English Language Learners (ELLs). When discussing students who may have struggled to meet provincial standard (Ontario & Ontario (2010) Growing Success document provided by the Ontario Ministry of Education indicates a level three as the provincial standard meaning the student has demonstrated knowledge and skills with considerable effectiveness), he noted:

That’s not always their fault. It’s not a learning disability, especially this community. . . . If you can’t speak English, you’re going to miss a lot of math at the earliest level. So is it a surprise that they’re not doing well now in math? No! And it’s not because they’re incapable.

Each teacher participant held very optimistic and positive attitudes towards math education and their students. These positive attitudes and beliefs contributed significantly to the success and environment they fostered in their classrooms every day. All participants were highly qualified and committed to the success of their student. They demonstrated a passion for teaching and recognized the need to foster student understanding. Their backgrounds, beliefs and attitudes majorly impacted their teaching abilities and, consequently, their students’ success.
Theme 2: Effective Teaching Strategies

Teaching to the student. Throughout the interviews with the teacher participants, many teaching strategies were discussed. One of the most prevailing strategies that each teacher illuminated was teaching to the student. It will become clear what this means as each participant’s implementations of this strategy are discussed.

Abby explained her commitment to each student by highlighting the importance of understanding “how would one particular student conceptualize this concept versus another. She continued, “Not all students see things the same way so it’s about picking a variety of different ways to show a particular concept.” Abby also discussed the importance of understanding what “students already know about the topic so that you can then start to anticipate where the difficulties are going to be.” Knowing where your students are at in their math education, knowing how they learn and knowing where to take them are all things Abby advocated for in her classroom.

From a coaching perspective, Lila explained that when it comes to students who struggle to grasp the concepts, “it’s really important to find out why they’re not getting it.” Lila discussed the importance of giving “them [students who struggle] another way of thinking about that or give them a different tool . . . they’re more familiar with or maybe more responsive with.” Jake felt it was important to assess his students by “figuring out where they are, going back far enough that they are comfortable and get it, and then building from there.” His philosophy was that curriculum levels were secondary to the students’ current learning levels. If students were not ready for their grade level math, he would begin where each student was at in their mathematical understanding. From the literature, we know that the main idea of constructivism is to focus on the process rather than the outcome and allow students to build on their prior
knowledge (Pirie & Kieren, 1992; Posamentier et al., 2010 as cited in Finlayson, 2014). Jake implemented this constructivist framework into his math program when he insisted upon beginning where students were at and building upon that knowledge.

Jake summed up this strategy of teaching to the student when he stated, “That’s basically it. I try and give the kids what they need.” A few practical examples of how the teachers taught to their students’ needs include: pulling students aside, breaking down concepts, beginning where students’ are at in their math understanding and parallel tasks. Abby described parallel tasks as “a couple questions that are all focused on the same big idea. . . . but then you might give three different levels of questions. . . . where they can pick the question they feel comfortable with.” Overall, the teacher participants were committed to their students’ individual levels and needs for math education and they strove to provide each student with the instruction they needed in order to be successful.

**Utilizing the three-part lesson.** Currently, there is an emphasis in Ontario school districts on using the three-part lesson to guide math learning. The three parts include a minds-on or activation component, an action component and finally, a consolidation or reflection component. The specific parts will be discussed throughout this section as each participant describes them.

All three participants explained their use of the three-part lesson designed for math. The first component of the three-part lesson was described by Abby as “activating the prior knowledge and getting students hooked in.” She went on to explain that the first part is “a good way to see what students already know about the topic.” Lila discussed the value of this first part when she stated, “Whatever I’m introducing at the beginning of the class is going to help support them with the grappling that they’re going to do during a problem or during the task.” In sum,
the first part of the lesson works to activate prior knowledge, diagnose where students are at with a concept and equip them with skills they may need as they continue through the lesson.

Jake described, “[The] second important component is . . . a larger open question, that requires them to manipulate what they know and hopefully apply it.” Abby explained that “the main thing is just making sure that it’s an open-ended question so the students can approach it at various levels. . . . Then it’s something that every student can be able to solve.” This part of the lesson is where students use the knowledge from the first part to explore, inquire and test out their knowledge on an open-ended question. Often times this is done in groups and the teacher is available to support students who may need extra help. Abby noted that this is often where she would make use of the parallel tasks described earlier so that “everyone has multiple entry points to be able to succeed in the classroom.”

The final section of the three-part math lesson, according to Jake “probably the most important . . . is coming together.” Lila asserted, “The real learning through the end piece of my three part lesson, that consolidation, is really helping all the learners in the class.” At the end of the lesson, the teacher gathers all students back together as a whole group and discuss and consolidate the learning that just took place.

This last part of the three-part lesson, the consolidation and reflection, is often supported and carried out using different strategies such as the gallery walk, bansho and math congress. A gallery walk happens when students’ work is complete. Work is put on display and every student has a chance to look at what other students have done. Observing students can note questions or comments they have about each other’s work for further discussion (The Elementary Teachers’ Federation Of Ontario [ETFO], 2015). Bansho, similar to the gallery walk, takes place when work is completed as well. The teacher displays the work in groups based on the strategies
students chose. Groups are organized from least to most mathematically rich and this gives students an opportunity to engage in higher order mathematical reasoning (ETFO, 2015). Lastly, math congress has the same goals as Bansho, but the teacher chooses select solutions to discuss with the class. Students responsible for the chosen solutions must then defend their thinking and mathematical process. This too leads to rich discussion and mathematical reasoning (ETFO, 2015).

Jake described many different strategies he used to facilitate this consolidation:

Coming together . . . often we’ll do a gallery walk, if I’ve had them make a poster . . . sometimes . . . kids who are kind of stuck or not finished, have them look at what another kid has done and so they learn from that other student and the other student learns by teaching. . . . after the gallery walk we’ll have math congress . . . and I try and get them speaking to each other so I’ll have kids present their solutions. . . . kids are motivated . . . and they get really into it and we’ll share different solutions on the Smartboard. Then sometimes we’ll record different strategies . . . Through doing that, basically with all those parts, eventually they kind of teach each other.

Every participant described his or her use of the three-part lesson plan in their math teaching. This effective teaching strategy allows students to activate their prior knowledge and make new, rich, connections with the material during the work period, which is necessary for the development of conceptual understanding (Hiebert & Lindquist, 1990). The consolidation at the end helps to solidify those connections which Lila explained was important as she stated, “When they have time to grapple and change it and are given that successful time to make those consolidations for themselves, we are seeing greater student success.”

**Cooperative learning.** Currently, a great deal of emphasis is placed on cooperative learning elementary education. Cooperative learning takes place when multiple students work together in a group to complete a common task. Li, Piccolo, Ding and Kulm (2007) conclude, “Cooperative learning is a good teaching method in math classrooms, but it is also a complex
system” (p. 173). According to Coates and Mayfield (2009) collaborative group work can enable students to complete tasks that would otherwise be too difficult for them. Having to explain their thinking to one another in a group helps students not only to grasp the concepts they are discussing, but also helps the others in the group to think of problem solving in new ways (Coates & Mayfield, 2009). Coates and Mayfield (2009) also discuss that when cooperative learning happens within the math classroom, it fosters higher levels of thinking as well as a greater conceptual understanding of the math. Li et al. (2007) suggest that there must be a balance between relying on peer collaboration, and students’ independent thinking. This can be balanced by having students explain their thinking to each other as well as to the teacher in order to foster students’ mathematical thinking while verifying its accuracy. In conclusion, although complex, peer collaboration should be used to foster math thinking (Li et al., 2007).

All participants in this study used cooperative learning as a strategy in their math teaching. Every teacher had their students working in groups and learning from each other and they all described the impact this had on student success. Abby highlighted the value of cooperative learning when she explained, “Students get a chance to really learn lots of different things from each other instead of just working in isolation at their seat. So it’s just a better way, I think, to reach every student in the classroom.”

Lila proposed that “maybe it’s hearing the thinking of someone else going through it [that] will help me [the students] make those connection.” She felt strongly that often times, working with another student could rectify the solution to a particular student’s misunderstanding. She gave an example of how to help students reason more conceptually versus being stuck in procedural thinking:

Sometimes it would be mixing up the groupings . . . so someone who did think conceptually could work with someone who thought procedurally and hopefully
that communication through the student talk, they would start thinking about why something represented on a number line was not actually showing a hundred meters.

Jake recognized, “It takes a long time to build the culture of math conversation and I try and get them speaking to each other.” He went on to explain that “you need to scaffold from the beginning and eventually what happens is, I [the teacher] don’t even need to participate except as a guide. They talk to each other. They will ask questions.” Referring back to the three-part lesson, which incorporates cooperative learning, Jake concluded, “Through doing that, basically with all those parts, eventually they kind of teach each other.”

Students can serve as teachers, mentors and co-learners to each other. All participants illuminated the significant value that cooperative learning can add to their math program. Often times students can conceptualize things and explain math concepts in a way that will benefit other students more than a teacher’s explanation. In addition, the literature explains that true understanding requires students to perform tasks that not only demonstrate an understanding of the material, but also enhance it simultaneously (Perkins & Blythe, 1994). When cooperative learning takes place, and students are acting as mentors and teachers themselves, this will help to enhance their understanding and that of their peers simultaneously.

**Nurturing math success.** The final common strategy shared amongst these teachers was their focus on nurturing the success of each student. All participants were passionate about their teaching and their students, as discussed, and therefore placed a heavy emphasis on supporting success in their students.

The first reoccurring theme was making math enjoyable and engaging for the students. Abby nurtured math success by doing “more fun activities in the classroom.” She revealed, “Just from what I’ve heard from students, they found that [activity-based learning] a lot more fun and
it was more memorable in that sense too.” Aligning with Abby’s strategy, Lila also declared, “I would say the biggest one [strategy] for me was fun. I had to sell it. . . . if you’re not engaged as a teacher the kids won’t be engaged and they’re going to back away.” Lastly, Jake stated, “We do a lot of activities around playing.” After time to play and explore, Jake explained that he gives his students open-ended questions and “the kids love doing them. It’s fun, it’s enjoyable.” He concluded, “They love math. I love math. And they’re sad when we don’t have it. So it’s effective and it’s fun . . . and they go hand in hand.”

Another common method of nurturing math success that the data revealed was giving students permission to make mistakes. Abby relieved pressure from her students by making “sure that students know it’s ok to make mistakes and that in fact that’s how we end up learning and there’s really no such thing as a mistake as long as you keep going at it.” She identified that success comes from learning through mistakes. Lila ensured “that they [her students] know if they didn’t get it right away, at least they’re going to try something and explain [it] to us.” She qualified this type of learning as “just as valuable,” and her students “feel just as confident telling you [the teacher] that that’s an important lesson.” In order for students to be able to view their mistakes in this manner, students must feel safe and confident that mistakes are welcomed. Building students’ confidence also plays an important role in nurturing their success. Jake explained, “I try and address that first and foremost the confidence level and try and make them successful because when you’re successful, you want to do more of it.”

All teachers explained their efforts to make sure all students had opportunity to be successful with the math by carefully choosing questions and activities to suit all learning styles. Abby was adamant on setting up her instruction and activities so that “kids who are maybe a little bit lower ability could approach it and still feel successful.” When she had students who
were struggling and anxious, Lila explained, “I try to give them a question where I think everyone will be fairly comfortable with it, they’re going to have a lot of success.” Lastly, Jake stated, “I’ll differentiate and I’ll often pull them in and chat with them and kind of guide them through it so they feel successful and they feel supported. I’ll give them things that they’re capable of doing.” Every participant was dedicated to making all learners successful by supporting their needs and scaffolding the material they gave them.

Each teacher also nurtured math success in his or her own unique ways. For example, often times, the curriculum demands that students understand mathematical concepts within tight time constraints. Abby resisted this by “giving them [her students] opportunity to come back to things and continue to work on it and not feel pressure that we [the class] have to move on by a certain time.” Jake facilitated this success by exposing his students to math for a quarter of each school day. He asserted, “The more you do it, the better you’ll get. If you have the experience, you’ll understand it.” Additionally, each teacher nurtured success by assessing their students through authentic and low-pressure assessments such as conferences, portfolios, discussions and meaningful tasks.

Many of the methods used by the participants to nurture math success align with Jansen and Bartell’s (2013) research about what makes a caring teacher. They found that encouraging success and giving math students opportunity to be successful, as well as the use of humour, were important qualities of a caring teaching. Supporting Abby and Lila’s philosophy of making mistakes, Jansen and Bartell (2013) state, “Caring teachers value their learners’ senses of well-being. This value for learners is communicated interpersonally through the high expectations they communicate for learners and by giving their students multiple chances to learn from their mistakes and demonstrate their knowledge” (p. 46).
Overall, each teacher participant revealed strategies that they used to build success and understanding in all of their learners. Through teaching to each individual student, implementing the three-part math lesson, engaging in cooperative learning and nurturing math success in various ways, these teachers clearly conveyed their commitment to a conceptually based math education in their classroom. Jake summarized why he implemented these strategies when he concluded, “Why do I choose these ways? Because it’s the only way to teach . . . it’s an effective way to convey the concepts. It engages the kids. They’re excited.”

**Theme 3: Math Anxiety**

**Teaching students with math anxiety.** The data revealed that all participants had experience teaching students with math anxiety. Each participant explained how he or she identified these students in the classroom and what it meant to teach students with math anxiety. Abby defined math anxiety as “either the fear of exposing yourself as not knowing something about a particular concept or the fear of asking for help and looking silly.” She added, “I think it also kind of carries on from year to year so students get that sort of self-fulfilled prophesy.” Lila identified one aspect of math anxiety as “the fear of not putting something down.” Jake also defined math anxiety as “a bit of a fear of math” however, he specified:

> It’s a combination of external and internal I’d say. An internal ‘I don’t think I’m good at it’ and confidence issues around ‘other people will see me as not smart.’ And externally it’s looking at these symbols and saying ‘I have no idea what they mean’ and they kind of feed into each other.

Fear was a common definer of math anxiety whether it was social or academic.

Lila identified multiple symptoms of math anxiety that she observed amongst her students. She described, “Sometimes it’s the complete disengagement, sometimes it’s the acting out, it’s physical symptoms in the class, it’s the wanting to get up and go to the bathroom like wanting to forget about it, sometimes it’s the over-analyzing.” Lila also discussed math anxiety
in terms of which students it affects. She recounted a situation she had with one level four
student who could not represent his thinking in a concrete way. She explained:

Although he was classified as the level four student, [he] had a full melt down, had the anxiety, had the standing up, the complaining, the ‘this isn’t fair, I don’t get it, I’m just going to do it the other way,’ started to tear up and verbalize his frustration and like ‘arrrggg’ and like really clenching his fists and like throwing the material . . . down.

This surprised Lila because “teachers primarily think of the anxiety as coming from students who are typically achieving level one/two, but it also comes at our level four learners from pressure of not getting it quick.” In clarification, according to Ontario and Ontario’s (2010) Growing Success Document provided by the Ontario Ministry of Education, a level four is given to a student who surpasses the provincial standard (level three being the provincial standard) and demonstrates knowledge with high degrees of effectiveness. Therefore it surprised Lila that students performing above standard would suffer from math anxiety.

The data revealed that math anxiety elicited fear surrounding math and that it can manifest itself in many different ways, cause various symptoms and it affects all levels of learners. Kitchens (1995), identified nervousness, the inability to concentrate and negative self-talk as a few of the symptoms of math anxiety (as cited in Godbey, 1997). The participants in this study identified these specific symptoms, from their experience as teachers, as well as many others that they had seen in their students with math anxiety.

Decoding possible causes of math anxiety. The teacher participants illuminated many different causes of math anxiety. The first cause was the insistence on doing math in one specific way and not teaching or accepting multiple strategies and methods to solve problems. Abby explained, “For a long time math was only taught one specific way so students thought, ‘if I’m not getting this particular strategy then I must be stupid.’” She recalled her personal experience:
Growing up I was used to very much the procedural approach . . . even when it came to learning addition and it was always taught using columns and using that standard algorithm so if I didn’t understand it and I’m going home and bring that home to do homework and a parent was trying to show me it a different way, I felt that the way that it needs to be done and the correct way is the way the teacher taught it through this procedure. So there was anxiety there even in the private setting as well that I wasn’t going to do it the right way.

She attributed much of her own math anxiety as a student to the fact that “it was just taught to me in a way that didn’t make any sense based on my learning style.” This relates back to the literature’s critique that procedural-based teaching fails to meet all learners’ needs (Hodges, 1983; Zaslavsky, 1994 as cited in in Sloan, Daane & Giesen, 2002).

Similarly, Abby revealed another cause of math anxiety as teachers being unapproachable. Again pulling from her history with math anxiety, she recalled, “I always thought ‘ok the teachers are not going to understand how I’m feeling’ . . . so I didn’t want to tell them I wasn’t getting it.” She continued, “I also felt that my teachers were impatient, they didn’t have the understanding of different strategies. . . . So they . . . didn’t know where to go with a student who didn’t get that one procedure they taught.” These causes that Abby described are confirmed in the literature as well. Finlayson (2014) discussed the “traditional delivery method” (p. 100) as problematic. Students do not feel free to ask teachers questions and they take in information passively (Finlayson, 2014). Finally Abby asserted that a poor history in math could cause anxiety. She recalled one student who revealed, “I haven’t got this the last couple of years.” Abby explained that because of this history, “she was very worried about it.”

Lila highlighted another cause of math anxiety as being put on the spot or embarrassed for a mistake in front of others. She described “the idea of making mistakes. So at some point someone being called out for having the wrong answer or that spotlight put on you and because it was wrong, or it wasn’t what the teacher wanted.” She mentioned the value of a teacher
modeling mistakes and evaluating “is everything in my room so pristine and perfect that students think that that’s how things are produced, that it’s a one shot perfect time? Because then they’ll never want to do that.” Another cause Lila discussed was the pressure that is on students to perform. When describing the level four student with math anxiety discussed earlier, she admitted, “The teacher had put so much pressure initially on those students who didn’t get the algorithm, so she valued the quickness, the speed, the ‘just do it like I’m [the teacher] doing it.’” This makes students “less likely to speak up because everyone expects them to get it quickly.” Research shows that these high-pressure situations can inhibit a student’s math performance if they have a high reliance on working memory (Beilock & Carr, 2005). A final cause Lila disclosed was “not accepting everyone’s answer.” Teachers can be particular and fixed on getting the correct answer and/or coming to that answer in a particular way. However, students conceptualize math problems differently and use multiple avenues to arrive at an answer. When these methods differ from the preferred method of the teacher, Lila asserted that the rejection of students’ responses causes math anxiety. This notion is directly supported by Geist (2010) who asserts that placing more value on the correct answers rather than on the understanding of the concept increases math anxiety.

Jake offered many causes for math anxiety. Firstly, Jake identified “lack of experience with math” as one cause and continued, “I think that’s the main one because if you don’t have the experience, you’re afraid of it.” Jake also identified “outside pressures” as a cause of math anxiety, which aligned with Lila’s thinking. Lastly, and in keeping with Abby’s assertion, Jake concluded that “procedural teaching” was a cause of math anxiety. “You know . . . if they had a teacher who isn’t into math then they haven’t gotten the concepts, just the procedures, and of course they have math anxiety because they don’t really understand it because their teachers
didn’t understand it.” This idea aligns with the literature revealing that math anxiety is transferrable from teacher to student (Geist, 2010) and also that teachers suffering from high levels of math anxiety and who have negative attitudes about math themselves practice procedural methodology (Karp, 1991).

Math anxiety manifests itself very differently depending on the classroom environment, the teacher and the students. Additionally, there are several different causes of math anxiety that these participants identified, many of which align with the research on math anxiety.

**Theme 4: Overcoming Math Anxiety**

**Nurturing math success.** The data revealed that nurturing math success was not only a common and effective teaching strategy amongst the participants, but it also served to reduce math anxiety. As discussed earlier, creating an enjoyable and engaging learning environment was one way the teachers nurtured math success. Abby postulated, “For the most part, I think just because the activities have been a little bit more on the fun side and math has become exciting and we’re using lots of different materials. . . . I haven’t seen as many kids shut down.” She added, “When you’re having fun with something you’re doing . . . that anxiety is reduced.”

Addressing a student’s confidence level and making them feel successful was another finding. When helping a student math anxiety, Jake explained, “I try and address that first and foremost, the confidence level, and try and make them successful because when you’re successful, you want to do more of it.” Additionally, Jake stated, “I’ll give them things that they’re capable of doing.” Aligning with this method, Lila revealed, “I give them a question where I think everyone will be fairly comfortable with it, they’re going to have a lot of success.”
allowing every student a chance to be successful by differentiating the level of questions asked nurtures math success. Abby explained how this also reduces math anxiety when she resolved:

They [the students] don’t feel like ‘this one problem is too hard for me and I’m not going to have anything done and then people are going to notice I didn’t get it.’ They can pick the one they feel best prepared to solve and that reduces that anxiety there.

Lastly, the data revealed that relieving students of the pressures put on them by taking the time to support their needs also serves to reduce math anxiety. Lila described her strong focus on the process of solving math problems when she disclosed:

I’m going to value to the students that ideal of either trial [and] error or coming up with a plan even if it’s not successful. . . . even if the math is completely wrong, I want them to feel comfortable putting something on the page so we can discuss it.

Jake was also adamant on giving the time and support to each student who needed it. He explained, “I’ll often pull them in and chat with them and kind of guide them through it so they fell successful and they feel supported.” Finally, Lila addressed the issue of time constraints. She disclosed:

It can’t just be a single teacher effort, it really has to be a school-wide effort because sometimes you actually have to say ‘I give you permission to slow down. I give you permission for the students to actually learn the information, not to feel like you got a gold star for covering the curriculum because you covered it, but nobody learned it.’ And that will not only help with that anxiety, teacher and student, but I think the whole school environment.

The data showed that nurturing math success was not only an effective teaching strategy adopted by these participants, but also served to reduce math anxiety by building students’ confidence, giving each student a chance to be successful through the questions given, making the learning fun and engaging, and taking time to support students rather than rushing through the curriculum. Stuart (2000) makes similar suggestions for reducing math anxiety which include: drawing on
students’ strengths in order for them to feel successful as well as implementing strategies to build student confidence.

**Creating a learning environment.** The data showed that the creation of a safe and comfortable learning environment that was conducive to math education helped to overcome math anxiety. Abby mentioned her efforts to “just [make] sure that it’s a real community of math learners.” Having that community sets the tone for the allowance of mistakes and the sharing of ideas amongst the math learners. Lila was insistent that the environment played a significant role in the experience of math anxiety. She explained, “It starts with right away how you introduce mathematics. It starts with, what they say is almost the third teacher in the room, that environmental piece. How does your room look? How is it set up to teach math?” Lila urged teachers to “set up the environment, to set up the attitude in the classroom, not the physical environment but the emotional environment.” Lastly, as a math coach, she also challenged “that idea of really creating an environment as a teacher because so often I would hear ‘well the students need to take risks . . . instead of what ownership do I have as the teacher to create an environment in which I value those mistake? Do I as the teacher model those mistakes?’” Creating an environment in the classroom where students can make mistakes, discuss their work and be affirmed for their efforts was shown to reduce math anxiety.

Establishing this type of environment for math learning is a notion supported by the literature. First of all, “caring mathematics teachers create a welcoming, supportive, and intellectually engaging community for middle school students” (Jansen & Bartell, 2013, p. 46). Jansen and Bartell (2013) found that this type of community provided safety in order for students to take risks. According to Taylor and Fraser (2013), an extremely important aspect of the learning environment is the emotion and affective feelings that students in the classroom have.
towards that specific subject. Taylor and Fraser (2013) looked at specific aspects of the learning environment such as peer relationships and task orientation, and found that math anxiety was reduced when the environment supported more of these factors. They concluded, “The relationship between anxiety and learning environment was negative, suggesting the possibility of reducing students’ mathematics anxiety through creating a positive classroom environment” (Taylor & Fraser, 2013, p. 310). Lastly, summed up by Captein (2015), a factor “that creates ideal conditions for student success is an environment where students feel comfortable sharing their ideas and students are able to respectfully listen to feedback from another student and use that feedback as a means of achieving success” (p. 1). Every teacher participant strove to set up this collaborative environment within their classroom as part of their conceptual framework.

**Exposing students to math.** Two of the participants discussed the importance of being exposed to math frequently and outside of the classroom. As a math coach, Lila felt it was her responsibility not only to influence one single classroom, but the school as a whole. She expanded:

If you can only walk into one teacher’s classroom in the school and see those math environment changes, I haven’t done my job, the principal hasn’t done their job . . . where is math in the hallway? Where is math on the announcements? Where is math in the school newsletter? And if it’s all the time, everywhere. . . . that math anxiety will be lessened.

Jake was also of the mind that exposure and practice with math would help to build a comfort and enjoyment with math, which would reduce math-related anxiety. He stated, “If you have the experience you’ll get it so you’ll like it so you’ll do more so you’ll get it so you’ll like it.” Jake also insisted that teachers need to expose themselves to math so they are “comfortable to understand the concepts” thereby reducing the transfer of math anxiety from teacher to student.
Defusing math anxiety. Another strategy for reducing math anxiety that the data revealed was the teachers’ efforts to defuse math anxiety in their students. Abby described her openness and honesty with her students and she saw value in “letting them [her students] know [she] was there too.” She also argued the importance of “making yourself approachable for students so they know that if they’re not getting it it’s not the end of the world, we are just going to find another way to figure it out.” Abby described how she really made efforts in her teaching to make sure students knew that if they didn’t understand the math, they would be given multiple chances and avenues to explore it and they would find a way, collaboratively, to figure it out. Stuart (2000) supports this notion of working collaboratively with students to create goals and acknowledges that when students are involved in the process, along with the teacher, it serves as a motivator for them.

Lila defused math anxiety in her students by celebrating their efforts, especially their mistakes. She reflected:

So I had to change my thinking because I never did anything perfectly the first time and I needed to start showing them [the students] more of my rough work and my rough thinking and purposely and intentionally making mistakes so that they would feel comfortable themselves doing that.

She used a strategy with her students to view their mistakes as learning opportunities by putting stickers of brains beside their work that they didn’t understand signifying the growth of their brain. Through the use of this activity, she explained, “In the end those kids who always felt like the power was taken away from them actually felt empowered in class to take those risks.” These ideas are confirmed in the literature. Li et al. (2007) discuss student errors in the context of deepening students’ thinking. They assert that errors should be viewed as an opening for inquiry rather than a mere diagnosis. Li et al. (2007) also model uplifting phrases to help encourage students when errors occur as Abby and Lila demonstrated in their teaching.
Having open and honest conversations with students about learning math, allowing for mistakes and overcoming those mistakes was shown to reduce math anxiety. Both Abby and Lila noted the value of being approachable and real with their students by demonstrating their weaknesses and their mistakes. The data showed that viewing mistakes as growth opportunities and supporting students until they understand the concepts helps reduce math anxiety.

Research by Stuart (2000) supports these diffusion strategies discussed by the participants. Stuart (2000) discussed ways to manage math anxiety in students. She states, “As teachers, we must be the mathematics coaches—the ones to build that self-confidence while refining the skills needed to be successful” (p. 330). Additionally, addressing students’ needs privately, conferencing with them to create learning goals and helping students focus on their strengths rather than weaknesses, were strategies used to reduce math anxiety (Stuart, 2000).

**Teaching conceptually.** The last finding that was revealed to reduce math anxiety was the practice of a conceptual teaching methodology for math. Abby postulated:

> They need to have everything done in a way that’s meaningful to them so that conceptual end of teaching, I think, helps to reduce that [math anxiety] because students feel that they have a variety of options in terms of how they see and conceive the ideas being taught.

Lila recounted, “When those students had some one-on-one time . . . we had some hands-on learning, the anxiety was gone. They were . . . confident enough to go back to the class and tell the teacher and say ‘well we can show you.’” When a student would struggle to grasp a concept, Jake explained, “I’ll take the student aside and that’s when I’ll do the kind of taking the concept and breaking it down. I’m going back . . . to what they get and show[ing] them that . . . ‘you get this.’” He strove to bring students back to a place in their knowledge they were comfortable with and then build upon that knowledge.
Building upon students’ prior knowledge and making math meaningful helps to make those rich connections discussed in the literature as being necessary for conceptual knowledge (Hiebert & Lindquist, 1990). Additionally, hands-on learning, group work and interaction were all elements being part of the constructivist approach to teaching, as highlighted in the research (Thirteen Ed Online, 2004). All teacher participants used these strategies in their conceptual math teaching. Finally, returning to Eisenhart et al. (1993), teaching math conceptually is helping students develop an understanding of the procedures they are using. As a result of building on prior knowledge, implementing constructivist strategies just mentioned, and the emphasis these teachers placed on guiding their students to understand the concepts, all participants claimed math anxiety was reduced and/or prevented in their students.

In general teaching math conceptually was explicitly found to reduce math anxiety. Jake explained, “I think it reduces anxiety because when you teach conceptually and a student has mastered a concept . . . they get it and when you’re good at something . . . you’re not anxious about it.” Abby concluded:

I think that conceptually again it’s just looking at . . . how is this student going to best see and understand and conceive this topic and . . . when a more conceptual approach is taken I think the anxiety is reduced versus the procedural.

Nurturing math success, creating a comfortable and engaging learning environment, exposing students and teachers to math all around the school, defusing math anxiety and teaching math conceptually were all found to help overcome math anxiety. Each teacher participant offered examples and experiences from their teaching that supported these findings. Additionally, the data was very conclusive and every participant explained that the use of conceptual strategies reduces student math anxiety and promotes the successful learning of math.
Chapter 5: Discussion

Discussion

The data of this study revealed some very specific and practical findings. This study sought to answer the question: What are teacher’s perceptions of the connection between the use of a conceptual methodology for math teaching and the level of math anxiety among elementary school students? Through the use of semi-structured interviews with three teacher participants many findings were revealed that have implications for myself as a teacher and the teaching community at large.

Teacher background and development. The data revealed multiple experiences, qualifications, attitudes and beliefs that each participant brought to their math classroom. Each participant was committed to his or her teaching career by participating in ongoing professional development and alternate but related career opportunities. Each teacher was highly committed to their students’ learning and spent extra time and energy analyzing their classroom needs and preparing each day for a new learning experience. Amongst all participants was the tendency to move away from a sole reliance on procedural methodologies. Each participant chose to teach using a conceptual framework and they recognized that there is room for procedures within their math program but it is not to be relied upon as a sole methodology. Lastly, the data revealed each participant as having a positive and engaging attitude towards math and their students.

All of these characteristics of a math teacher contribute to richer learning experiences for students. There are so many complexities and intricacies that accompany the role of a teacher. Being qualified and prepared for the job is merely a beginning point that contributes to a deeper learning experience. Additionally, some of the most important planning a teacher must commit to takes place outside of school hours in their efforts to reflect and prepare for their students, as
each of these participants did. Teaching cannot be approached from a “one-size-fits-all” method and if teachers are not willing to put in the extra time and effort to support their students, consequently, the learning that takes place will be hindered. These teachers seemed to have a common understanding that teaching elementary students math through procedures and memorization was not an effective method. From personal experience and research-supported knowledge, I strongly agree with their resistance to this method of teaching. I did, however, appreciate the recognition that there is a time and place for formulas, procedures, etc. but an understanding of the concepts must support them. Lastly, I strongly advocate that a teacher’s attitude is one of their most important characteristics. We know from the research (Jackson & Leffingwell, 1999; Malinsky et al., 2006; Scarpello, 2007; Stuart, 2000) that teacher attitudes do in fact play a huge role in the students’ attitudes and the teachers’ effectiveness. I am in agreement with this notion and believe that these participants were more successful in their delivery of material to their students because of their positive, hopeful and committed attitudes towards math education.

**Effective teaching strategies.** The next theme revealed the effective teaching strategies that the participants engaged in as a part of their conceptually-driven math program. Each participant was committed to assessing where their students were at in their math understanding and meeting them at their level to support them. Finding different ways to present the same material, scaling the content back to a place where the students felt comfortable and breaking it down for them were efforts that participants made to teach to the student. All participants were actively using the three-part lesson framework and encouraging exploration, inquiry and consolidation. Additionally, they incorporated cooperative learning in their daily classroom routines and encouraged rich math discussions amongst the students. Each teacher participant
made efforts to facilitate and nurture success in all of their students and accommodated learning needs in order to allow for those successful experiences.

The implementation of the three-part lesson and cooperative learning are strategies currently emphasized by many school districts across Ontario. In fact, as a math coach, Lila trained other teachers how to effectively plan and implement lessons structured this way. These strategies give students opportunities to explore math in a non-threatening, collaborative and meaningful way. Working in groups on open-ended problems also reduces the pressure in students’ minds that the solution has to be found using a specific method or formula.

Additionally, I agree with Jake, that the most important part of the whole process is the rich discussion and consolidation of learning that takes place at the end of each lesson. Structuring math education in such a way allows for more open-endedness and the implementation of parallel tasks discussed by Abby. In my opinion this makes it more feasible for teachers to teach to individual students and nurture math success because it allows for multiple entry points to the same learning. All of the strategies discussed by the participants allow for a more student-centered and holistic education experience. In addition they are all very feasible and, I believe, really benefit students’ learning.

**Math anxiety.** All participants experienced the phenomenon of math anxiety with students in their classroom as well as personally. Participants commonly defined math anxiety as a fear of one or more aspects of math whether it was writing down an answer, exposing themselves to the class, or math in general. Math anxiety was revealed to manifest itself amongst participants’ students through external symptoms such as visible frustration, internal beliefs, disengagement and even avoidance by making frequent trips to the washroom. These teachers also identified what they believed to be the cause of such anxiety. Amongst the causes were the
rejection of certain answers, the approachability of the teacher, previous negative experiences, pressure to perform, lack of experience with math and rigid and procedural teaching methods.

Interestingly, math anxiety can manifest itself in many different ways in the classroom. From personal experience with math anxiety, I have experienced the inward and internal doubts and beliefs as well as the outward, emotional manifestations of anxiety. Kitchens (1995) discusses multiple symptoms of math anxiety as well and it is therefore important to be open to and aware of how students may handle their anxiety. I believe the findings illustrating the causes of math anxiety are extremely insightful and align with much of the research. We have already discussed the participants’ revelation of the power of positive attitudes, but the opposite is certainly true for the detrimental effects of negative attitudes (Jackson & Leffingwell, 1999; Malinsky et al., 2006; Scarpello, 2007; Stuart, 2000). We know the anxiety producing power that procedural teaching can have on math students (Finlayson, 2014; Geist, 2010) and so it is essential that educators focus on mitigating these effects. Without the freedom to explore concepts, coupled with the intense pressure to perform the right solution, teachers allow for negative experiences to plague students’ math education and thus begin a negative pattern of math anxiety.

**Overcoming math anxiety.** The last theme this research revealed was Overcoming Math Anxiety. Participants identified multiple solutions and practical strategies to help overcome student math anxiety. Returning to this idea of nurturing math success, teachers who promote an enjoyable and engaging math program will help their students be successful. All participants reiterated the importance of finding avenues for all students to succeed. What Lila described as “the third teacher in the room,” the environment that teachers create was found to play a role in overcoming math anxiety. Allowing for mistakes to be made and creating a community of math
learners were revealed to help promote this positive learning environment. Exposing students to math, both inside and outside the classroom, was found to make it less of a novelty and feared subject. In addition, making it applicable to real-life and becoming comfortable with math through exposure was affirmed to be positive for students. Participants discussed ways to defuse math anxiety such as reassuring students, working together to find solutions, again allowing for mistakes and the taking of risks. Lastly, participants revealed that teaching math conceptually reduced math anxiety. In sum, the participants shared many conceptually-based and practical strategies for overcoming math anxiety with which they had great success. Making math meaningful, slowing things down for students who struggle, providing hands-on learning experiences, breaking concepts down and building on prior knowledge were all practical ways these participants helped their students to make sense of the math material. These strategies were founded in their commitment to guiding students’ development of a conceptual understanding of the math concepts.

These identified solutions are not to be implemented individually. I believe it is the combination of a positive environment, constant mathematical exposure, the nurturing of success, the defusing of math anxiety and conceptual teaching that work together to reduce the prevalence and experience of student math anxiety. For example, a teacher could have the greatest three-part lesson planned allowing for student exploration and flexible solutions, but if he or she hasn’t set up a risk-free learning environment for his or her students, resistance and anxiety may still manifest. Considering all suggestions from the participants compositely, I believe, will lead to maximum success.
Implications/Recommendations

The purpose of this study was to investigate the question: What are teacher’s perceptions of the connection between the use of a conceptual methodology for math teaching and the level of math anxiety among elementary school students? As discussed, the findings unveiled many themes surrounding this question. Overall, this study demonstrated that teachers perceive conceptual math instruction to have positive effects on math anxiety in that it reduces or prevents it. As mentioned, these teacher participants had experience teaching junior-level grades (four-six), as well as others, however the findings of this study can apply to all elementary grades. A major implication of this study, then, would be that elementary teachers must teach math in a more conceptual and less procedural way. Unfortunately there are complex factors to take into account such as the development of reflective practice, teacher resistance, training and readiness.

A considerable theme that arose from this study was the “what” and “how” of math anxiety. Participants revealed many different symptoms and manifestations of math anxiety such as: fear of putting something down, visible frustrations, internal beliefs and even frequent trips to the washroom. More important was the revelation of the various causes of math anxiety being: rigid thinking, only accepting one answer, pressure to perform, negative experiences, approachability of the teacher and procedural teaching. These findings have critical and practical implications for math teachers in order to prevent students from suffering such experiences.

Firstly, teachers must be aware of the experiences and situations that lead students to develop math anxiety and avoid their manifestation in the classroom. As discussed, this study revealed causes of math anxiety. Teachers can take preventative action in order to avoid the onset of math anxiety. These actions include: being cognizant as not to put pressure on students to perform, allowing for multiple avenues and solutions to one problem, being approachable as a
teacher, preventing negative experiences of math students and avoiding the sole reliance on procedural methods of math instruction.

Secondly, it is essential for math teachers to be observant and aware of their students’ reactions to math. If students are demonstrating any of the symptoms of math anxiety revealed in this study or previous research, teachers must take action with those students to mitigate the effects math anxiety is already having on them. In order to do this, teachers need to be aware of these symptoms and know what to look for. After a student has been identified as suffering from math anxiety, teachers need to make efforts to reduce this anxiety and help students overcome it. Teacher participants in this study shared some practical advice for overcoming math anxiety in students, which serve as preventative and remedial measures. Among these strategies were: defusing math anxiety (verbal reassurance and encouragement), nurturing success (choosing tasks you know your students will be successful with), promoting an enjoyable and engaging environment, exposure to math and teaching conceptually. It is imperative for teachers to be observant and reflective in their practice and not create or permit situations that may cause or worsen the effects of math anxiety.

There are many factors that influence the pedagogical approach teachers take to any subject. Philipp et al. (2007) studied pre-service teachers’ philosophies in math teaching and found that participants were resistant to adopting a conceptual framework for their math program because of two reasons. First of all, pre-service teachers were not willing to engage the math material in a new and “deeper” way: this would be in contrast to how they themselves were taught during their schooling. Secondly, pre-service teachers believed that their college-level math understanding was sufficient for any child-level education and therefore they did not feel the need to relearn the material. Unfortunately, many current teachers were not taught math in a conceptual way but
rather a procedural way. Being used to math education the way they were taught, these teachers risk being opposed or resistant to learning effective methodologies for teaching. Another possible hindrance to the implementation of a conceptually methodology is what Hill et al. (2005) identify as the concept of “knowledge for teaching” (p. 373). This differs from a teacher’s ability to perform math tasks as it focuses on their deeper understanding of math content and conventions, and how prepared they are to teach the knowledge in the classroom (Ball, 1990). Therefore, math teachers are wrong to assume that their knowledge of math is sufficient to teach it (Ball, 1990).

This current study has revealed the heavy importance that teaching methodology has on math anxiety in the classroom. Therefore, the second implication of this study is to educate current and pre-service teachers about the significance of teaching math in a conceptual way. I have witnessed a lot of resistance from teachers to the three-part lesson and inquiry-based pedagogy for math. Perhaps, if teachers, both in-service and pre-service, understood the positive effects that teaching math in a conceptual way could have on the learning experiences of their students, they would be more open to adopting this framework. Thanheiser (2012) asserts, “Procedural fluency will not, however, prepare PSTs (pre-service teachers) to teach in a way that fosters conceptual understanding or strategic knowledge in the children they teach” (p. 221). It is therefore essential that pre-service and current teachers are made aware of the insufficiency of procedural knowledge for conceptual teaching. As well, teachers need to be educated in ways that will foster conceptual understanding so they can learn to adopt such teaching methodologies in their classrooms. However, convincing pre-service and in-service teachers of the necessity of teaching math conceptually is no easy task, especially if they were taught in a completely different way. This current study’s findings contribute to the evidence that conceptual math
instruction has positive effects on decreasing and preventing math anxiety. That said, it is of utmost importance that pre-service and in-service teachers are convinced of its necessity despite their reservations.

The teachers interviewed in this study were all highly qualified teachers who were reputable for their adoption of conceptual teaching methodologies in their math classrooms. Each of their specific strategies they discussed as being useful and promoting students’ success was therefore a part of their conceptual framework. Thus, teachers who wish to teach math in a more effective and conceptual way would benefit from implementing these strategies. The major barrier in carrying out this solution is the lack of training and preparation teachers receive in order to teach math. In my pre-service training, within my cohort, I was one of three students out of 29 with a teachable in math, indicating I had more undergraduate math experience than my peers. Secondly, we received 36 hours of math training the first year of the program and 18 hours the second year. Being in a two-year program, we received significantly more training than most Bachelor of Education Programs. The major question here is, if teaching math conceptually and integrating the practical strategies revealed in this study will help reduce math anxiety and better the learning experience of students, is there enough training in pre-service education programs to prepare and equip new teachers to implement these effective strategies and methodologies? If teachers are not engaged in adequate training to understand math conceptually themselves, it would be a major challenge to implement such strategies into their classroom. For these reasons, Ontario’s teacher education programs continue to deny students the opportunities for achieving success in math.

Therefore, a third implication of this study would be to increase the amount and quality of math instruction in Ontario pre-service teacher education programs in order to equip teachers
with the training and preparation they need to implement effective teaching strategies and methodologies. We know from the research that having a mathematical “knowledge for teaching” (Hill et al., 2005, p. 373) and a conceptual understanding of the math themselves (Ball, 1990; Thanheiser, 2012) helps teachers to adopt a conceptual framework for teaching math meaningfully. Therefore, focusing on these factors, as well as the specific conceptual strategies identified in this study, throughout teacher education programs would support the adoption of a conceptual framework for teaching math and therefore benefit the students of such teachers.

For me, as a future elementary school math teacher, this study will shape the way I approach math education. In my practicum experiences alone, I have realized the extra dedication and effort it takes to teach math in a more conceptual way. Making students memorize a formula and do seat work is a lot easier for a teacher than planning inquiry-based three-part lessons. However, in the end if it reduces math anxiety, as this study demonstrated it does, then I owe it to my future students to provide a conceptual learning experience for them in math. I have had the opportunity to implement many of the strategies discussed in this study throughout four practicum placements. I have already begun structuring many lessons to include the three-part lesson components, providing my students with hands-on learning experiences, structuring many classes that include group work and collaboration, meeting with individual students who struggle to grasp concepts to try and break it down more, and I have tried to take pressure off students who are clearly nervous or anxious about a math task. In my practicum experiences I strove to teach conceptually and I intend to continue my teaching practice in this way. That being said, I agree with the participants in this study that there must be a balance between conceptual and procedural teaching. I will still teach my students procedures and formulas, however I will strive to ensure they understand the concepts behind the formulas first. Furthermore, I intend to engage
in professional development, take Additional Qualification (AQ) courses and better understand math conceptually myself in order to better help my students.

Lastly, as a researcher, I have grown tremendously throughout this process. This being my first ever research project, I have learned so much. In my program at the Ontario Institute for Studies in Education (OISE), and throughout the writing of the literature review, I deepened my understanding of what teaching math conceptually means in theory. This project gave me the opportunity to marry theory with practice as I went into the field and gathered first hand data on the very theoretical concepts I was studying. To see theory in practice is not only eye-opening but also very motivating and inspiring. I know, because I researched it myself, that teaching math conceptually is not only beneficial for the students but also feasible for teachers. I hope to be able to bring this practical, observant and research-oriented mindset into my future teaching practice and study more aspects of education from this lens.

**Future Research**

As discussed earlier this study contains limitations. Having only interviewed three teacher participants makes the findings of this study difficult to generalize. Additionally, each participant adopted a conceptual framework for their math education thereby creating biases as they advocated for their teaching method. As a Master of Teaching (MT) student at OISE, I also brought my own personal biases to this study based on my experiences, education and assumptions. Lastly, the only form of data collection in this study was semi-structured interviews.

Future studies on this topic should incorporate more participants in order to achieve generalizability. Teachers from different areas, schools and grades would offer more perspectives. Additionally, this study only examined teachers who taught conceptually, while
future studies should collect data from teachers who do not necessarily teach math conceptually or who teach it procedurally in order to compare and contrast findings from different methodologies.

One aspect I would have loved to explore further would have been the perceptions of teaching math conceptually and math anxiety from the students’ perspectives. Adding data based on classroom observations and interviews with students would have brought many different perspectives and rich data to this study. Future studies should look at this topic from students’ perspectives and include them in the collection of data.
Appendices

Appendix A: Letter of Consent for Interview

Date: ___________________

Dear ___________________,

I am a graduate student at OISE, University of Toronto, and am currently enrolled as a Master of Teaching candidate. I am studying the conceptual teaching methodology of mathematics and its relationship with math anxiety for the purposes of investigating an educational topic as a major assignment for our program. I think that your knowledge and experience will provide insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching Program. My course instructor who is providing support for the process this year is Dr. ___________________. My research supervisor is ___________________. The purpose of this requirement is to allow us to become familiar with a variety of ways to do research as well as study a topic in teaching that will better inform my future practice as a teacher. My data collection consists of a 40-60 minute interview that will be tape-recorded. I would be grateful if you would allow me to interview you at a place and time convenient to you. I can conduct the interview at your office or workplace, in a public place, or anywhere else that you might prefer.

The contents of this interview will be used for my assignment, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a conference or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the paper has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Yours sincerely,

Researcher name: Krista Meier
Phone number: ___________________ Email: ____________________________

Instructor’s Name: ________________________________
Phone number: ___________________ Email: ____________________________

Research Supervisor’s Name: _____________________________
Phone #: ___________________ Email: ____________________________

Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by Krista Meier and agree to participate in an interview for the purposes described.

Signature: ________________________________

Name (printed): ________________________________

Date: ___________________
Appendix B: Questions for the Interview

Interview Questions

Section 1: Participant Background (make the participant feel comfortable and at ease)

1) For how many years have you been teaching?
2) What specific qualifications do you have? (degrees, teachables, specialists, additional qualifications)
3) How much experience do you have teaching math?
4) How would you define math anxiety?
5) How would you define teaching conceptually?
6) How would you define “conceptual understanding” in the context of your experiences teaching math?

Section 2: Teacher practices – beliefs and values

1) What has been your personal experience teaching math?
2) What are some effective teaching methods and strategies that you implement in your math teaching?
   a. Why have you chosen these methods?
   b. What are some challenges associated with these methods?
   c. What are the benefits of this teaching methodology?
3) When a student struggles to grasp a math concept, what do you do?
4) What are your thoughts about procedural versus conceptual teaching strategies?
   a. How do you capture that balance?
5) What methods do you use to assess and evaluate students in your math class?

Section 3: Connecting Methodology and Math Anxiety

1) Have you any personal experience with math anxiety? (either the teacher’s personal struggles or with their students).
   a. How do you deal with math anxiety in your classroom?
2) In your opinion and personal experience, what contributes to the cause of math anxiety in your students?
3) What are your thoughts on teaching mathematics conceptually and math anxiety?
4) How would you advise teachers of math to best prevent and/or reduce math anxiety in their students?
References


