

MATH SUKS: WHY AND HOW

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Abstract

“Math suks” is a commonly used phrase in mathematics class. It is a way for students to express their negative experiences and relationships with mathematics. This study focuses on essentials of mathematics 11 students and examines what they mean by “math suks” and the situations that lead to “math suks”. Charmaz’s constructivist design to grounded theory is used to create students’ mathematics stories. These stories, and the themes that emerged from them, are then analyzed. The analysis shows that there is no single cause to students’ negative relationships with mathematics and every student is affected by a different set of themes.

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For my family,
who offered me unconditional love, patience, and support.

For my beloved dog,
who had always pushed me to do my best throughout my education.

For all mathematics educators,
who strive to make mathematics magical.

Table of Contents

Approval	i
Abstract	iii
Acknowledgments.....	iv
Chapter 1 Introduction.....	1
Chapter 2 Literature Review.....	3
Attitude.....	3
Beliefs.....	5
<i>Beliefs about Mathematics</i>	5
<i>Beliefs about Self / Self-Efficacy</i>	8
<i>Beliefs about Teaching</i>	12
<i>Beliefs about the Social Context</i>	13
Emotions.....	13
Anxiety	15
Motivation	17
Interest	20
Chapter 3 Methodology.....	24
Research Questions	24
General Setting	25
<i>The Essentials of Mathematics 11 Course</i>	25
<i>My Classroom</i>	26
<i>Research Procedure</i>	29
<i>Participants</i>	30
Grounded Theory.....	31
Chapter 4 Students and their “Mathematics Stories”	35
Vivian’s Story.....	35
Andy’s Story.....	40
Kevin’s Story.....	44
Mia’s Story	46
Diane’s Story.....	51
Steve’s Story.....	55
Elle’s Story	61
Caroline’s Story.....	64
John and Fiona’s Stories.....	68
Summary	72
Chapter 5 Analysis.....	75
Mathematics as Building Blocks	75

Mathematics as a Race Against Time.....	79
Mathematics as My Own Method.....	81
Mathematics as Computation	84
Mathematics as a Self Fulfilling Prophecy	86
Mathematics as Successful Performances	93
Mathematics as Sink High.....	96
Mathematics as One Answer	98
Mathematics as Elementary and Secondary	101
Mathematics as Avoidance Behaviors.....	103
Mathematics as Chores.....	105
Mathematics as Lack of Connections	107
Mathematics as Methods of Delivery	114
Mathematics as Physical Objects	116
Summary	117
Interactions of the Themes	118
Chapter 6 Summary, Discussion, and Conclusion	120
Students' Views and Definitions of Mathematics	120
Students' Views and Beliefs about Themselves	122
Students' Goals and Expectations of Mathematics.....	124
So, Does Math Suk?	125
Bibliography	128
<i>Appendix A Introduction Activity</i>	<i>132</i>
<i>Appendix B Three-Dimensional Puzzle</i>	<i>133</i>
<i>Appendix C Numeracy Task.....</i>	<i>134</i>

Chapter 1 Introduction

Mathematics fascinates me. The thrill, emotions, and satisfaction that come with mathematics are difficult to explain. I see mathematics as a path and connection to the real world, a link between genius and insanity. However, many of my students seem to disagree. They often complain about mathematics and mathematics class. These students simply do not feel excited about mathematics as I do.

I sincerely believe that mathematics has lost its appeal in today's classroom. Students seem to have many misconceptions about mathematics and have negative attitudes towards it. I try my best to provide students with positive mathematical experiences in and outside class. In the past several years, I have used numerous teaching techniques to excite my students in mathematics including numeracy tasks, group projects, manipulatives, etc. I have seen some positive results. However, many still complain that "math suks". Based on my observations, the "math suks" complaint fluctuates – students may find "math suks" one day but not on another day. The phrase "math suks" is loosely used in the mathematics classroom. It seems to be a reaction or response to situations where students experience negative emotions, such as anger and frustration. Because each student experiences mathematics differently, students may have very different reactions and responses to the same situation. A student may enjoy a certain mathematics activity while another finds it frustrating or boring. In this research project it is my intention to explore the circumstances that lead to a "math suks" response and students' reactions to these situations in order to gain a deeper understanding of this response.

In chapter 2, I look at literature that may have a link to “math suks”, with a focus on attitudes, beliefs, emotions, anxiety, interest, and motivation. I provide a general setting of the research and discuss the methodology used in the research in chapter 3. Chapter 4 provides the details of each student participant’s mathematics experience during the school year, followed by the various themes that emerge from these experiences in chapter 5. Finally, in chapter 6, I offer some conclusions regarding my research project on “math suks”.

Chapter 2 Literature Review

“Math suks” is an expression many students use to associate their negative feelings and experiences with mathematics and mathematics class. It is an affective response that carries various meanings. In this chapter, I will explore six ideas in the literature that describe students’ negative relationship with mathematics and mathematics class, including attitude, beliefs, emotions, anxiety, interest, and motivation.

Attitude

McLeod (1992) defines attitude as “affective responses that involve positive or negative feelings of moderate intensity and reasonable stability” (p.581). Based on this definition, attitudes are either positive or negative emotional dispositions towards mathematics. A positive attitude involves positive emotions, such as pleasure and satisfaction, towards mathematics, while a negative attitude involves negative emotions, such as frustration and anger, towards mathematics.

Although McLeod’s definition is nice and clean, it does not paint a clear and complete picture of attitude. Based on this definition, the attitude “I like mathematics” is positive and implies the disposition of positive emotions, such as joy and happiness, towards mathematics. However, it may not necessarily be the case. Students may only hold this attitude towards mathematics because they are performance goal oriented and enjoy the feeling of success. Dewey (1913) describes this as the pleasure that accompanies the activity, which is found along with success and achievement. While students “like mathematics”, they may still feel anxious or frustrated about mathematics.

While McLeod looked at attitude as a single-dimensional construct (either positive or negative), other researchers describe attitude as multi-dimensional. For example, Martino and Zan (Martino and Zan, 2001; 2009a; 2009b; Zan and Martino, 2007) believe that attitude involves three deeply interconnected dimensions: emotions, beliefs or vision of mathematics, and perceived competence. Together, these dimensions of attitude influence the individual's behavior.

Similarly, Hart (1989) divides attitude into three components: emotional response, beliefs, and behavior. Based on this perspective, the attitude "I like mathematics" involves emotions, beliefs of mathematics and self, and behaviors. Emotions include feelings such as pleasure and frustration, which can be expressed through facial expressions and other bodily reactions such as heart rate, perspiration rate, and blood pressure. Beliefs include beliefs about mathematics such as "mathematics is useful", "mathematics is important", "mathematics is rules", and beliefs about the self such as "I am good at math", "I will not understand math", etc. Behaviors include the engagement in the meaningful learning of mathematics, completion of mathematics homework, avoidance of mathematics, and more subtle behaviors such as the hesitation to share the work, being consumed by the mathematics and ignoring environmental inputs, etc. (Ajzen, 2005; Polo and Zan, 2005; DeBellis and Goldin, 2006).

Attitude is complicated. It is almost impossible to study students' attitudes towards mathematics without paying attention to their emotions, beliefs, and behavior. In the following sections, I will examine some literature on beliefs and emotions.

Beliefs

Beliefs, in general, are one's "mathematical world view" (Schoenfeld, 1985, p. 44). They are the most stable amongst emotions and attitudes. They are slow to form, and just as slow to change (McLeod, 1992). Beliefs are "an individual's understandings and feelings that shape the ways that the individual conceptualizes and engages in mathematical behavior" (Schoenfeld, 1992, p. 358). An individual's beliefs about mathematics determine how the individual approaches mathematics and mathematical tasks, create meaning of learning mathematics, and shape the individual's goals involving mathematics (Muis, 2004). McLeod (1992) suggests that students' beliefs include the following four categories: beliefs about mathematics, beliefs about self, beliefs about teaching, and beliefs about social context.

Beliefs about Mathematics

Students' beliefs about mathematics are created from their mathematics experiences, which in turn are based mostly on the mathematics classroom. Their experiences, therefore, depends on the mathematics curriculum and how the teacher presents the curriculum. From my observations, when teachers present mathematics as rules, computation, and finding the correct answer, students seldom associate mathematics with discovery and exploration. Sometimes mathematics lessons are taught in isolation of each other. As a result, students fail to see the connections between various pieces of mathematical knowledge (Schoenfeld, 1988). For example, students often memorize the distance formula, $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$, instead of applying the Pythagorean Theorem. Students' typical beliefs about mathematics include:

- 1) *Mathematics is a collection of facts, rules, formulae, and procedures presented by the teacher or found in the textbook. These rules are sufficient to solve almost all mathematics problems known to students* (Garofalo, 1989; Mtetwa and Garafalo, 1989; Crawford, Gordon, Nicholas, & Prosser, 1994; Hekimoglu and Kittrell, 2010). Although this may hold some truth for those whose mathematical experiences are mostly classroom based, this belief restricts students' ability to problem solve, as they look for procedures and rules to follow rather than try to think outside the box;
- 2) *There are restricted methods for solving textbook exercises. Other methods of solving these textbook exercises probably do not exist or do not work.* This belief restricts students to follow the procedures given in the textbook and stops students from using their own methods to solving the problems. This may also prevent students from deepening their understanding of the mathematical concepts and the mathematical problems (Garofalo, 1989);
- 3) *Solving mathematics problems involve little time (no more than five to ten minutes) and only a few steps* (Frank, 1988; Schoenfeld, 1988; 1989; Spangler, 1992; Chinn, 2009; Hekimoglu and Kittrell, 2010). This belief lowers students' ability to solve unconventional problems, as students give up too easily and too early (McLeod, 1992). Unfortunately, these beliefs are developed from their mathematics experiences. In typical mathematics classes, students are given a short period of time to solve mathematics problems, and problems, such as homework and practice questions, that require a short amount of time to solve. When students fail to solve the problems within the time period, the teacher (an authoritative figure) interferes and provides the students with the procedures or algorithms they need. As a result,

students see themselves as passive learners of mathematics and are rarely actively engaged in understanding the concepts and constructing their knowledge. They may also believe that they have mastered a concept when, in fact, they do not have a good understanding;

- 4) *The goal of doing mathematics is to find the one and only correct answer, and there is no gray area.* The answer is either completely correct or completely incorrect, and students fail to see the possibility of having more than one correct answer (Schoenfeld, 1989; Spangler, 1992; Chinn, 2009; Hekimoglu and Kittrell, 2010).

Also, the teacher is the authoritative figure who knows if the answer is correct or not (Frank, 1988; Lampert, 1990);

- 5) *Mathematics is computation, which includes addition, subtraction, multiplication, and division. These computations involve memorizing procedures and rules* (Spangler, 1992, McLeod, 1992), which extend into (6);

- 6) *Following and memorizing rules, facts, formulae and algorithms, and drill exercises are sufficient in learning mathematics,* which means understanding the concepts behind the formulae is not important (Garofalo, 1989; Mtetwa and Garafalo, 1989; Crawford et al., 1994; Diaz-Obando., Plasencia-Cruz, & Solano-Alvarado, 2003). It was shown that while students were able to “do the math”, they do not “understand the math” (Spangler, 1992), and students often fail to use their commonsense knowledge to check the solution of a given problem.

These beliefs imply that students’ knowledge of mathematics is very restricted to their classroom experience. In a study done by Spangler (1992), it was shown that students in general believe that mathematicians fit the negative “nerd” stereotype, and

that they practice mathematics in an isolated area, which is not related to reality. As mentioned before, students' mathematics experiences, which are mostly from the classroom, shape their beliefs. Sometimes mathematics classrooms focus on procedures and performance rather than understanding and mathematics in relation to students' everyday lives. Students' lack of a broad mathematical experience does not allow them to see the relations between the concepts behind the procedures and how these concepts could be useful to them. For example, when calculating volumes, students often memorize the formulae, but never understand the concept behind volume. Many students are able to calculate the volume of a regular cylinder, but fail to see how the volume of this cylinder is related to a "slanted" cylinder. For many, therefore, mathematics remains a mystery.

Beliefs about Self / Self-Efficacy

Self-efficacy is "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391).

Self-efficacy influences not only students' behavior, but also thought processes, motivation, and affective states. Students' performance varies greatly under different circumstances due to the fluctuations of their self-efficacy beliefs (Bandura, 1997).

Students' efficacy towards mathematics, similar to their beliefs, develops through their mathematics experiences. However, students' efficacy also helps construct experiences.

Students' beliefs about their capabilities in mathematics are a better predictor of their performance than their actual capabilities, as these beliefs greatly influence how students approach a task. When students are given a task, their self-efficacy beliefs are a factor that influences the amount of effort, persistence, and time spent on the task (Bandura,

1982; Pajares and Miller, 1994; Hekimoglu and Kittrell, 2010). Students with strong self-efficacy beliefs are more willing to take on challenges. They remain focused and they are persistent in the face of obstacles. These students tend to attribute failure to the lack of effort and their sense of self-efficacy recovers quickly after failures. On the other hand, students with low self-efficacy in particular domains shy away from challenging activities within those domains. They have low motivation and persistence, and their self-efficacy is slow to recover from failures within those domains. These students tend to focus on their deficiencies rather than their capabilities (Bandura, 1997).

Unfortunately, students' self-efficacy beliefs towards mathematics are often negative. These beliefs, which are extensively based on their classroom experiences, include "I can't understand mathematics", "I can't do mathematics", and "It takes a genius to do mathematics and I am not a genius" (Schoenfeld, 1988; Mtetwa and Garafalo, 1989; Tobias, 1993). It is also suggested that self-efficacy is highly and negatively correlated with mathematics anxiety (Wigfield and Meece, 1988).

Students construct their self-efficacy based on their enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states (Bandura, 1997). Enactive mastery experiences are the most influential source of information because they provide students with the most personal experiences of success and failure. Challenging tasks, especially ones with obstacles, help develop self-efficacy by providing students with a chance to exercise their control over obstacles. As students overcome these difficulties through perseverance and effort, their sense of self-efficacy strengthens. Easy tasks, on the other hand, do not provide students with sufficient challenges and obstacles. Students who experience only easy success are discouraged easily in the face

of obstacles and failures. Self-efficacy beliefs and performances are directly related to each other. Research has shown that, in general, performances interpreted as successful raise self-efficacy, while repeated performances interpreted as failures lower self-efficacy. This happens especially when these failures occur before a strong sense of self-efficacy is established and a large amount of effort is put into the task. The extent of influence on self-efficacy depends on the perceived difficulty of the task. Tasks perceived to be easy do not raise self-efficacy because they do not provide students with a chance to showcase their abilities. Mastering difficult tasks, on the other hand, provides students with new information on their capabilities and raise self-efficacy (Bandura, 1997).

Vicarious experiences provide students with social comparison opportunities. Social comparisons serve as an important influence on the development of self-efficacy. For example, after a difficult mathematics exam, a low score is not a sufficient indicator of performance because students socially interact with each other. Students often compare their scores with each other and use that as a better judgment of their performance. Surpassing others with similar or better abilities raises self-efficacy, while being outperformed by others with similar or lower abilities diminishes self-efficacy. Students use their peers' achievement as a judgment of their own capabilities. Students are more motivated to take on similar challenges after seeing their peers succeed, because if others with similar capabilities can do it, they can too. Observing others with similar competency fail, despite high effort, lowers self-efficacy (Bandura, 1997).

Positive and realistic verbal persuasions of one's ability can strengthen self-efficacy. Effective persuasions ensure success is attainable not because of effort but

ability. Research has shown that while students' self-efficacy is raised through verbal persuasions, they also become more persistent in their efforts. This leads to a higher level of competency, which further positively influence self-efficacy through successful performances. On the other hand, verbal persuasions that focus on students' effort rather than ability diminishes self-efficacy, as these persuasions imply that ability is limited as effort is constantly required (Bandura, 1997).

Students also judge their level of efficacy based on their emotional and physiological experiences. Emotions and physiological arousals can influence students' performances and produce different results. For example, some students believe that hyperventilation, nervousness, pounding heart and upset stomach, stress, fear, etc., are natural somatic states and reactions they encounter when they face obstacles. These reactions do not affect their self-efficacy beliefs. On the other hand, some students believe these are negative emotions and physiological arousals that stem from their inadequacies. Their self-efficacy may be lowered when they experience these somatic states and reactions (Bandura, 1997).

Factors that influence self-efficacy include family, community and culture, and education. Families who provide their children with a positive learning environment and learning opportunities, and encourage their children to try various activities and take on challenges foster self-efficacy. In the secondary school setting, students' peers greatly influence their self-efficacy through modeling. As students observe their peers with similar abilities take on challenges and succeed, they become more self-efficacious and are motivated to take on challenges (Schunk and Pajares, 2005).

Students' confidence level in doing mathematics declines as they grow older (McLeod, 1992). Our school system, unfortunately, may have contributed to the decline of student's confidence level in mathematics. While group instruction loses students who fail to keep up with the pace, grouping students according to their abilities further diminishes the perceived efficacy of students who are placed in the low ability groups (Bandura, 1997). These situations often direct students to focus on their deficiencies and lead them to believe that they are mathematically incapable.

Students' perceived efficacy determine their slate of options. They abandon the options which they consider unattainable due to perceived inefficacy. Perceived efficacy also affects decision making through the type of information gathered, the interpretation of information, and the management of situational challenges (Bandura, 1997). Some students would even alter their career choices in order to avoid mathematics and failing mathematics (Betz and Hackett, 1983; Hekimoglu and Kittrell, 2010).

Beliefs about Teaching

Students believe mathematical knowledge is created by exceptional and creative people and passed down by authority figures such as teachers and textbooks (Schoenfeld, 1988; Garofalo, 1989). The roles of the teacher are to pass the knowledge onto students and verify that students have received the knowledge, while the roles of the students are to receive the knowledge and demonstrate that they know it. As the teacher assumes the active role of teaching, students assume the passive role of receiving knowledge (Frank, 1988). In a study by Stodolsky, Salk, and Glaessner (1991), it was found that mathematics classes rarely involve discussions where ideas are exchanged. Rather, the teacher does most of the talking and explaining, while students listen and ask questions.

Students also believe that they cannot learn mathematics on their own. Rather, they need the presence of their teacher or a knowledgeable authority to provide assistance in order to learn mathematics, because mathematics is difficult and the teacher is the one who can provide them with the correct answer.

Beliefs about the Social Context

Research has suggested that the social context students experience influence their beliefs. Beliefs are communicated and developed as students interact with their friends and peers, teachers, and other adults. Examples of positive social contexts provided by the school and home include a safe, friendly, non-judgmental learning environment, and supportive and encouraging teachers and parents. Research has shown that positive social contexts foster positive affective reactions such as enjoyment and independence, perseverance, and motivation (Grouws and Cramer, 1989).

Students' beliefs are created based on their experiences in mathematics. Beliefs are a very broad construct that involves mathematics, the self, the teaching, and the social context. Together, these categories help shape students' view of mathematics and affect their attitudes and emotions towards mathematics (Hart, 1989; Schoenfeld, 1992; Op't Eynde, De Corte, & Verschaffel, 2006).

Emotions

McLeod (1992) defines emotions to be the least stable, yet most intense, amongst beliefs and behavior. Emotions are dynamic. They are responses to the present situation, which constantly changes. For example, a student may experience anger, frustration, sadness,

joy, etc., during a problem solving exercise. These emotions are intense, yet short-lived, as anger and frustration can change into joy and satisfaction when the problem is solved.

In a study done by Op't Eynde, De Corte, and Verschaffel (2001), it was found that students' negative emotional experiences trigger them to find alternate cognitive strategies and alter their behavior in order to remove themselves from these negative emotional experiences, even though the strategies chosen may not be effective or efficient. For example, when a student experiences frustration and anxiety during a problem solving exercise, s/he may try to look at the problem differently, try a different approach or method, ask for help, or simply give up. These strategies may not help the student solve the mathematics problem, but serve as a way for the student to remove him/her negative emotions.

Some common emotions that students experience during problem solving in a mathematics classroom include: annoyance, frustration, anger, worries, anxiety, relief, happiness, nervousness, satisfaction, etc. These emotions are affected by students' cognitive interpretations and evaluations of the specific situations, their beliefs and knowledge, and the people surrounding the students (Gómez-Chacón, 2005; Op't Eynde et al., 2006). For example, while a student feels happy and proud that she scores 50% on a test because she studied hard, another student may feel sad and angry she only scores 50% because she studied hard. The first student is content that she has reached her goal, while the other is angry because she believes she failed.

Students' interpretations and appraisals of the situations are also affected by their knowledge and beliefs. For example, a student may feel confident about solving a problem because s/he has seen this type of problems before. On the other hand, a student

may be intimidated by the same problem because s/he has not seen this type of problems before and does not believe in his/her abilities. People with whom students interact also affect their emotions. As students interact with others, they create a sense of social belonging, and their emotions are affected by their social identity (Gómez-Chacón, 2005).

Op't Eynde et al. (2006) also describe students' emotions during problem solving as unstable and constantly changing, because the situation and the person involved in the situation continue to evolve. This dynamic description of emotions is similar to that of McLeod's (1992). The emotions associated with mathematics, however, are usually negative. In the next section, I explore literature on anxiety, which is a highly negative affective response to mathematics.

Anxiety

Many students claim that they have mathematics anxiety, that they are scared of anything associated with mathematics. Mathematics anxiety “centers on negative affective reactions to math” (Wigfield and Meece, 1988, p. 214). It is associated with feelings of tension, defeat, helplessness, discomfort, fear, and stress. It is also associated with poor mathematics performances, the lack of confidence, low self-esteem, and negative affective reactions to mathematics. Mathematically anxious students may also experience an increase in heart rate and respiration rate when faced with situations that involve mathematics. While some students may see these bodily reactions as normal responses to obstacles, as discussed in the previous section, it may also result in mathematics avoidance behaviors in mathematically anxious students (Morris, 1981;

Cemen, 1987; Wigfield and Meece, 1988; Tobias, 1993; Malinsky, Ross, Pannells, & McJunkin, 2006; Chinn, 2009).

Wigfield and Meece (1988) categorize mathematics anxiety into two major categories: worry and emotionality. Worry is a cognitive component, while emotionality is an affective component. Worry includes self-defeating thoughts such as “I will not pass this test”, or “I am going to fail no matter how much I study”, while emotionality includes feelings of fear and tension, nervousness, etc. Wigfield and Meece also argue that worry and emotionality are related to students’ self-efficacy beliefs, their values of mathematics, and mathematics performance (Wigfield and Meece, 1988).

Bessant (1995) categorizes mathematics anxiety into six factors: general evaluation anxiety, everyday numerical anxiety, passive observation anxiety, performance anxiety, mathematics test anxiety, and problem-solving anxiety. General evaluation anxiety includes things such as the completion of mathematics assignments, preparing for tests and quizzes, reading mathematics textbooks, etc. This coincides with Hembree’s idea of mathematics anxiety being “a general fear of contact with mathematics, including classes, homework, and tests” (Hembree, 1990, p. 45, as cited in Bessant, 1995, p. 334). Everyday numerical anxiety deals with the anxiety of using basic arithmetic skills and the manipulation of numbers to carry out daily activities. Passive observation anxiety involves things such as feeling anxious while watching and listening to others perform mathematics tasks. On the contrary, performance anxiety is the anxiety the learner experiences while carrying out mathematics tasks and being observed by others. Mathematics test anxiety refers to things such as preparing for and taking tests

and exams. Finally, problem-solving anxiety is related to the anxiety of using one's various mathematics knowledge to perform problem-solving tasks.

Environmental factors such as mathematics class, pressure from home, the attitudes of other learners, etc., also play an important role in mathematics anxiety (Hadfield and McNeil, 1994). Oberlin (1982) and Cemen (1987) suggest that teachers in the mathematics classroom may also contribute to the onset of mathematics anxiety in their students through rote learning, the lack of correlation of mathematics with life situations, the assertion of one correct way to solve each problem, the use of drill exercises, the lack of individual help, etc.

Mathematics anxiety is common to many, from students with weak mathematics skills to mathematically able students. It is probably something that cannot be "cured" (Tobias, 1993). Cemen (1987) suggests that students react to mathematics anxiety differently. While some are able to manage mathematics anxiety and channel it to the task at hand, others feel defeated and it hinders their performance. These students may also choose to avoid mathematics in order to cope with mathematics anxiety.

Motivation

In general, motivation is the inclination to do work. However, motivation also includes the inclination to avoid work (motivated to avoid). Students may avoid work in order to avoid failures and embarrassments. In both cases, motivation causes behavior (to do work or to avoid work). Students with a strong sense of self-efficacy are motivated to take on challenges because they believe they can handle these challenges and succeed.

On the other hand, students with low self-efficacy beliefs avoid challenges in order to avoid failures (Bandura, 1997).

The lack of motivation, or amotivation, refers to those who neither actively seek nor avoid. These individuals are not inclined to do either and they lack behavior. An individual is likely to be amotivated when s/he “lacks either a sense of efficacy or a sense of control with respect to a desired outcome” (Deci and Ryan, 2000, p. 237). Motivation is “a potential to direct behavior that is built into the system that controls emotion. This potential may be manifested in cognition, emotion and/or behavior” (Hannula, 2006, p. 166). Cognition may be subtle and difficult to observe. Similarly, emotions are only partially observable through facial expressions and body language. Behavior, however, is observable and can be used as a manifestation of motivation. Hannula (2006) explains that for example, motivation to solve a mathematics task may be manifested in beliefs about the importance of the task (cognition), in sadness or anger if failure occurs, or joy and satisfaction in the presence of success (emotion), but most obvious in behavior such as effort and persistence.

Motivation can be categorized as intrinsic and extrinsic motivation (Walker, Greene, and Mansell, 2005). Intrinsic motivation originates from within an individual. The individual engages in activities for his/her own enjoyment and satisfaction. On the other hand, extrinsically motivated students perform to attain or avoid. For example, an intrinsically motivated student is engaged in a problem solving exercise to gain personal satisfaction, while an extrinsically motivated student works on a problem solving exercise for a desired grade, external reward, or to avoid punishment or embarrassment.

Needs are goals structure motivation. They are “specific instances of the potential to direct behavior” (Wæge, 2009, p.87). In the educational setting, needs are fundamental for “the growth and well-being of people’s personalities and cognitive structures” (Ryan and Deci, 2002, p.7), and includes competence, relatedness, and autonomy. Competence refers to confidence and the ability to exercise one’s capabilities, relatedness is having a sense of social belonging, and autonomy is the perceived origin of one’s behavior (Ryan and Deci, 2002).

Goals are more specific than needs. For example, a student feels the need for competence may have a goal for getting a good mark on a test. Goals are derived from needs. At different times, students have different needs, and one need may be dominant over another. The domination of needs leads to the prioritization of goals, which results in various behaviors (Hannula, 2006). For example, a student may experience both the need of competency and the need of social belonging. If the student determines that social belonging is more important than competency, s/he may spend more time and energy on socialization rather than mastering a task. Together, needs and goals provide students with motivation and help direct students’ behavior.

A second approach categorizes motivation into mastery, performance, and ego-defense goals (Hannula, 2006; Lemos, 1999). Students who are mastery or learning goal oriented often seek to learn, understand, or master something new, and to increase his/her competence. These students look forward to challenges and demonstrate perseverance when they face obstacles. Satisfaction is based on the degree of effort they have exerted. These students take pride in their learning rather than their performance. For example, a student who is mastery goal oriented chooses challenging tasks to foster learning. S/he is

willing to risk looking incompetent in order to learn (Dweck, 1986). On the other hand, students who are performance goal oriented often seek to demonstrate their abilities and to attain favorable judgments (Lemos, 1999). These students find opportunities to demonstrate their abilities. Satisfaction, in this case, is based on the ability students believe they have displayed. They take pride in showing off their competence and believe that failure is a sign of low ability (Hannula, 2006). Research also shows that performance goals are negatively related to the self-efficacy of students with low abilities, but positively related to the self-efficacy of students with high abilities (Bell and Kozlowski, 2002).

Ego-defense goals fall under performance goals, in which the students focus on avoiding negative judgments instead of attaining favorable ones (Dweck, 1986). These students avoid challenging tasks and demonstrate low perseverance when they face obstacles. Research also shows that ego defensive goals are a negative predictor of students' self-efficacy (Taye and Zhou, 2009). For example, a student who is ego-defensive goal oriented avoids challenges by choosing easy tasks to ensure success and to avoid the chance of failing in order to protect him/herself from being judged as incompetent (Dweck, 1986).

Interest

Interests are content specific and serve as a motivator which can be used to explain one's choice and behavior. It is "the sole guarantee of attention; if we can secure interest in a given set of facts or ideas, we may be perfectly sure that the pupil will direct his energies toward mastering them; ... if we have not secured interest, we have no safeguard as to

what will be done in any given case” (Dewey, 1913, p. 1). Similar to motivation, interest is also “central in determining how we select and persist in processing certain types of information in preference to others” (Hidi, 1990, p. 549).

There are two types of interest: situational interest and individual interest. Situational interest is temporary. It involves an external stimulus that captures one’s attention, and is accompanied by positive emotions. Situational interest may initiate behavior. For example, a fascinating introduction to fractals may capture students’ attention and encourage them to explore or study the topic (Schiefele, 1991, 2009; Hidi and Renninger, 2006). Situational interest leads to “a short-term psychological state that involves focused attention, increased cognitive functioning, persistence, enjoyment or affective involvement, and curiosity” (Schiefele, 2009, p. 198).

Individual interest is more stable than situational interest, relatively long lasting, and internally driven, although it can also be triggered by external stimuli (Schiefele, 1991, 2009; Hidi and Renninger, 2006). Individual interest is “the interest that a person brings to some environment or context” (Mitchell and Gibson, 1997, p. 4). Individual interest can be observed through behaviors such as “focused attention, displays of pleasure, and a high degree of persistence at a task” (p. 4). Individual interest also includes stored knowledge and value. Stored knowledge is the individual’s knowledge about the subject content, while stored value originates from the individual’s involvement with the subject, including the feelings the individual experiences during the process of creating stored knowledge (Schiefele, 2009).

Although temporary, situational interest is important in the development of individual interest. Mitchell and Gibson (1997) found that highly interesting situations

result in an increase in individual interest, and environments that provide low situational interests result in a decrease in individual interest.

There are two phases of situational interest: triggered or catch interest, and maintained or hold interest (Mitchell, 1993; Hidi and Renninger, 2006). Triggered interest involves stimuli that spark interests by catching students' attention, such as group work, puzzles, interesting stories, etc. However, triggered interest does not sustain or hold the interest. Maintained interest, on the other hand, sustains interests by providing students with a chance to actively participate in their learning process. Maintained interest also empowers students by making the content of learning meaningful (Mitchell, 1993).

There are also two phases of individual interest: emerging individual interest, and well-developed individual interest. Although internally driven, emerging individual interest may require some external support such as encouragement from peers and suitable learning environments. Emerging individual interest involves positive feelings, stored values, and stored knowledge. Students are willing to reengage in tasks, and internally become curious about the subject of interest. Well-developed individual interest also involves positive feelings, stored values, and stored knowledge. Students choose to reengage in tasks of their interest, and are persevered to work in the face of obstacles. External support and learning environments can contribute to deepening the understanding and interest by providing the students with encouragement and challenges (Hidi and Renninger, 2006).

In this chapter I examined six ideas in the literature that describe students' relationships with mathematics, including attitude, beliefs, emotions, anxiety, motivation,

and interest. These relationships are constructed based on their experiences with mathematics, which are extensively based on the mathematics classroom. Inside the classroom, students experience success and failure, satisfaction and frustration, and develop their attitude and beliefs about mathematics. They may bring interest to the classroom, or find mathematics interesting because of a fun activity. On the other hand, they may also lack interest and find mathematics boring. Depending on their goals and needs, students may become motivated to do (or avoid) mathematics. Together, these factors shape students' relationships with mathematics.

Based on my observations, many students find their relationships with mathematics negative despite their positive classroom experiences. More importantly, their relationships with mathematics seem to deteriorate as they grow up, and they seem to believe that this negative relationship is normal. They complain that “math suks”, but seem to enjoy the activities in class. A closer look is warranted. In the chapters that follow the methods, results, and analysis of my closer look are elucidated.

Chapter 3 Methodology

Research Questions

Most students in my mathematics classes claim that they do not hate mathematics, and seem to enjoy the in-class activities. However, some complain that “math suks”. “Math suks” is a loosely used phrase in mathematics class. It is a personal and emotional response to mathematics that carries different meaning for different people under different situations. There are students who frequently complain “math suks” and avoid mathematics, those who complain “math suks” but seem to enjoy mathematics, and those who rarely complain “math suks” but avoid mathematics. It is my experience that when students complain “math suks”, they become disengaged in class, lose interest, and give up easily when they face obstacles in their learning of mathematics. Learning becomes inefficient. Also, “math suks” seems to be contagious. When one student expresses the feelings that math suks, others soon follow. Therefore, it is important for mathematics educators to understand what students mean by “math suks” and what contributes to “math suks” in order to make the learning of mathematics effective.

In this research, it is my intention to gain a deeper understanding of “math suks” and answer the following questions: What do students mean by “math suks”? What contribute to “math suks”? Do students use “math suks” as an excuse to avoid mathematics? What do students do when they find “math suks”? If “math suks” is a response or a reaction to negative mathematics situations, what do these situations look like? Are there times when mathematics does not suk? What do these situations look like?

General Setting

The Essentials of Mathematics 11 Course

The research was conducted during terms 1 and 2 of the essentials of mathematics 11 course. There were three mathematics streams during the time of the research: principles of mathematics, applications of mathematics, and essentials of mathematics. On top of these three streams designed by the ministry of education, many schools also offer enriched mathematics. My school offered enriched mathematics, the principles of mathematics, and the essentials of mathematics. Enriched mathematics provides students with the same credit as the principles of mathematics, but it is designed for students with strong skills in mathematics. The principles of mathematics courses satisfy the secondary school graduation requirement and serve as an entry requirement for many post-secondary institutes. The essentials of mathematics courses, although satisfy secondary school graduation requirements, do not satisfy university entry requirements. Therefore, many parents and students see the essentials of mathematics courses as “failure courses”, because these courses limit students’ post secondary school choices. Very often students enrolled in the essentials of mathematics classes are labeled as incapable due to their limitations after graduation.

The school offered two essentials of mathematics 11 classes, and I taught both. There were twenty-five to thirty students in each class, with the number of students enrolling in each class fluctuating throughout the year. In general, students transferred into the essentials of mathematics 11 class throughout the year because they found the

principles of mathematics course too difficult. During the year of research, no student transferred out of the essentials of mathematics 11 class into the principles of mathematics 11 class.

According to the ministry of education, the essentials of mathematics 11 course focuses on numeracy, which includes “the ability to explore, conjecture, reason logically, and use a variety of mathematical methods to solve problems. It also involves the development of self-confidence and the ability to use quantitative and spatial information in problem solving and decision-making.” (Ministry of Education, 2006) The essentials of mathematics course is less abstract and more concrete than the principles of mathematics courses. It emphasizes the development of problem solving skills, data analysis and interpretation skills, and focus on financial planning, probability and statistics, patterns and relations, and shapes and space measurements.

The ministry of education puts a positive tone to the learning of mathematics. The ministry of education states that “[as] students develop their numeracy skills and concepts, they generally grow more confident and motivated in their mathematical explorations. This growth occurs as they learn to enjoy and value mathematics, to think analytically, and to understand and appreciate the role of mathematics in everyday life” (Ministry of Education, 2006). In other words, the learning of mathematics should foster positive emotions, attitude, and belief, confidence and motivation, and interest in mathematics.

My Classroom

Generally speaking, a traditional mathematics class begins with going over homework and ensuring students’ understanding of the concepts previously learned. The teacher

then moves on to the new concepts, or the focus of the lesson. The teacher first presents the new concept and provides students with notes and formulae, asks students questions related to the new concepts and has students practice the newly learned concepts in class, and finally assign homework. Occasionally a teacher may engage students in group work or projects in a mathematics lesson (Corey and Bower, 2005). However, I believe this kind of lesson structure does not work for the essentials mathematics students. Although some of these students require structure in class, the kind of structure described above is not effective in their mathematics education. Since many of them have experienced failure in previous mathematics classes (often with similar lesson structures), many have expected themselves to fail in mathematics, especially if the class has the same, traditional lesson structure. Most students in the essentials of mathematics have complained that math suks, have disengaged themselves during mathematics class, and have refused to have anything to do with mathematics. By bringing in a new mathematics class structure, it helps students experience mathematics differently, hopefully in a positive manner, and possibly foster a positive attitude towards mathematics.

My typical mathematics lesson begins with an engaging idea, or a goal that we need to achieve in the hour (the immediate goal) or in the unit (the ultimate goal). The idea serves as a stimulus that captures students' situational interest. This idea, or goal, becomes the driving force behind each lesson. It provides students with a desire to learn. As mentioned in the previous chapter, if we can secure students' interests in mathematics, we can secure their attention and direct their energies towards mathematics (Dewey, 1913). Students need to feel the need and the driving force to do mathematics. If there is

no need to do, there is no need to learn. For example, I began the measurement unit with the idea of building and designing a dream house (the ultimate goal). I presented the idea as a problem that students need to solve. In order to achieve the ultimate goal (to build and to decorate their own dream house), students need to know measurements, unit conversions, money exchange, spatial orientation, budgeting, taxes, etc, which are the goals for the individual lessons. At the end of the unit, we have covered a lot more topics than the prescribed learning outcomes listed in the curriculum. In each lesson, after we have set the goal for the hour (for example, spatial orientation), students work in groups/teams to finish or solve a task, whether it is to determine the size of a bathroom, the height and width of a flight of stairs, etc. Students are engaged, they enjoy the learning experience, and are able to immediately apply what they learn in class to solve problems. This satisfies their immediate needs, and avoids the question “when will I ever use this?” The class structure also fosters a safe and cooperative environment where students work together and help each other. Not only do students learn and apply the content, they also communicate with each other as they report their findings to the rest of the class, a process that is explicitly outlined as important in the curriculum.

I have abolished timed tests in my essentials of mathematics class. Instead, projects are used to assess students’ learning. These projects become means for students to demonstrate and to show off what they have learned in the unit. I have also made calculators readily available in my class to assist students’ learning. For example, when students are learning about area and volume, they need to understand the concepts of area and volume, not just how to multiply and divide. Although these mathematics skills are important to master, I keep in mind that it is important to not hinder students’ learning by

focusing on the arithmetic skills, especially in the essentials of mathematics class. In general, my classroom is ready for learning, safe, and as judgment free as possible.

Although not every student experience success in my essentials mathematics class, most enjoy this atypical structure. Students enjoy class, arrive on time, and are eager and excited to work during our time together. I seldom have attendance problems. Mathematics has expanded from lectures, computations, and worksheets to fun and adventures. Students enjoy mathematics class, and have positive attitudes towards mathematics. However, students still complain that “math suks”.

Research Procedure

At the beginning of the year, I informed both my essentials mathematics classes that I was working on a project about “math suks”. Students were excited and were willing to participate because “math suks” is an interesting topic, especially when it comes from a mathematics teacher. I asked those who were willing to participate in the study to fill out consent forms and ensure them their participation in the project will not influence their grade in any way. At this time, I also assigned an introduction activity to all students, where they express their views about mathematics and their relationships with mathematics creatively¹.

During terms 1 and 2 of the school year (between September and February), I used this time to build a trusting and non-judgmental relationship with my students. I also observed students’ behavior and noted the students who displayed any kind of “math suks” attitude. The “math suks” attitude cannot be directly observed other than students voicing “math suks”. However, students who carry the “math suks” attitude may

¹ The introduction activity was done at the beginning of first term. See appendix A for the activity.

complain that mathematics is boring, that they do not like math, and that mathematics is too difficult. These students may avoid any work related to mathematics or lack interest and motivation in mathematics.

During this time, I also administered a questionnaire about mathematics and mathematics class to the student participants. They were asked to list three things they enjoy and dislike about mathematics and mathematics class, and to circle a list of words that apply to their experiences with mathematics. This list provides me with a basic idea of students' relationships with mathematics.

Participants

Based on my observations over this period, I asked ten students from my two essentials of mathematics class to partake in an interview with me. I chose students for these interviews based on the frequency with which they express “math suks” as well as their engagement in class. The interviews involved a wide range of students, from those who express “math suks” often and avoid mathematics, to those who never say “math suks” but avoid mathematics, to those who express “math suks” every once in a while, to those who express “math suks” frequently but do not avoid mathematics.

These interviews were conducted towards the end of term 2 and during term 3 (between February and May). Of the ten participants, six are female: Vivian, Diane, Mia, Caroline, Elle, and Fiona; and four are male: Kevin, John, Steve, and Andy.² These students are of various nationalities and cultural backgrounds. Some of the students come from low-income families while some come from middle class to high-income

² All names have been changed to maintain anonymity.

families. Since they were all enrolled in the essentials of mathematics class, these students had trouble fitting into the principals of mathematics classes.

With the exception of two students who felt more comfortable being interviewed together due to language barriers, students were interviewed individually. The interviews were conversational in nature, and began with general, open-ended questions about students' relationship with mathematics, their experiences with mathematics and mathematics class. Some open-ended starter questions include "What is your relationship with mathematics so far?", "Tell me about a typical mathematics class", "What are some of the activities that you enjoy (or hate) during mathematics class?", "What do you remember most about mathematics?", "What do you think mathematics is?" Based on their responses to these starter questions, more questions that allowed me to draw details about their thoughts on and views of mathematics followed. The interviews were audio-recorded, transcribed, and coded.

Grounded Theory

My research methodology was informed by grounded theory. Grounded theory was originally developed by Barney V. Glaser and Anselm L. Strauss in the 1960s. The intention of Grounded theory is to generate a theory that explains the situation being researched based on the data collected rather than using an existing theory to explain the situation. In order to use grounded theory effectively, the researcher needs to remain open-minded about the research question and allow a theory to emerge naturally from the data collected. Therefore, the researcher may choose to use data that represents the situation being studied, instead of collecting data that represents the population.

Grounded theory allows data collection and data analysis to occur simultaneously, and allows new theories to develop based on the collection of new data (Charmaz, 2006; Creswell, 2008).

Although Glaser and Strauss developed the grounded theory together, they have different opinions about the theory. After publishing *The Discovery of Grounded Theory* together, Glaser and Strauss have further defined the grounded theory separately. Strauss, with a strong training in qualitative field research, developed the systematic design in grounded theory with J. Corbin. Glaser, who was trained in quantitative research and worked with researchers who used both quantitative and qualitative data, developed the emerging design in grounded theory (Creswell, 2008).

The systematic design of grounded theory “emphasizes the use of data analysis steps of open, axial, and selective coding, and the development of a logic paradigm or a visual picture of the theory generated” (Creswell, 2008). Open coding puts data into various categories, or themes. In axial coding, a category from the open coding phrase is selected as the “core phenomenon”, and all other categories developed from the open coding become the causal conditions that influence the core phenomenon, strategies or responses to the core phenomenon, contextual and intervening conditions that influence the strategies, and consequences of the strategies. A coding paradigm is a diagram that shows the interrelationship between the core phenomenon and the rest of the categories is developed. Finally, selective coding allows the researcher to develop a theory based on the coding paradigm (Creswell, 2008).

The emerging design of grounded theory also uses open coding but does not force data into the categories such as core phenomenon, causal conditions, strategies, etc., as

mentioned in axial coding in the systematic design. Rather, data is constantly being compared to other data and categories developed during open coding. Theoretical coding is also used to reveal the relationships between the themes developed, and connect the themes to the emerging theory. A theory is then developed based on the themes and the relationships between the themes without the use of a coding paradigm (Charmaz, 2006; Creswell, 2008).

After reviewing Strauss and Glaser's work on grounded theory, Kathy Charmaz suggested the constructivist design towards grounded theory. According to Charmaz, "a constructivist approach places priority on the phenomena of study and sees both data and analysis as created from shared experiences and relationships with participants" (Charmaz, 2006, p. 130). In the constructivist design, data is constantly being analyzed and coded as new data is collected. Data is constantly compared to new data collected and to the emerging themes. Charmaz also acknowledges the role that the researcher plays in research. Since data is coded and interpreted, the resulting theory is an interpretation that is dependent on the researcher's perception. She warns researchers to not make assumptions about the research participants, or to force data into preconceived categories. There are two phases of coding in the constructivist approach. Initial coding allows the researcher to stay open-minded about all possible themes that may emerge from the data. Focused coding allows themes and categories to be developed from the data collected. The constructivist approach also allows the researcher to go back and re-interview the participants in order to gather more rich data and to gain a deeper understanding of the situation or phenomenon being studied. Through this analysis

method, categories or themes are formed and refined, and a theory that supports the answers to the research question forms (Charmaz, 2006).

In this study, I adopt Charmaz's constructivist design to grounded theory. The constructivist approach to grounded theory allows me to deepen my understanding in what students mean by "math suks" without forcing any existing theories on "math suks". I choose this approach over the systematic design and the emerging design because although relationships between categories or themes may exist, these relationships may not be the ones described by the systematic approach or the emerging approach. Since my goal of this project is to understand "math suks" and the situations that lead to "math suks" rather than to explain "math suks", I believe the constructivist design fits the research project the best.

In order to better understand the ten student participants and their relationships with mathematics, I provide a description of their mathematics stories in the next chapter. In chapter 5, I provide an analysis of the themes that emerged from these stories.

Chapter 4 Students and their “Mathematics Stories”

In this chapter, I introduce the student participants and present each student’s story separately. I gathered information and wrote their stories based on the interviews and my observations in and outside of class. At the end of each story, I offer a subjective synopsis of the student’s history with mathematics. These synopses show the changes students experience with respect to their relationships with mathematics over time. Other than revealing their stories, I also offer some data analysis relevant to each student using the literature presented in chapter two. I present and discuss the emergent themes from these stories in chapter 5.

Vivian’s Story

Vivian is an international student from Germany who is outgoing and is actively involved in many school events. She loves sports, especially skiing, and has made many new friends at school. She is talkative outside class, but does not behave like her usual self during mathematics class. Although she works with her friends in class, she often works quietly. She lacks confidence and often double checks her answers with her friends or with me before she hands in her work.

Vivian has low self-efficacy and is convinced that she is bad at math. She has been told since a very young age that she requires extra help in mathematics. Based on her experience, she takes longer than others to understand mathematics concepts, and needs drill exercises to help her grasp the concepts taught in mathematics class. Vivian had very bad experiences with grade 11 mathematics in Germany, because the course

focused on functions, and she did not understand functions. Therefore, when Vivian came to our school, she volunteered herself for the essentials of mathematics course. She believes that the principles of mathematics 11 is too challenging for her, and the essentials of mathematics class will save her from all the bad experiences she has had with mathematics. As identified by Bandura (1997), Mtetwa and Garafalo (1989), and Tobias (1993), Vivian's behavior is typical to many mathematics students who have low self-efficacy. Vivian focuses on her deficiencies and her negative experiences in mathematics, and believes that she cannot succeed in this area.

V: I dunno. I always am bad at math. And I always, in grade 3, I always had to do extra exercise everyday, 3 extra exercises for my math, cuz I am so bad.

Like text exercises, like the text and you have to turn the exercises.

R: Like drill exercises?

V: Yup. I hate it.

V: When we try to learn something, and some people, like, they see it on the first few and like, oh, look at that it's so easy. You have to do this and this and this. And when I see something, or when I hear an exercise, I first have to think about it, a long time, and I don't get it as fast.

Vivian hates functions and many other branches of mathematics because of her negative experiences with them. During the interview, however, Vivian mentions that she loves geometry. Because she understands the concepts and believes that she can succeed, she does not shy away from these challenges.

V: Yea, yea, and so I usually get like, a C, or C- or something. And not always but. And I have to take extra lessons, like, every week. Not so much fun. [laugh] But yea, I mean I have a nice teacher, but it's always so hard so...

V: ...And, this year, in Germany, grade 11, it's all about functions... It's really bad. And I don't like text exercises as well. But, I like, I like... geometry.

R: Why do you think you like geometry?

V: I dunno, it's easy for me.

Her behavior is described by Bandura (1997) as typical to students who have a strong sense of self-efficacy in a particular domain, in which they are motivated to take on challenges. On the other hand, when Vivian believes she is not able to handle the challenges and is likely to fail, she shies away from them in order to avoid any embarrassment.

Although the essentials of mathematics class involves some geometry and Vivian is successful in class, Vivian does not consider this course to be an authentic mathematics course because she finds the curriculum covered too easy. Vivian believes that mathematics should be a lot more difficult and challenging, and she should be experiencing a lot more difficulties instead of success.

V: Honestly I think I don't learn much [in this class]. ... [The stuff we do now] is so easy..... I mean, I'm totally bad at mathematics as well. But I think it's so easy. Like the smarties exercise³, it was so easy. And I was thinking grade 11, we should do something more difficult.

The essentials of mathematics class challenges Vivian's self-efficacy and her view of mathematics. While she does not believe she can succeed in math, she does not think mathematics can be full of fun either. Her definition of mathematics is built upon her experiences in her previous mathematics classes. She describes typical mathematics classes to be rushed, routine, and boring. From her experiences, class always begins with homework checks and review, follows by a new topic and note taking, and ends with homework problems. In general, there are not a lot of fun activities that would capture her interests. The experience she has in this class is new to her, and it is challenging her beliefs.

³ The Smarties Exercise is an activity that I use as an introduction to probability. Students are given a bag of Smarties, and they need to determine the chance of finding "the red one" (among many other things) in each bag.

V: [In a typical mathematics class], we get homework every class. And usually when class starts, we check homework, and if there are any questions, we go over it. And our teacher explains that to us. And after that, it depends. Usually he introduces us to a new topic, or tells us what [today's class] is about. And then we practice. Or, we usually write it down in our notebook. We copy it, the whole board, and then we do exercises, sometimes we do group work, or working in groups. And yea, we practice, then we get our homework, and then yea, that's it.

In a typical mathematics class, a lot of time is spent covering new concepts, and little time is spent going over previously learned concepts. There is an expectation for students to remember and apply the concepts previously taught and to solve mathematics problems quickly. This contributes to some of students' misconceptions, where learning mathematics and solving mathematical problems involve very little time, and that mathematical knowledge is passed down by authoritative figures such as the mathematics teacher. Students are passive receivers of mathematical knowledge, where they sit at their desks and copy notes from the board (Frank, 1998; Stodolsky et al., 1991).

Vivian often fails to apply what she learned in previous classes to what she currently does because she has not fully grasp the concepts taught. When she was in Germany, she often fell behind in mathematics, and was left alone to figure things out. She ended up hiring a tutor and had extra lessons. Mathematics was a torture because she had to spend time and money on things she did not enjoy. Vivian believes that she is capable, but recognizes that she needs more time than others to fully understand the materials. She feels that if mathematics class can go slower, she will enjoy mathematics more.

V: Yea, but everybody goes so fast. And then, I am confused, and it's so much every class. We get new stuff, and it always gets harder and when you don't get it the first class, you won't get it the second, and the third, and

R: And you feel a little fall behind...

V: Yea, I think, if it would just be a bit slower... like, if we don't go so fast, and yea... I have to get extra lessons from my [tutor], I have to get it on my own, like, and I have to pay it on your own. So, it doesn't make sense at school, cuz usually the teacher should explain it to you, and so... if somebody would just explain it to me, after a few times, I would get it. I mean, I'm not stupid at all. It's just at the first time, I, yea... I mean some people, they just need a bit more time than other people, and I think in math, I just need a bit more time to get it.

Vivian gages her enjoyment of mathematics based on her performance, because she feels good when she succeed.

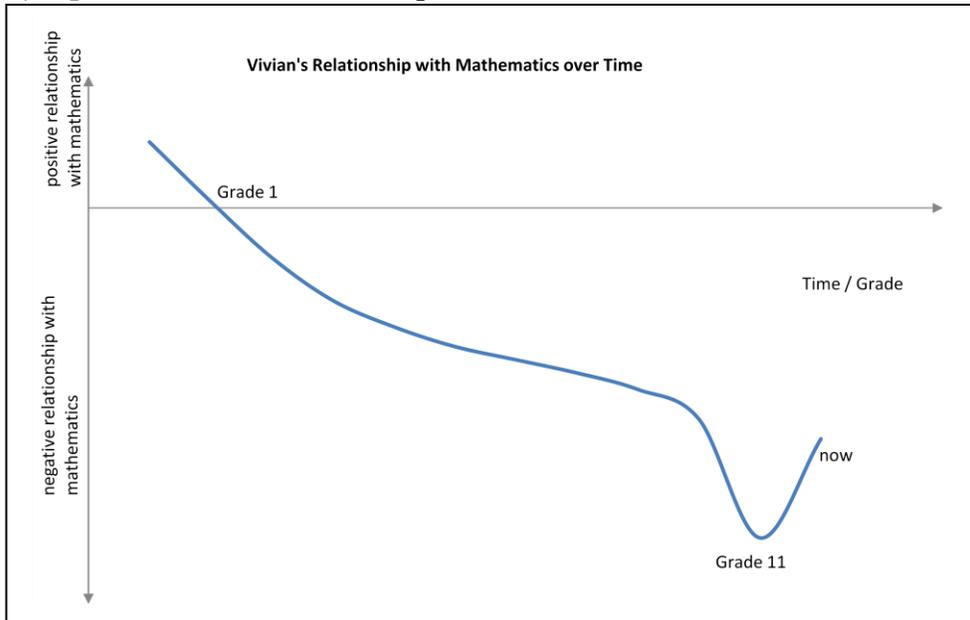
V: Sometimes it's really fun, if it's easy, and if you get the right answers, I mean, that is fun.

R: And you feel good right?

V: Yea.

Vivian is performance goal oriented and enjoys success. As mentioned before, she takes on challenges in domains which she believes she will succeed but shies away from those which she thinks she will fail. Although Vivian believes that she does well in this course because of the easy curriculum, and mathematics should be difficult, she enjoys mathematics class. Her experiences with mathematics have expanded from fast-paced routines and exercises to activities that focus on understanding, where class only moves on when she's ready. The following is a subjective synopsis of Vivian's relationship with mathematics over time.

Synopsis 1 Vivian's Relationship with Mathematics over Time



Andy's Story

Andy is an outgoing and fun-loving individual who enjoys the company of his friends and does not like rules. He often showcases his talents and success but shies away from challenges that he believes he may fail. Although Andy understands that he has trouble with mathematics, he chooses to hide from these deficiencies. He avoids mathematics to avoid feeling incompetent. This is a very typical behavior for students who are performance and ego-defensive goal oriented (Dweck, 1986; Hannula, 2006).

A: [Mathematics is] something that I go to school with, and struggle with. I've never really failed hard, like every time I failed I was in the forties, like high forties right, but it was always the last thing that I would do, out of like all the homework. And if I kept it for the last, like screw it, I'm not going to do it.

R: Why do you think you would leave it for the last minute?

A: Because it was the one with most, it was the most difficult out of, like, all the subjects. And I knew it would take the most time.

Andy finds that mathematics involves mostly seat work and very little hands-on work from his experience. Unfortunately, he hates seat work and believes mathematics restricts him to his seat and forces him to follow rules and instructions. His previous experiences have also led him to think that mathematics is numbers and solving equations, where following specific rules and instructions is the key to success. He also believes that mathematics provides no room for exploration.

A: It feels more fun and creative then, for example, English, say okay the teacher says write an essay on whatever. Like in a certain subject, you can actually branch off into many things. And with mathematics you are given the equations, and you just simply do them. So... It's like, it's like restricted. And when there is a restriction, people are like, this suks. But if there are extra stuff you can actually do, it would probably be more interesting.

Andy holds many misconceptions about mathematics. He believes that mathematics is a collection of facts, rules, formulae, and procedures that the teacher and the text book present (Mtetwa and Garafalo, 1989; Crawfoord et al., 1994; Hekimoglu and Kittrell, 2010). Also, these rules and procedures are used to solve mathematics problems, and students are restricted in using these methods to solve mathematics problems (Garofalo, 1989). Since Andy's beliefs about mathematics and his interests are opposite to each other, he is not interested in what he believes to be mathematics.

A: ... If you don't have an interest in it, than you won't wanna do it right? I don't really have an interest in it. Like, I would rather be doing things.

Andy needs "hands on" stimuli to keep him engaged. He hates worksheets, but enjoys the three-dimensional puzzles⁴ in class. These puzzles are used to encourage students to think outside the box, to communicate with each other, and to become better problem solvers. After solving these three-dimensional puzzles, students need to provide

⁴ These three-dimensional puzzles contain pieces which fit together to form objects with various shapes. See Appendix B for an example of these puzzles.

others with written solutions. Andy finds them fun because they allow him to be creative in both its solution and in the demonstration of the solution. Unlike solving equations, he is not restricted to do the question following a specific method.

A: Like those little puzzles you have, those were fun. Yea.

R: But I always make you guys sit down and write me the instructions.

A: Um... that was fine.

R: That was fine?

A: Yea. Cuz like, how would you know that we know how to do it right? We have to show it to you. It's either we show it to you, or we write down the instructions. And if we basically show it to you, it may take a longer time, because you have to go around and sit down with every person.

R: While if you write me something then I can read it later. It's still pen and paper, but it's better than the equation stuff.

A: yea.

Andy also believes that mathematicians practice mathematics in an isolated area that is unrelated to reality (Spangler, 1992). He found that many of his prior mathematics classes boring and unpractical because what he learnt in class was not applicable to him. The essentials of mathematics class has shown him a different side of mathematics.

A: Yea. It's more practical mathematics to me. It's something that you can actually, like when you are teaching it's stuff that you can use later on in life, right? Like all the insurance things and all the taxes and everything we did. Like seriously why do we need to know learn those crap, pentagon crap, like those mathematics right? Like in my life when am I ever gonna use that? So a lot of people see it like, if you don't, like, they don't see practicality in it, why would you do it?

While Andy appreciates mathematics that is practical and applicable, he feels that it is difficult for him to find success in mathematics. He recognizes some of his troubles originate from the gaps in his mathematics education. He understands that mathematics concepts are built upon one another, and that he needs to remember and apply his knowledge to what he currently learns. Andy compares elementary school mathematics to a simple puzzle with only a few pieces. He believes that he was successful in

elementary school because he was able to link together and apply the few mathematical concepts he learnt then. However, secondary school mathematics is a bigger and more complicated puzzle with many more pieces. He feels it is difficult to connect and apply these concepts because he often fails to recall the things he learned. Therefore, he experiences a lot of trouble with secondary school mathematics.

A: ... Cuz highschool is a lot more complicated.

R: What do you mean by more complicated?

A: The stuff in elementary is very simple and basic right? They are meant for you to understand. But in highschool you have to think beyond and you have to like, you still have to use the basic steps, and put together with the other basic steps that you learned.

R: So more linking concepts together.

A: Yea. Like in elementary school there are a couple of puzzle pieces and you put them together. But when you get to highschool it's like, all puzzle and you have to put them together. And you have to use the knowledge that you've learned in your previous years. And I know a lot of kids here who actually forget the stuff they've learned in the previous years.

After experiencing difficulties with mathematics throughout secondary school, Andy believes failure is the norm and success is rare. When Andy finally experiences success in mathematics, he attributes this success to the easy materials rather than his abilities.

R: But you do fine in this class.

A: Do I?

R: I think so.

A: Oh because this class is designed for stupid people.

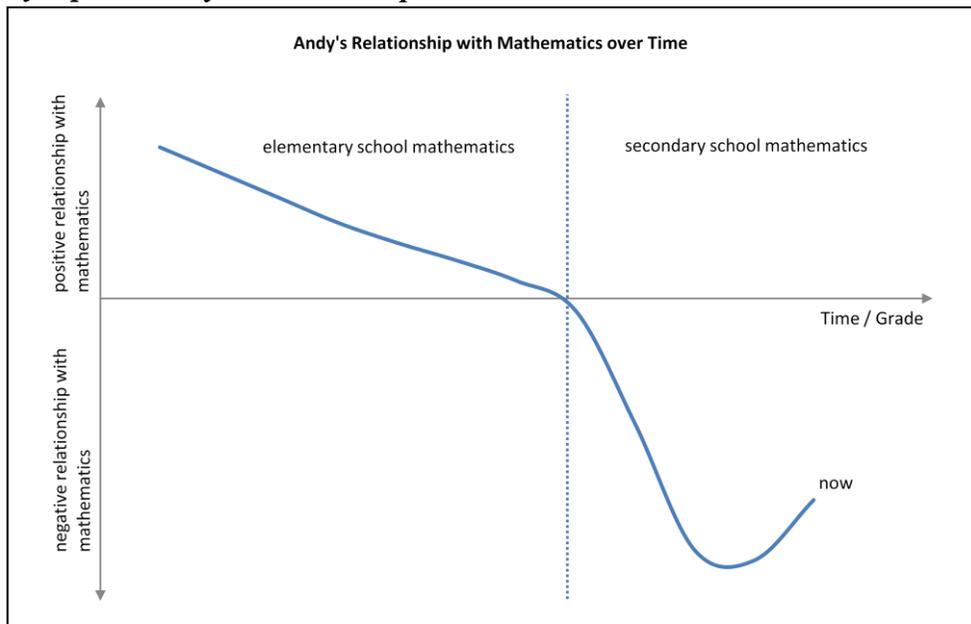
R: No...

A: So it's like really easy to pass.

Secondary school mathematics has crushed Andy's self-efficacy. Because of these negatives experiences, Andy associates mathematics with failure, and compare it to tedious work which he is compelled to do. Throughout the course, I find Andy's view of mathematics moves slightly away from the extremely negative zone. Andy may never

find mathematics enjoyable. However, mathematics is now bearable, because it is more than seat work that restricts him to follow specific instructions. He finds mathematics practical and useful, and breaks away from the misconception that mathematics is inapplicable. The following is a subjective synopsis of Andy's relationship with mathematics over time.

Synopsis 2 Andy's Relationship with Mathematics over Time



Kevin's Story

Kevin is a typical teenager who finds anything that does not involve school and work interesting. He is often disengaged in class and finds mathematics boring because he loses track of what is going on in class. He has trouble articulating his thoughts and defining mathematic. After much thoughts, Kevin decides that mathematics is a useful

skill that is better for him to master, but fails to elaborate on what he means. He finds most of the mathematics he learns at school useless, but he fails to give examples of this.

Kevin does not hate mathematics, but he does not like it either. He lacks individual interest in mathematics. As identified by Mitchell and Gibson (1997), students with individual interest are focused and persistent at a given task. These individuals also show pleasure in what they do. Kevin lacks these behaviors. He gives up easily and is only willing to work on a task as long as he finds the task interesting. If given a choice, however, he would still learn mathematics, because he does not want to look bad in front of others. Kevin is performance and ego defensive goal oriented. While he avoids negative judgments and believes that failure is a sign of incompetence, he is also proud to display his achievements. Showing off his mathematical skills makes him feel and look smart.

R: If you have a choice...

K: Oh if I have a choice? No. Well, yes, because we need to learn more.

R: But you said the angle stuff is not useful.

K: It's not useful but, better to know it.

R: Why?

K: I dunno, cuz you won't look stupid when someone ask you.

Similar to Vivian and Andy, Kevin believes that he is only successful in the essentials of mathematics stream because the mathematics he learns is much easier compared to the principles of mathematics stream.

K: This mathematics class, I think the mathematics we learn is like, grade 3 mathematics or something.

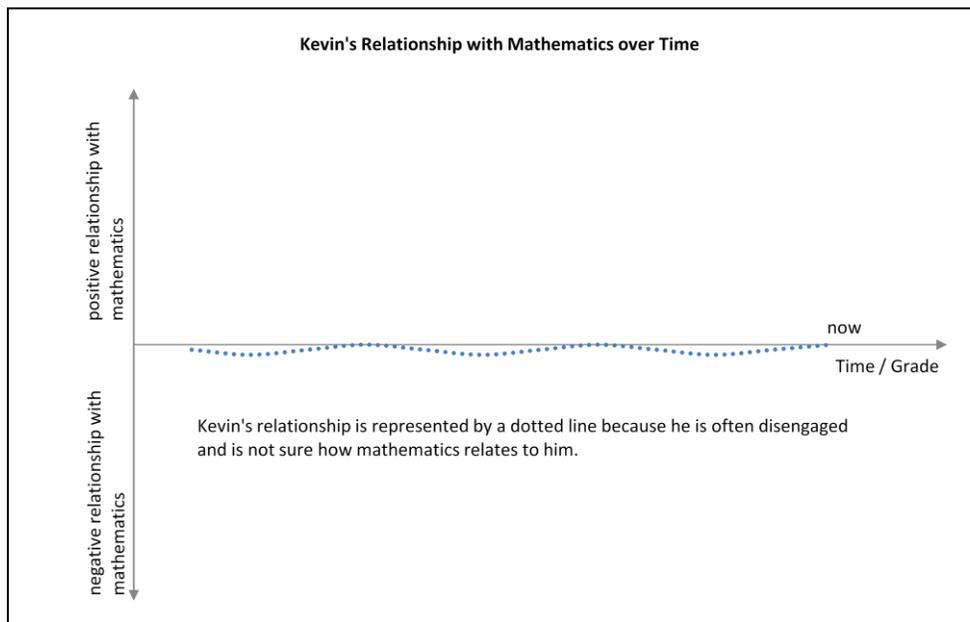
R: Really?

K: Yea. The mathematics like all the grade 11's are doing are much harder.

In general, Kevin's attitude towards mathematics is neither positive nor negative. He lacks an understanding of how mathematics is related to him, and he seems to be

having a difficult time deciding if what he does in mathematics class is actually mathematics. Kevin feels the needs to “know” some mathematics so that he is not labeled as a dumb kid, but does not need to know a lot of mathematics because he won’t use it. The following is a subjective synopsis of Kevin’s relationship with mathematics over time.

Synopsis 3 Kevin’s Relationship with Mathematics over Time



Mia’s Story

Mia is a very sociable and friendly girl who has been experiencing problems with mathematics since a young age. She was placed in the “plus program”⁵ in grade 8, and then the principles of mathematics program in grade 9 because of her success in the “plus program”. However, she failed grade 9 mathematics miserably and has been enrolled in

⁵ The “Plus Program” is a grade 8 adapted mathematics and science program designed for students who are weak in mathematics and science. Elementary school teachers identify the students who need extra help and enroll them in the “Plus Program” in their first year of secondary school.

the essentials of mathematics stream since grade 10. She works hard and enjoys mathematics class, including the company of her friends and the various activities she participates in, and believes that the essentials of mathematics stream is the correct placement for her.

Mia's experience of mathematics class is different from many others because most of her experiences are based on the essentials of mathematics classes. In general, these classes have a slower pace and provide students with more support. Mia's description of a typical mathematics class includes note-taking, some mathematical computation and problem solving exercises which she always works on with her friends or receives help from the teacher, and group projects that involves a lot of moving around. There are also quizzes and tests towards the end of each unit. Mia finds that her mathematics classes relate mathematics to reality. Instead of doing calculations at the desk which may or may not mean anything to her, she works on a lot of projects and problems that are applicable to her in life. Her mathematics experiences break away from students' typical beliefs about mathematics, such as mathematics is a collection of facts and rules, and mathematicians practice mathematics in an isolated area that is unrelated to reality (Garofalo, 1989; Spangler, 1992).

The essentials of mathematics 11 class is similar to her other mathematics classes, with the exception of note-taking and tests. Mia believes that she has learned just as much as in this class as in prior mathematics classes without a large amount of notes and tests. She enjoys the projects we do in class, which are served as assessment tools, along with other activities and challenges.

M: Ok, something I like, is, like the house sort of thing⁶. I thought that was cool. Cuz you know, you get to do your own stuff in the house. You gotta know the measurement and everything.

Mia displays a strong sense of self-efficacy in the essentials of mathematics classes and is eager to do work and take on challenging tasks. Most of her experiences with mathematics in school are positive, with the exception of one mathematics class. Mia was placed in the principles of mathematics 9 class when she was in grade 9, but she failed miserably despite of her hard work. This negative experience has greatly affected her sense of self-efficacy. She believes that she was misplaced into the class and that she will never succeed in the principles of mathematics program. On the other hand, her experiences with essentials of mathematics are positive. Mia finds success in these classes and her sense of self-efficacy remains strong. She takes on challenges without hesitation and believes she is capable. Her different behaviors are parallel with Bandura's description self-efficacy. Students with a strong sense of self-efficacy are keen to take on challenges, and students with a weak sense of self-efficacy hide from challenges (Bandura, 1997). In Mia's case, she displays a low sense of self-efficacy in the principles of mathematics program, but her self-efficacy raises when she is in the essentials of mathematics program.

Similar to many others, Mia's emotional experiences are based on her cognitive interpretations and appraisals of the situations, which in turn are based on her beliefs and knowledge of mathematics (Op't Eynde et al., 2006). Since Mia has faith in the ability in the essentials of mathematics class, she feels good and is enthusiastic about class. She describes class as "an adventure", although some of the mathematics she does in class

⁶ The House Project is an assessment tool for the measurement and part of the business plan unit. In this project, students design and build a scaled model of their dream house. They are also required to calculate the cost of the house, including all furniture and decorations.

drives her crazy. On the other hand, Mia feels anxious and discouraged when she is faced with mathematics from the principles of mathematics curriculum. She relates the principles of mathematics to failure and loses faith in her abilities.

Mia's enjoyment of mathematics is related to her achievement. Mia's attitudes towards mathematics remain positive when she experiences success and fun in the essentials of mathematics classes. However, her attitudes towards mathematics changes when she experiences difficulties. She feels frustrated and hates mathematics when she is stuck. Mia would ask for help, but gives up easily if she does not understand it immediately. These are typical behaviors to students who are ego-defensive goal oriented.

M: Sometimes I like math. And when I get really really stuck I just feel like I hate math. I... it's an on and off kinda thing for me. ... I would do it, when I don't get it, I would, I would ask for help. If I still don't get it, I, I'd give up. I, like, I dunno what to do.

Mia believes the teacher's teaching style and the pace of the class also contribute to her attitudes towards mathematics. During the year when she was placed in the principles of mathematics class, she found the pace of the class too fast, and she was not given enough time to grasp mathematics concepts before moving on to the next. She could not understand the concepts even with one-on-one help, and the experience was frustrating for her. Mia believes that she was misplaced into the principles of mathematics class. During the year, her self-efficacy was low, and she did not believe she could succeed.

M: Ever since elementary school I've been struggling with math. But then, um, once I hit this essentials program, I think, like, I got to know more stuff.

R: Oh, what do you mean?

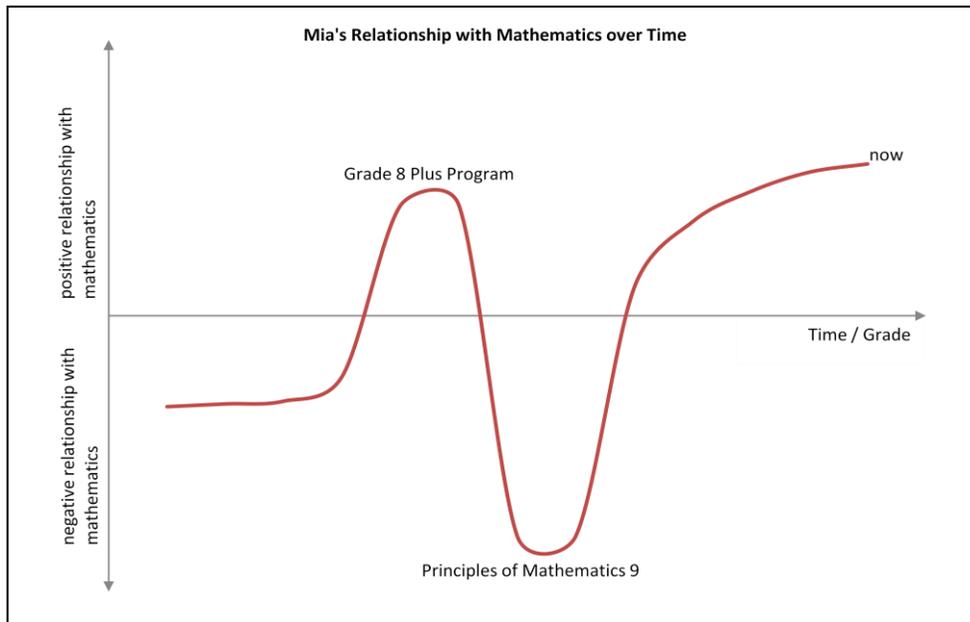
M: Like, I figure out how to do, how to solve all the problems, and, like, you know, do all the, like, equations out. In regular classes, it was kinda different,

cuz they will give you the work, like they explain it once, and then they give you the work to do. And then I wouldn't understand how to do it even I got one-to-one help. But then in the essentials, I find it a bit, like, totally different. Like it's more, I feel like, more, um, information I get, how to do stuff.

Mia failed all three terms in the principles of mathematics 9. However, she is successful in both the essentials of mathematics 10 and 11 classes. Mia believes the slower pace allows her to grasp mathematics concepts better, and feels that she is not left behind as she was in grade 9. I believe her stronger sense of self-efficacy also contributes to her success.

Mia is reluctant to enroll in the principles of mathematics stream again. She connects principles of mathematics with failure, and her sense of self-efficacy drops when she is faced with materials from the principles of mathematics curriculum. She doubts her ability and becomes emotionally distressed. On the other hand, Mia enjoys the essentials of mathematics program and her sense of self-efficacy remains strong in class. She finds success in class, and believes the essentials of mathematics program fits her needs. The following is a subjective synopsis of Mia's relationship with mathematics over time.

Synopsis 4 Mia's Relationship with Mathematics over Time



Diane's Story

Diane has experienced a lot of trouble with mathematics despite her effort. She attempted the principles of mathematics 10 course three times and failed the course each time. Diane describes her relationship with mathematics as “off and on”, where there is more off time than on time. She has very low self-efficacy, and believes that she will not succeed in mathematics. As Bandura and other researchers point out, while students' experiences contribute to their self-efficacy, students' efficacy beliefs also help construct their experiences (Bandura, 1982; Pajares and Miller, 1992; Hekimoglu and Kittrell, 2010). Diane was in my principles of mathematics 10 class on her third try. Compared to the essentials mathematics class, Diane was extremely quiet in the principles of mathematics 10 class. She found that the pace of the class too fast and felt left behind as the class moved on before she was ready. Diane's low self-efficacy affected her

persistence and effort on mathematics tasks. She stayed at the very back of the room and never asked questions. Instead of seeking help when she was stuck, she gave up quickly. She was unmotivated and “[lacked] a sense of efficacy or a sense of control with respect to a desired outcome” (Deci and Ryan, 2000). As a result, Diane spent most of her time in the principles of mathematics 10 class with her head down.

In the essentials of mathematics class, however, Diane behaves like a different person. She participates in group work and asks questions when she is stuck. She seems to believe that she has a chance to succeed, and mathematics becomes interesting. Diane has a stronger sense of self-efficacy. This is extremely interesting because while my teaching style remains the same for both mathematics courses, Diane’s behavior is different. Diane demonstrates much better thinking skills and confidence in the essentials of mathematics class. For example, Diane sits in the front of the room and is not afraid to voice her opinions. She finds that it is easier to grasp the materials in the essentials of mathematics class although a part of the curriculum overlaps.

D: ...This mathematics class is pretty easy. Other mathematics classes, it’s kinda like, I go there, and then they talk, and I’m just like, oh, okay... they write a bunch of numbers on the board, and I go... oh, okay... and I go home, and I forget about it... like, whatever...

R: So... is mathematics class easier?

D: Yes... like, easier because, well... if they taught the same materials in regular mathematics class, but they elaborate on it, it’d still be the same, because the material is like, easier, right? It’s just, you know, in essentials, it’s also because it’s presented in a very simple, easy way.

While Diane finds that mathematics becomes simpler in the essentials of mathematics class, she also finds mathematics easier with her tutor. However, mathematics remained difficult in the principles of mathematics class. She acknowledges

that this mentality is stereotypical and roots from the negative reputation mathematics has at school.

D: It's the same thing, but it feels simpler. So like, it must be a mentality thing or something that I stop thinking that "math suks" cuz we are in school, a bunch of kids, you know. A stereotypical thing.

D: As you go to highschool, you start connecting mathematics classes with bad things, cuz you are bad at math, I mean like...

R: Why is that?

D: Well... cuz you are bad at it, of course you are gonna be like, oh it's boring, I don't like it, I get bad marks in it right?

Diane believes that mathematics becomes easier outside the principles of mathematics classroom because she is not bound to do mathematics in the teacher's way (Garofalo, 1989). Some of her beliefs about mathematics and teaching that restrict her from learning have lifted outside the classroom.

D: I could figure things out, but I get confused when people tell me different things kind of thing.

R: So are you saying then if you are allowed to use different ways, or figure out your own way...

D: yea. Cuz. I dunno. I found tutoring, when I get tutors, basically we just get someone next to us, and we did the work and when we have questions, we ask right? I found that like, a lot easier to do than mathematics class, cuz...

R: Cuz you are not bound to do it the teacher's way?

D: Yea... it's just like, you figure it out, but you can't, you can ask, and they teach you how to do it. and then it's like, really simple I guess. It feels simpler, but not really.

Based on her mathematics experiences, Diane defines mathematics as numbers, equations, and worksheets. Although she enjoys the mathematical activities in class, Diane does not consider this work mathematics. For example, while she considers doing unit conversions on paper mathematics, applying unit conversions to build a model house is only doing work that is related to mathematics. Her beliefs of mathematics are similar to that described by Schoenfeld (1987) and Spangler (1992). Diane's world of

mathematics “consists of mastering formal procedures that are completely divorced from real life” (Schoenfeld, 1987, p. 197).

D: I just think mathematics is numbers, it’s just numbers right? I dunno. I kinda always like gotten that mindset.

D: Doing things like, like related to math, like, building the house and stuff, it seems more productive than doing actual math, cuz, you know...

R: What do you mean actual math?

D: Like, numbers and stuff. On the sheet, like, worksheet stuff.

R: But you do mathematics in the house thing though.

D: Yea, but it doesn’t feel like math. You know what I mean, cuz like ... Cuz people get used to like, sitting down, doing worksheets, right?

This misconception has negatively impacted Diane. For example, she fails to see the use of mathematics in her life, and the reason to learn and appreciate mathematics.

As a result, she does not care for mathematics and believes that basic computations, including adding, subtracting, and calculating taxes, are sufficient for her.

D: You know, like English, of course you are gonna use it everyday right? You are talking right? And you know that you are gonna use it. Mathematics you, oh, when am I ever gonna use math? Well I know addition subtraction, I know how to do like, you know, simple taxes and stuff.

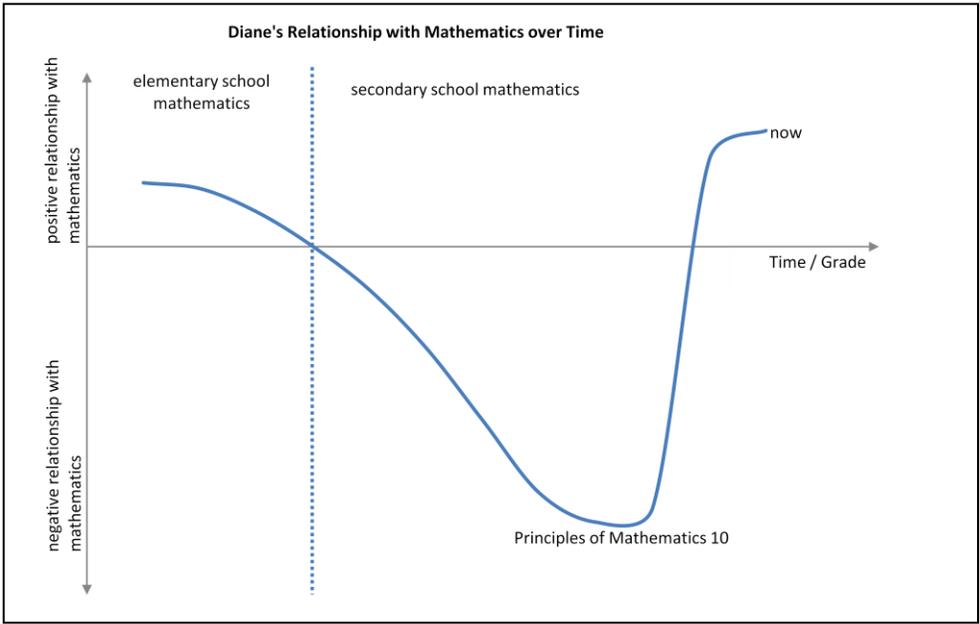
Diane is very creative and artistic, and dreams to become an artist. Yet, she fails to see beauty in mathematics. She believes that mathematics is for chemists, architects, and other professions that are “mathematical”, but not for artists. Diane’s definition of beauty and art simply do not involve any mathematics.

D: ...I don’t feel like it’s useful to me because of what I wanna do in the future. Like, you know, some people wanna be chemists, or like, architects, or whatever, they need mathematics right? Artist, it’s just, you know ... It’s not for me, you know.

Diane does not care about mathematics because she fails to see how it applies to her. Her definition of mathematics remains narrow although she has been exposed to a different side of mathematics. On a positive note, Diane’s attitude towards mathematics

is more positive than when she was enrolled in the principles of mathematics class. She also has a stronger sense of self-efficacy. The following is a subjective synopsis of Diane's relationship with mathematics over time.

Synopsis 5 Diane's Relationship with Mathematics over Time



Steve's Story

Steve is an ex-Montessori student who sometimes has trouble following instructions and often acts rather immaturely with his peers. He talks a lot, never sits still in class, and often asks to go to the vending machine with his buddies. However, he is a capable student who usually gets his work done on time. His ideas are often creative, but not always appropriate. Throughout his secondary school career, Steve has been struggling with mathematics.

Steve was enrolled in the Montessori program⁷ from grades 8 to 10. There were thirty students in the program, and they spent most of their time at school together. The decision for Steve to transfer into the essentials of mathematics class during his grade 10 year was not only a tough choice, it was also an embarrassing decision. Steve had to leave his friends during mathematics class to attend the essentials of mathematics class, and come back to spend the rest of the day with his friends in the Montessori program.

Similar to many others, Steve defines mathematics based on his experiences in mathematics classes (Garofalo, 1989). In particular, Steve believes mathematics is numbers with signs that carry some meanings which he does not understand. He has a negative image of mathematics.

R: So what do you think mathematics is?

S: It's um... numbers. Numbers and like little stupid signs that mean stuff.

R: Anything other than that?

S: No, that's all mathematics is. It's numbers and little signs that mean stuff.

R: Numbers and...

S: Like little signs, like the equal sign, like, you know, square, and times and yea...

Mathematics worried Steve. While he was enrolled in the principles of mathematics stream, he would spend nights studying for a mathematics test, and memorize mathematics questions in attempt to pass these tests. He had a tutor, but he felt that it was a waste of time and money because he could not understand mathematics. He hated it, but could not find a way out.

S: With math, like I didn't understand it, and I was like, what the fuck, cuz I've been working on this subject, I spend my parents' money on this tutor, like two hours, and I have come away with nothing. And my parents would be like did you learn anything in tutoring, and I'd be like, yea, yea, and I was trying to make my parents happy, I'd say after a test, even though I knew I did

⁷ Our Montessori program follows the principles of mathematics curriculum at the grade 10 level and students receive the principles of mathematics 10 credit. Therefore, I consider Steve to be enrolled in the principles of mathematics 10 course when he was in the Montessori program.

so shitty and I'd say yea, I think I passed this one, and I always failed. So... but I know, I know I failed.

R: But you know you also tried really really hard.

S: Yea, yea. And I made it hard for my parents to believe I was trying hard, because they knew I had trouble, they didn't think I was great, but they didn't know how much I hated it. So... they was like, you don't put enough effort in, or you don't do enough work at home, or you don't listen well enough in class. But I knew that I was doing the best I could. And it made me upset that I was doing the best I could, but I was still failing. And my parents were basically wasting their time and money, on... like I waste my parents' time and money and my tutors' time and everything doing this.

While enrolled in the principles of mathematics class, Steve was upset because he did not understand the mathematics while everyone has moved on without him. He felt frustrated and stuck. Many times he thought of giving up, and wanted to drop out of school because he did poorly despite of his efforts. Steve assumed that he was labeled as a dumb kid in general because of his inability in mathematics. He also worried that his poor performance in mathematics means life is over, because mathematics is a basic requirement to many things in life.

S: I was worry when I was in [regular] mathematics that I would grow up, never have a good job, basically be in like, I wouldn't have any family or anything, then I just die. That's basically what I thought.

Steve is very performance goal oriented. He wants to show off his talents, and sees failure as a sign of incapability (Hannula, 2006). Switching from principles of mathematics to essentials of mathematics was a difficult and stressful decision for Steve. Although Steve knew that essentials of mathematics is better for his personal well-being, he felt that his peers would look down on him and label him as incapable because of the switch. This is in parallel with Bandura's (1997) description of how group instruction and ability groups diminish students' confidence level in mathematics.

S: I wasn't happy, so basically it was a hard decision, like it was kinda of an embarrassing decision.

R: Why embarrassing?

S: Cuz I was in Montessori at the time, leaving the program, cuz I had to, it was kinda like, why are you leaving? Oh, because I am not smart enough.

S: And it's kinda like, I hate it when, when people get labeled into that because, you know, the world shouldn't revolve around how like, freakishly smart someone is, or like, what their grades are. ... It also suks that essentials mathematics can get you labeled as "not as good" sort of thing. And how there's the thought of it always, when I was in regular math, oh essentials math, oh my gosh, life is over.

The principles of mathematics course eventually became too stressful for Steve.

Finally, Steve switched out of class and into essentials of mathematics 10 after term one.

S: Yea, grade 10. I switched half way through grade 10. And... I switched because I just found normal mathematics too hard, and like too many concepts to understand. And I couldn't understand it, couldn't figure it out in my head. So basically I, I hate math. And... switching into essentials, and found essentials 10 easily, like it was pretty easy compared to what I was doing before. I never failed math, normal math, but I just never, I never pass, like, I was get like 50%, or 55%. So, nothing good enough passing, you have to not worry about exams, so um... yea I had to switch.

After the switch, Steve felt that he could pass the course and he was the "smarter" kid in class. He had higher self-confidence, and paid attention and was engaged in class.

S: I understand the stuff, and I was one of the better, like I was the smarter kid in the class, and being the outcast who did that. It was good, it was good cuz I actually knew how to do the stuff.

R: You mentioned um... you mentioned there are algebra in e-10, even though you weren't doing extremely good on that, you said you did better.

S: Because my self-confidence was high. And I thought that I was, well, I knew that I was one of the smartest kids in the class. And so because of that, I listened better, and I didn't labeled myself as a dumb-ass. It made a lot of difference.

Steve admits that he finds mathematics less stressful and more enjoyable because he performs better. When he was enrolled in the principles of mathematics, Steve often felt disappointed because no matter how much he studied, he was only barely passing mathematics. In the essentials of mathematics classes, Steve still needs to study hard in

order to pass mathematics, but he starts to feel better about himself, displays higher confidence, and believes that he now understands mathematics better than before.

S: Yea. Uh... it felt different and ... ok, in the e-mathematics class, it's a whole different feeling. ...In normal math, I was trying really hard, uh... and failing still. And then in here, I was trying really hard and passing.

S: Before when I was like that kid who didn't know anything, I kind of, like, believe that too... and then, I guess our competence was better, and you would have to listen, I would at least, actually listen, cuz I believe that I could actually do it.

Similar to many others, Steve fails to see the relevance of the mathematics he learns in the principles of mathematics class, such as square roots and solving equations. He is a physical and visual learner, and has trouble understanding things that he cannot see and touch. For example, he has trouble understanding the square root of 25 is 5, but understands that if the area of a square is 25cm^2 , the length of each side of the square is 5cm.

The essentials of mathematics program provides Steve with more support and has opened a new door for him. Mathematics is no longer just numbers and little symbols that carry mysterious meanings which he will not use outside the mathematics classroom. He understands the mathematics he learns. Mathematics has transformed into something useful, applicable, and enjoyable.

S: Yea. Yes. So... which I'm happy I did switch, but yea. I like math, like I like essentials math, because it's more mathematics I'm gonna use in my everyday life after highschool. You know like how to, like what we are doing right now, like products and stuff⁸.

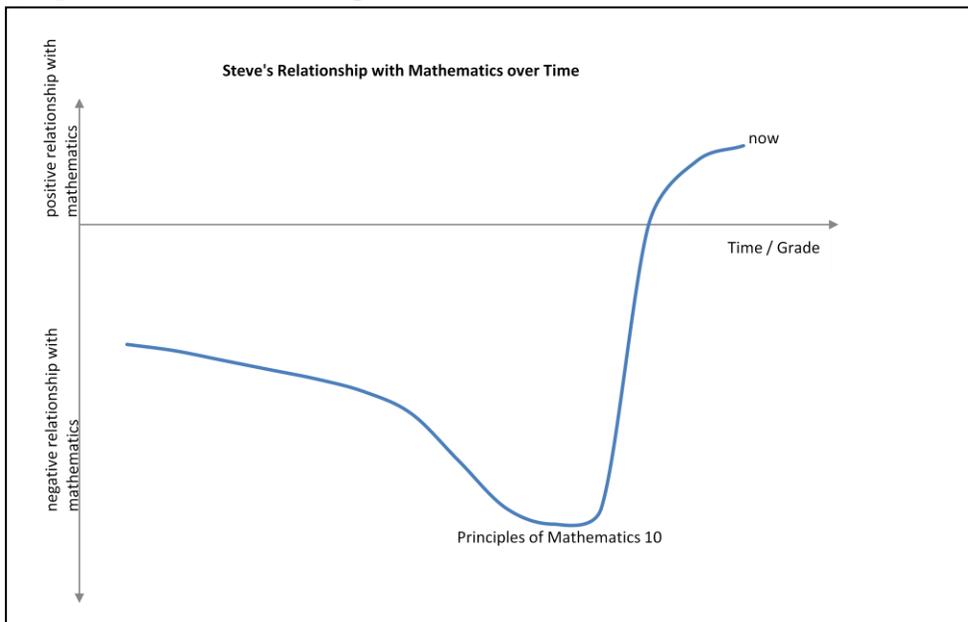
S: Because [essentials mathematics is] actually stuff they need to know. And like, and like um... the stuff that you, they teach you in principles, not all of it necessary but most, lots are just stuff like you use if you are gonna be like

⁸ Steve is referring to the business plan unit, where he designs and writes a business plan for a product. This includes production and promotion costs, profit margin, etc.

um... like a teacher, when you teach people how to do that or you going to be some kind of scientist or something, or I'm not sure, I'm not...

Overall, the essentials of mathematics program has shown Steve a different side of mathematics, where mathematics is useful and applicable. Steve understands that the essentials of mathematics stream suits him better, but still hopes to take the principles of mathematics class. He believes that enrolling in the principles of mathematics class makes him “mathematically capable” and allows him to do anything he wants. On the other hand, the essentials of mathematics program removes him from many of these opportunities, especially those involve post secondary school. Steve feels that society labels him incapable based on his mathematics skills. The following is a subjective synopsis of Steve’s relationship with mathematics over time.

Synopsis 6 Steve’s Relationship with Mathematics over Time



Elle's Story

Elle loves shopping and works at a retail store. She has weak mathematics skills and therefore relies heavily on calculators and the cash register. She believes that her difficulties in mathematics have been a result of her not understanding fundamental concepts that others are built upon. In her prior mathematics classes, she was expected to understand the materials quickly, and the pace of the classes was fast. She felt that there was never enough time for her to go back and relearn the concepts if she missed a step in class.

E: Mathematics class? Um... it's good at the beginning of class, cuz I start to get things, but then, well in the past, once I miss a step, the rest of the class I'm stuck. I miss a step, the rest of the class I'm confused. I need to go back and do it really slowly, and there's never enough time to do so, cuz they will be on another section, but then I'll be like [still on the previous one].

Elle also uses time as an excuse to avoid mathematics. She recognizes that she needs to spend time to relearn the mathematics she missed, but does not want to because it takes too long. She gives up and loses persistence in mathematics easily. Elle finds mathematics overwhelming, and gives up easily when she faces obstacles. Typical to others with a low sense of self-efficacy, she focuses on her deficiencies instead of her abilities (Bandura, 1997).

E: Talking about mathematics is just like, a lot... to handle. Mathematics is like, is like, I dunno, Mathematics is like super hard for me.

E: No, math. Math, I have no motivation, discipline, once I don't get it, like, once I don't get it I just don't want to do it anymore.

Elle attempts to remove herself from these negative emotions associated with mathematics by avoiding mathematics (Op't Eynde et al., 2006). She is even willing to scale down her dreams, because she believes she will struggle and fail.

Elle also holds many common misconceptions towards mathematics. For example, she believes that mathematics is numbers and equations (Spangler, 1992; McLeod, 1992). She also believes that mathematics is either black or white with no gray area. She claims that mathematics means “use the numbers, find the answer”, where the process and work that lead to the answer do not matter (Schoenfeld, 1989).

E: When I think of math, I just think of finding an answer using numbers. ... I dunno, math's just... find the number. Use the numbers, find the answer ... It's like, mathematics and numbers, and like, there's always just one answer and like, there's never like, a “what if”, or like “but”, just one answer.

Elle believes there is a big difference between the principles and the essentials of mathematics program. As mentioned before, Elle found the pace of the principles of mathematics classes too fast. She often felt lost and left behind. On the other hand, she feels better in the essentials of mathematics class, because the pace is slower and more time is spent on reviewing materials before introducing new ones.

E: ... Essentials is a lot easier, cuz it covers the basics, and then you review them, and then I know most of it.

Similar to Diane and Steve, Elle also believes that mathematics is isolated from reality. She feels that most of the mathematics she learnt in the principles of mathematics program is useless because she does not see it outside the classroom. On the other hand, she finds the essentials of mathematics curriculum useful, because she sees the use of it in her future.

E: ... and also we get stuff like, calculating getting a car, which is good for the future, and like taxes and stuff, that all helps.

R: So do you consider these math?

E: It's math, but it's mathematics that has to do with the future and your life, like ... like on a different scale.

R: But you just said mathematics is so useless.

E: Yea, that, mathematics is useless, I think that mathematics 11 and mathematics essentials are totally like, different levels. Like, one is like, stuff

that I don't think I'll ever be like, pi divided by two, over 4, and then like essentials, I'll use, like, how to do my taxes, and I'll use. But then, I'll use like, how to pay for a car and stuff.

Because Elle is performance goal oriented and feels good when she understands and succeeds, she hates it less in the essentials of mathematics class. She claims that she will never enjoy mathematics, but it is less depressing in this class.

E: ...It all comes down to me not getting it. If I get it and it's useful, I'll use it sometimes. I don't mind doing it again. But if I don't get it, then no.

R: You don't mind it, doesn't mean you like it.

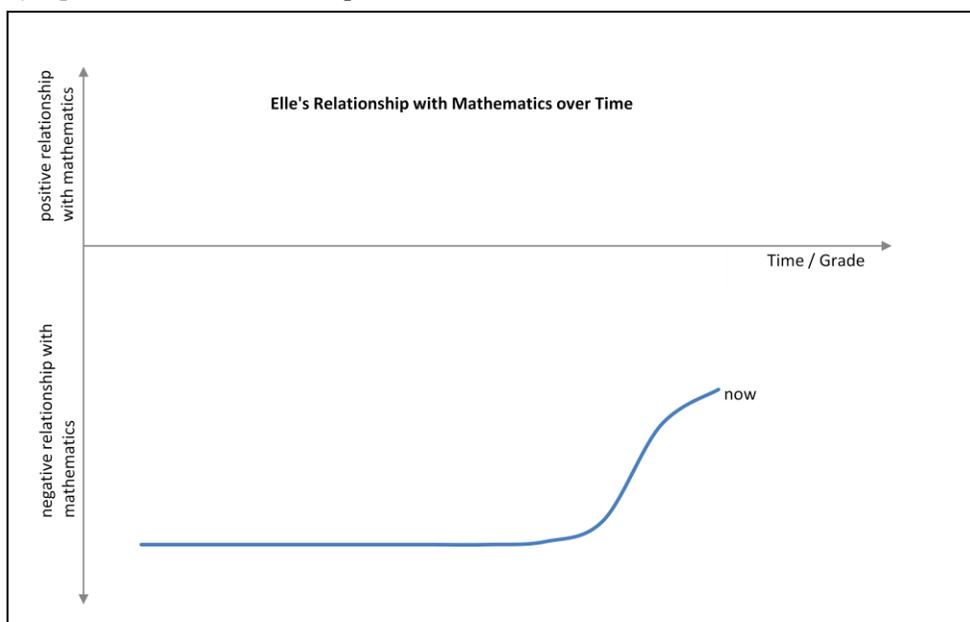
E: No.

R: You still don't like it.

E: No. Mathematics will never be like, "I like it". It will either be like, neutral, or negative.

It does not sound like Elle will enjoy mathematics in the near future. Her many negative experiences have contributed to her strong dislike of mathematics. The essentials program has helped Elle to see mathematics differently. Mathematics becomes more applicable in her life. It is more than useless numbers and answers. The following is a subjective synopsis of Elle's relationship with mathematics over time.

Synopsis 7 *Elle's Relationship with Mathematics over Time*



Caroline's Story

Caroline is an extremely talented ballroom dancer who trains and competes nationally and internationally. As a result, she misses class often, falls behind, and struggles to keep up. She eventually gives up and decides she hates math.

C: I hate math.

R: Why?

C: Because it's so hard. I don't get it. ... I don't understand it. It's hard... yea.

Caroline is very ego-defense goal oriented. When she does not understand something, she gives up easily and removes herself from the challenges in order to avoid negative emotions associated with her failure (Dweck, 1986; Op't Eynde et. al, 2001). Therefore, she steers clear of mathematics whenever possible in order to avoid feeling incompetent and deficient.

C: Yea. When I get something I feel good, but when I don't get it, I feel dumb. That's why I don't want to try doing the work.

Caroline believes she has weak mathematics skills and sometimes needs to count with her fingers instead of doing the calculations in her head. She feels that this is a sign of incompetence and failure. She also thinks that if she gets it wrong, others will judge her negatively because she is incapable of simple calculations. In other words, mathematics is a showcase of incompetence, where her self-esteem is under attack.

C: ... I avoid it because I know I'm not good at math, so then I'm saving myself from embarrassment. That's why I avoid mathematics questions cuz if I get it wrong, and I, you know, it's embarrassing. People ask you, they expect a good answer right?

R: It makes you look kinda bad.

C: Exactly!

Caroline was successful in mathematics at a younger age, but suffers from failure now because she fails to keep up. She also blames her current failure on her teachers and feels that her mathematics teachers have influenced her mathematics education negatively.

C: All [he] did was talk, the whole class and I just slept. It was so boring.

R: What would work for you then, in a class?

C: Maybe if we did like group project stuff, and work together, or something. We didn't even work together. We just did stuff, and he explained to us the whole time in class. He was talking. I fell asleep.

Although Caroline admits she fell asleep in class because class was boring, she also believes that she tried her best. When I suggested during the interview that maybe she has not given mathematics her best shot, she became very defensive. She claimed that she did try her best, but mathematics was too difficult, and her mathematics teacher was the reason that she failed mathematics.

R: If you fall asleep, you...

C: I do try, but, but... I did try, I almost passed mathematics 11, freaking, yea. But then I failed. So I gave up.

R: Um. So if you would try hard enough you would be able to pass it then?

C: I did try hard enough. It was too hard, I didn't understand it, the teacher suked.

In class, Caroline requires many stimuli to keep her engaged. She shows little intrinsic interest, is easily distracted, and falls asleep in class when things do not interest her. She finds seatwork boring but enjoys projects and group work. Therefore, typical mathematics classes where ideas are rarely exchanged as students assume the role of passively receiving mathematical knowledge from the teacher torture her (Stodolsky et al., 1991). She believes that during a typical mathematics class, all she does is takes notes and plugs numbers into equations to solve for the answer. She finds this boring.

Caroline claims that she will be able to focus and enjoy mathematics class if it is more fun.

C: If it's fun, then everyone would go to it. But then, I think, I went to class, and than all we did was... questions.

R: Questions...

C: Questions like he gave us numbers and we then we just try to solve it. He doesn't really explain it to us all.

Based on her experience, Caroline believes that mathematics is mostly numbers and computations. When mathematics involves only abstract calculations and equations that do not relate to her, she finds mathematics boring, and gives up quickly. On the other hand, when mathematics involves group work, projects, and things that she relates to, she engages herself and learns quickly.

R: Ok... what about the stuff we do in class?

C: Ok that's fun.

R: ... How's that different from what you did?

S: Oh, it's different because all we did was numbers, like subtraction, fractions, BEDMAS stuff, and algebra, oh my God, algebra, and all these like, weird things, it has like x's and y's.

When she was enrolled in the principles of mathematics class, she felt she was the outcast. Her image of mathematics class was distorted, that everyone in class had no trouble with mathematics, and they were all passing with flying colors. She felt that while everyone understood the lesson, she had no clue what was going on. She did not talk to anyone in class although she had questions, because she did not want to feel embarrassed or incompetent. Instead of asking the teacher or her friends for help, Caroline talked to her cousin outside of school. However, when he could not help her, she gave up.

R: So if you had questions, who would you talk to?

C: I don't ask questions. Usually I ask my, I had like, my cousin, he's a mathematics genius and I usually asked him.

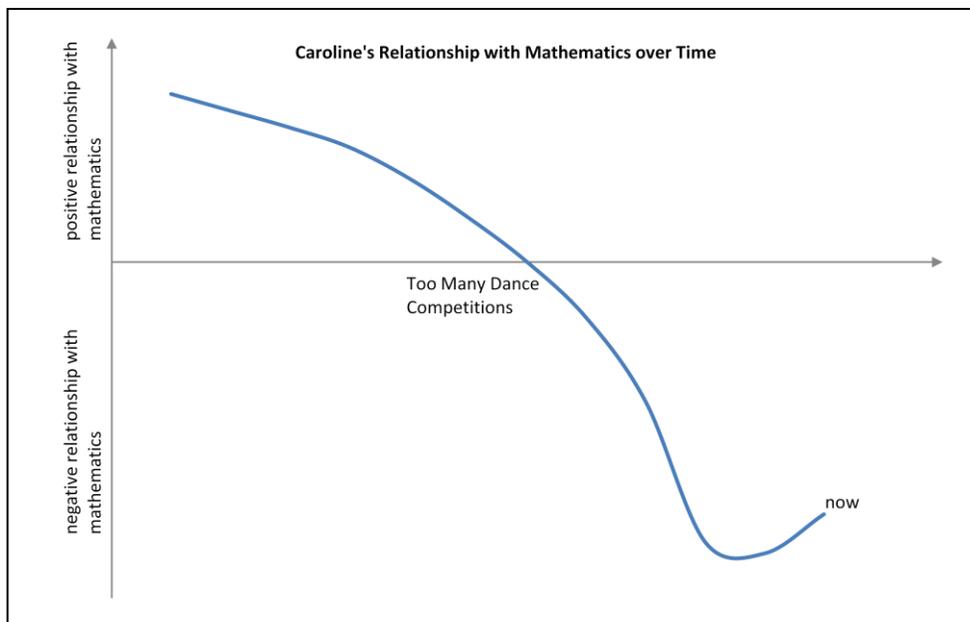
R: So did you ask him?

C: I did ask him, but he's a total fop. So I can't understand half the things he said. [laugh] that's why I hate math, cuz mathematics is too hard for me.

Other than ego-defensive goal oriented, Caroline also focuses on performance goals. In class, she takes every chance she can to show off her ability, whether it is telling everyone that she understands a particular mathematics problem, or that she is the first to solve the problem, or that she acs a project (Hannula, 2006).

Caroline hates feeling incompetent much more than enjoys success. Therefore she tries to steer clear of challenges that may embarrass her and blames her mathematics teacher for her failures. On the other hand, she still looks for chances for her to shine, but she is careful in choosing these challenges, because failures outweigh feeling good. The following is a subjective synopsis of Caroline's relationship with mathematics over time.

Synopsis 8 *Caroline's Relationship with Mathematics over Time*



John and Fiona's Stories

John and Fiona are new immigrants to Vancouver from the Philippines. They were interviewed together as a pair because they feel more comfortable. John is stylish and loves fashion design, and Fiona enjoys hanging out with her friends. They both find mathematics difficult, but different from what they were used to in the Philippines. One of the difficulties is the language barrier. They have been in Vancouver for only a few months, and they often have trouble understanding the questions and instructions in class.

Like many others, John and Fiona hold misconceptions of mathematics. They believe mathematics is numbers and calculations. John also claims that he hates problem solving questions, where he needs to follow rules and procedures in order to determine the answer. He feels that this kind of problem solving questions are isolated from reality, that there is no connection between mathematics and his daily life (Garofalo, 1989; Mtetwa and Garafalo, 1989; Crawford et al., 1994; Hekimoglu and Kittrell, 2010).

F: Mathematics is calculating lots of numbers. And solving problems. And it's so difficult.

R: John what do you think mathematics is?

J: Lots of numbers. Oh and I hate problem solving.

When John finds the connection between mathematics and fashion, however, he enjoys the mathematics. For example, John has created the most stylish and well designed house among the two classes. All the measurements of his model house were to scale and well done. He enjoyed the project and had fun, but did not enjoy the section where he needed to calculate slope, because he could not see how slope relates to him in life.

J: I hate problem solving.

R: What kind of problem solving? I mean, we do a lot of problem solving stuff in class.

- J: Yea, but like more... more... not like... cuz in the Philippines, we have like, different kind of problem solving stuff. I can't figure out the..... given the equation. But like here, we do different, like different methods. Like, lots of fun here.
- R: What makes it fun?
- J: Like, the houses.
- R: But the houses have lots of numbers, and building the house is a big problem solv...
- J: It's okay. It's like, I dunno. It's just fun.
- R: What's so good about it? What makes it different? Cuz they both have numbers in it. Houses and the problem solving stuff you were talking about.
- J: It's more style.
- R: What do you mean? More...
- J: Like, I can relate. Like, cuz, I love fashion. Like, style.

On the other hand, Fiona enjoys mathematics when she understands and is not rushed to finish. She finds that if she is given enough time to figure out the answer to a question, she can enjoy mathematics.

- F: Like, it's difficult, then your teacher like, gives you a time to, like, figure your answer. It makes it fun, cuz you learn.

Unlike John, Fiona does not feel the need to relate to the mathematics she practices. Fiona finds mathematics difficult, but when she receives help from the teacher and is given time to think and grasp the concepts, she gets it, feels good about herself and finds mathematics enjoyable.

- R: What about you? Do you like the stuff we do in class?
- F: Yea. Sometimes. Sometimes fun, sometimes not.
- R: Okay. Tell me the sometimes not part.
- F: Cuz I don't understand.
- R: Which part of it do you not understand?
- F: Like the slope stuff.
- R: Why was it so bad?
- F: I don't get it.
- R: So it's not fun when you don't get it.
- F: Yea. As long as I get it, as long as I know the answer. But if I don't, then, no.

Unlike Fiona, John enjoys mathematics although he does not always understand it. For example, he loves the three-dimensional (brain) puzzles because they make him think.

R: Is there a time like, when you don't get it but it's still kinda fun?

J: Oh I love the brain puzzles.

R: You love those, but do you get it all the time?

J + F: No.

R: But it's still fun.

J: Fun. Yea. It makes your mind exercise. Like, how do you build this, like how. It makes you think. Yea.

R: But what about the regular mathematics stuff. It makes you think too.

J: Yea but... No.

Fiona thinks otherwise. She would rather work on worksheet exercises where she can use her calculator to figure out the correct answer and get it right. These worksheets allow her to achieve her goals and feel good about herself. This is, again, a typical belief about mathematics – the goal of doing mathematics is to determine the one and only correct answer (Schoenfeld, 1989; Spangler, 1992; Chinn, 2009; Hekimoglu and Kittrell, 2010). Fiona also avoids the negative emotions she experiences when she gets stuck. She asks for help immediately, and gives up easily if she does not receive help. As Op't Eynde et al (2001) suggests, when students experience negative emotions, they find alternate cognitive strategies to remove themselves from these negative emotions.

F: I think it's easier than the puzzles.

R: Do you like the puzzles?

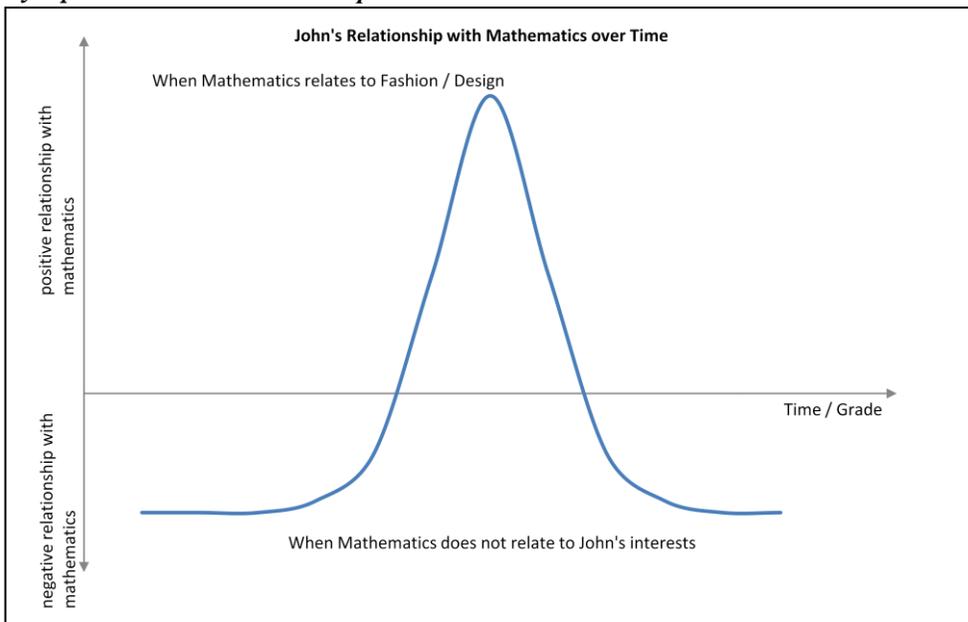
F: So so. So so cuz it's so hard to fix it, but like the mathematics thing, like the counting stuff, you just use your calculator. And then use some formula to get the answer.

It is interesting how two people with similar cultural background believe in similar yet different things. While both Fiona and John believe that mathematics is numbers and calculations, they have very different ideas of what makes mathematics

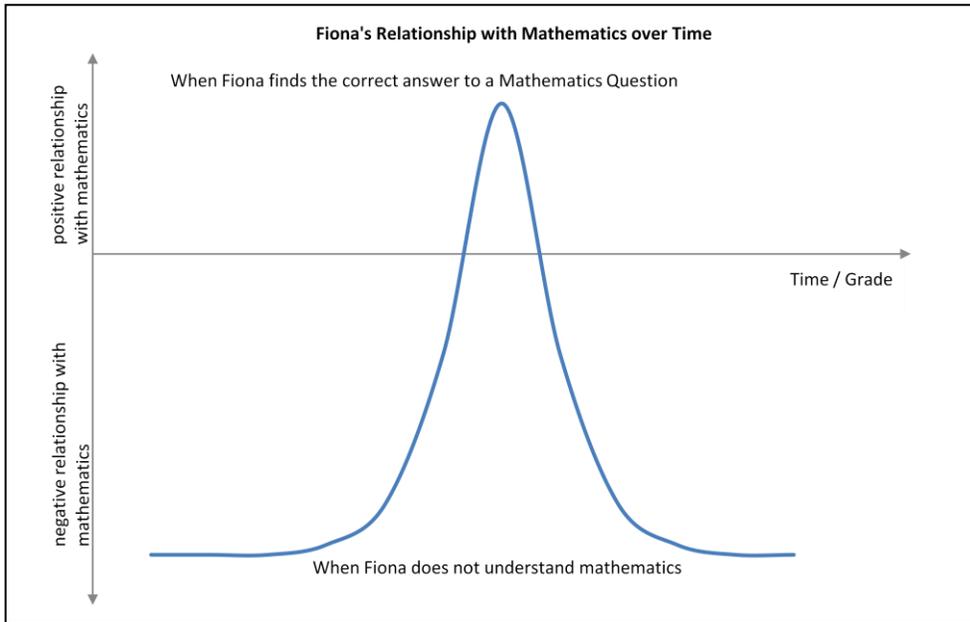
enjoyable. John needs to relate himself to the mathematics he is doing. He finds the essentials mathematics class enjoyable because he finds a link to mathematics, making it more than meaningless numbers and calculations. On the other hand, Fiona prefers the mathematics she is used to, which involves using numbers and formulae to find the correct answer. She is satisfied with achieving the goal of determining the correct answer is satisfying. Synopses 9 and 10 show John and Fiona’s relationships with mathematics over time.

All the student participants have positive and negative experiences with mathematics throughout their mathematics education. While some students’ relationships with mathematics deteriorate as they grow up, others find their positive experiences in the mathematics program that suits them. In the next chapter, I offer the common themes that emerged from these stories.

Synopsis 9 John’s Relationship with Mathematics over Time



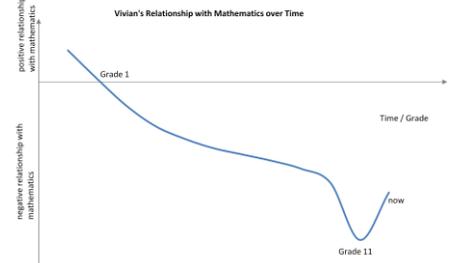
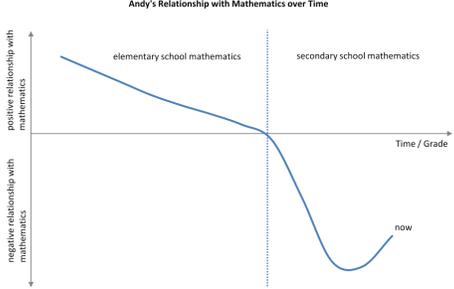
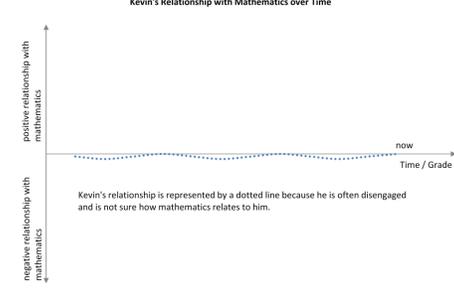
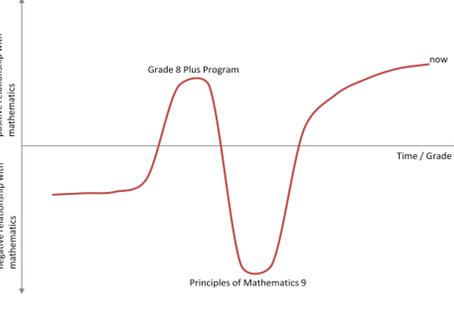
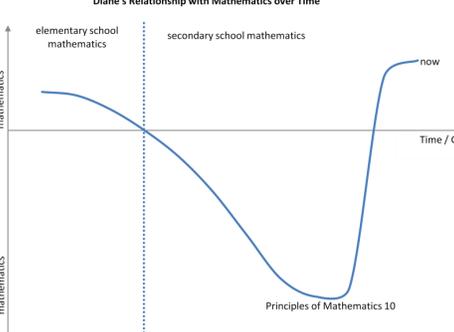
Synopsis 10 *Fiona's Relationship with Mathematics over Time*



Summary

The following table gives a summary of the student participants' defining characteristics and their synopses of relationships with mathematics.

Table 1 *Student Participants' Defining Characteristics and their Synopses of History*

Name	Defining Characteristics	Synopsis of History
Vivian	<ul style="list-style-type: none"> The German exchange student who hates function but loves geometry 	 <p>Vivian's Relationship with Mathematics over Time</p> <p>The graph shows a blue line representing Vivian's relationship with mathematics over time. The vertical axis is labeled 'positive relationship with mathematics' (top) and 'negative relationship with mathematics' (bottom). The horizontal axis is labeled 'Time / Grade'. The line starts in the positive region at 'Grade 1', crosses the zero line, and continues into the negative region. It reaches a sharp dip at 'Grade 11' and then rises slightly towards 'now'.</p>
Andy	<ul style="list-style-type: none"> The hands-on guy who hates seat work and avoids mathematics 	 <p>Andy's Relationship with Mathematics over Time</p> <p>The graph shows a blue line representing Andy's relationship with mathematics over time. The vertical axis is labeled 'positive relationship with mathematics' (top) and 'negative relationship with mathematics' (bottom). The horizontal axis is labeled 'Time / Grade'. A vertical dashed line separates 'elementary school mathematics' (left) from 'secondary school mathematics' (right). The line starts in the positive region, crosses the zero line, and reaches a sharp dip in the negative region during secondary school, then rises slightly towards 'now'.</p>
Kevin	<ul style="list-style-type: none"> The disengaged teenager who thinks it's better to know math although he does not see how mathematics relates to him 	 <p>Kevin's Relationship with Mathematics over Time</p> <p>The graph shows a dotted blue line representing Kevin's relationship with mathematics over time. The vertical axis is labeled 'positive relationship with mathematics' (top) and 'negative relationship with mathematics' (bottom). The horizontal axis is labeled 'Time / Grade'. The line is nearly flat and stays very close to the zero line. A note below the graph states: 'Kevin's relationship is represented by a dotted line because he is often disengaged and is not sure how mathematics relates to him.'</p>
Mia	<ul style="list-style-type: none"> The social butterfly who enjoys the essentials of mathematics classes, likes mathematics, and finds mathematics applicable in life 	 <p>Mia's Relationship with Mathematics over Time</p> <p>The graph shows a red line representing Mia's relationship with mathematics over time. The vertical axis is labeled 'positive relationship with mathematics' (top) and 'negative relationship with mathematics' (bottom). The horizontal axis is labeled 'Time / Grade'. The line starts in the negative region, rises to a peak in the positive region labeled 'Grade 8 Plus Program', falls to a deep dip in the negative region labeled 'Principles of Mathematics 9', and then rises to a high peak in the positive region labeled 'now'.</p>
Diane	<ul style="list-style-type: none"> The artist who does not care for mathematics 	 <p>Diane's Relationship with Mathematics over Time</p> <p>The graph shows a blue line representing Diane's relationship with mathematics over time. The vertical axis is labeled 'positive relationship with mathematics' (top) and 'negative relationship with mathematics' (bottom). The horizontal axis is labeled 'Time / Grade'. A vertical dashed line separates 'elementary school mathematics' (left) from 'secondary school mathematics' (right). The line starts in the positive region, crosses the zero line, and reaches a deep dip in the negative region during secondary school labeled 'Principles of Mathematics 10', then rises sharply to a high peak in the positive region labeled 'now'.</p>

Name	Defining Characteristics	Synopsis of History
Steve	<ul style="list-style-type: none"> The ex-Montessori student who felt destroyed by mathematics and related essentials of mathematics to incapacities 	<p>Steve's Relationship with Mathematics over Time</p>
Elle	<ul style="list-style-type: none"> The “only the answer matters” girl who is overwhelmed by mathematics and would alter her dreams to avoid mathematics 	<p>Elle's Relationship with Mathematics over Time</p>
Caroline	<ul style="list-style-type: none"> The dancer who was successful at a young age but experiences failure now 	<p>Caroline's Relationship with Mathematics over Time</p>
John	<ul style="list-style-type: none"> The fashionista who enjoys anything that is related to fashion and design 	<p>John's Relationship with Mathematics over Time</p>
Fiona	<ul style="list-style-type: none"> The girl who believes mathematics is numbers and the correct answer is the key to success in mathematics 	<p>Fiona's Relationship with Mathematics over Time</p>

Chapter 5 Analysis

In this chapter, I describe fourteen common themes that emerged from the interviews. These themes contribute to “math suks” as a response to students’ experiences with mathematics. Therefore, the phrase “math suks” appears in some of the excerpts. The exploration of these themes provides a better understanding of students’ negative relationship with mathematics, their response to these negative relationships using the phrase “math suks”, and the situations that lead to “math suks”. In the next chapter, I offer a deeper discussion of these themes.

Mathematics as Building Blocks

Unlike many subjects, mathematics is cumulative, where mathematics concepts build upon one another. In mathematics, students have to constantly apply their knowledge in mathematics when they learn new things. Based on the interviews, it seems that students find it difficult to keep up if they missed a step or a concept.

Caroline used to love mathematics when she understood and was successful at it. As she has missed many classes at school due to dance competitions, she needed to put in extra effort to keep up. At first, she was able to keep up and understand the mathematics she was learning, and she loved mathematics. Unfortunately, as she missed too many classes, it became difficult for her to keep up. She struggled, fell behind and disliked math. Caroline eventually gives up.

- C: ... I don't like it cuz I don't understand it. When I don't understand something, I don't, I can't, I can't work with it. If I don't understand [George], I wouldn't be his friend.
- R: So what if you understand math?
- C: Yea, I think, no, there is a point where I understand it, and it was so easy, like fractions, and I loved it. I love mathematics actually, I was getting a B in math, in grade 9. Can you believe it?

While it is unfortunate for Caroline to dislike mathematics because she falls behind, she is not the only victim of this building block model of mathematics. Of all the students I have interviewed, Elle stood out from the rest of the students. When asked to list three things⁹ she likes about mathematics, she wrote "I hate math" in big letters. Elle believes that her difficulties in mathematics originate from her not understanding the fundamental concepts that other concepts are built upon.

- E: Mathematics was really hard for me, I avoid [it]. It seems like I missed stuff when I was younger. So, when I got to like, grade 8, grade 10 math, it was way harder for me. I always struggle with it, it's never been easy.
- R: Why do you think that's the case?
- E: Um... I guess when I was learning it, I didn't really grasped concepts, and I never asked questions, therefore I missed the fundamental stuff.

Elle always tries hard at the beginning when she learns a new concept. Unfortunately, she does not grasp everything at once. Elle finds that although she pays attention in class, she often misses a step or two, and this is when things sour. She is confused and frustrated, and fails to follow the rest of the lesson. Because the class would have moved on to a different topic before she figures things out, Elle feels that there is never enough time for her to catch up and figure out the step(s) she missed. Mathematics becomes a frustrating experience. Therefore, Elle gives up on mathematics to remove these negative emotions caused by it.

⁹ Students' answers to the questionnaire are embedded into their "mathematics stories". Their answers also coincide with what they say during the interviews.

E: Mathematics class? Um... it's good at the beginning of class, cuz I start to get things, but then, well in the past, once I miss a step, the rest of the class I'm stuck. I miss a step, the rest of the class I'm confused. I need to go back and do it really slowly, and there's never enough time to do so, cuz they will be on another section, but then I'll be like still on the previous one.

Elle also struggles with mathematics because she finds that mathematics to be a completely different language with new rules, and she can't simply "jump into it". She feels that because she has a weak foundation in mathematics, she needs to do a lot of catch up before she will succeed.

E: ... Mathematics is a different language to me. So like, I have to like learn everything all over again, like, English I can like already know it, so easier. But mathematics it's like learn a separate language, so like different set of rules.

R: Does it feel like you are now in grade 12, but being dump back in kindergarten when you learn your ABC's again?

E: Yea, talking about math, yea. I feel like learning things from the beginning cuz like for me I can't just like jump to it, I have to go back and like, I missed that.

R: Let's say you can fill in all the gaps that you missed. You think that would help you?

E: Yea. It would have been a lot easier.

Andy and Diane express a similar concern. Andy admits that when he forgets about the things he has previously learned, he does not go back and review what he forgot. He acknowledges that is what he needs to do in order to succeed, but allows mathematics to grow into a bigger problem he cannot handle.

Diane compares basic or foundational mathematics, including things that she learns in elementary school, to her ABC's. She admits that she does not have a solid foundation and finds that mathematics class goes on whether or not she is able to keep up. Diane has trouble understanding new material because she of her weak foundations, and mathematics becomes a problematic snowball that rolls bigger everyday.

- D: Well... this mathematics class, is like a breeze, unless you have to do divisions and fractions, cuz that's like, basic stuff that you are so familiar when you are little, but, like, when you don't get it then, you just don't go anywhere, just don't.
- R: You mean the divisions and fractions stuff?
- D: Yea, like, you are supposed to learn it so it's like your base, right? But if you don't get it then, as you go on in mathematics class, it goes on without you, right? Cuz you either know it or you don't, right?
- R: So it's more like... tell me if this is right? It's more like, there is some stuff that you are supposed to know. But then, since you've missed it, you don't know it, then you kinda fall behind, and it's just like a snowball...
- D: Yea yea yea.... Cuz like, ok, you can teach it after, but, it's stuff that, you know, your ABC's you remember when you're little? They stick with you forever right? Same as, like, subtraction, addition, multiplication, division right? If you don't get it, like, life goes on without them, and you kinda get left behind.

Vivian made a similar comment. She finds mathematics class moving too fast for her, that the class has already moved on before she understands the first concepts taught. She finds that if she does not understand the first class, she won't get the rest of it, because the lessons are built upon the first class, which she has trouble with.

- V: ... Everybody goes so fast. And then, I am confused, and it's so much every class. We get new stuff, and it always gets harder and when you don't get it the first class, you won't get it the second, and the third, and...

These students struggle to keep up because they have holes in their mathematics education. While they see the need to go back and learn what they have missed, they fail to do so. Most of them use time as an excuse. While some students claim that it takes too long for them to catch up, others believe that the class does not allow them time to catch up. As a result, they fall behind and do not understand the mathematics they currently learn. They eventually give up.

Mathematics as a Race Against Time

Students often complain that mathematics is difficult because mathematics teachers go over topics too fast. Students are not given enough time to absorb and digest the material, and are left to figure it out themselves when they get home. Vivian believes that she is smart enough to understand mathematics but may require more time to grasp the concepts than her fellow classmates. She believes that if mathematics classes could go a little slower, she could understand the concepts and enjoy mathematics. A colleague once described mathematics classes as an expensive bill. Because mathematics teachers go over the curriculum too fast, students don't understand the concepts, and they end up hiring mathematics tutors.

V: When we try to learn something, and some people, like, they see it on the first few and like, oh, look at that it's so easy. You have to do this and this. And when I see something, or when I hear an exercise, I first have to think about it, a long time, and I don't get it as fast... Everybody goes so fast. And then, I am confused, and it's so much every class. We get new stuff, and it always gets harder and when you don't get it the first class, you won't get it the second, and the third, and...

R: And you feel a little fall behind.

V: Yea, yea, and so I usually get like, a C, or C- or something. And not always but. And I have to take extra lessons, like, every week. Not so much fun. [laugh] But yea, I mean I have a nice teacher, but it's always so hard so...

When asked what she would change about mathematics class and the mathematics she does in class, Vivian simply wants class to go slower. Making mathematics enjoyable has nothing to do with how difficult the topics are, but how fast the teacher teaches. Vivian believes that she is mathematically capable and she could be successful if the pace is slower. Unfortunately, class goes too fast and she has a difficult time keeping up. She ends up hiring a tutor and doing extra mathematics exercises. It defeats her self-esteem, and mathematics becomes a torture.

V: Yea, I think, if it would just be a bit slower... like, if we don't go so fast, and yea... I have to get extra lessons from my extra teacher, I have to get it on my own, like, and I have to pay it on your own. So, it doesn't make sense at school, cuz usually the teacher should explain it to you, and so... if somebody would just explain it to me, after a few times, I would get it. I mean, I'm not stupid at all. It's just at the first time, I, yea... I mean some people, they just need a bit more time than other people, and I think in math, I just need a bit more time to get it.

Other than Vivian, Diane and Elle also commented on time when I asked them what they would change if they were to complete the principles of mathematics 10 again. They feel that the secondary school mathematics curriculum is so packed that it is a race against time. Similarly, Fiona feels that she would enjoy mathematics more if class is not rushed and she is given time to "figure it out".

Caroline finds that she learns better when she goes to her tutor. Other than receiving more one-on-one help, there is no pressure on time. In class, Caroline feels that the teacher is not able to provide her with the help she needs, and the class does not wait for her to understand the lesson before moving on.

C: Like, okay, I used to be ok, I used to be good at it, until I stopped going to tutor. Cuz tutor was probably my only hope of passing math.

R: What do you do at the tutors?

C: They actually teach you how to do it... and they have more time to show you and they have more one-on-one time. When you are here, the teacher has so many people to take care of and stuff.

R: Okay. So what if in mathematics class, you get more one-on-one time, and let say there is no time limit on the class.

C: That's good. It would help me pass. Yea.

Steve is another student who finds that the principles of mathematics classes go too fast for him. He felt that when he was enrolled in the principles of mathematics class, he slowed everyone down, and he was the sole reason the teacher was holding back the group.

- S: ...Yea, yea they were all like, I was in Montessori, so we have all been a close group for like lots of years. We weren't gonna actually tell someone they were like, you are stupid or whatever. But they were like, you could tell, like they were, in the class we were in, in Montessori they had to, they had to take it a lot more, we were all in one group, so they had to do all one level. They couldn't, like, it was slowed down for us. There were people in the group who were like "oh my gosh, you don't understand this still", like she's still on this section when we should be ten sections ahead. Then there some people who were, who could be going faster but we were doing better because we were going slower. And then there were people like us. If we were doing it at the pace we were doing it, we'd be in the 15%'s, or 10%'s or stuff. So...
- R: So that wasn't a very good feeling, even though all your friends accepted you.
- S: Yea, it wasn't a good feeling, knowing that I was the sole reason they were holding back the whole group that sort of thing. Um... yea.

In these cases, students feel that the pace of the lessons contributes to their failures in mathematics. Because the curriculum is packed, class moves on quickly, often before they are ready. They feel that class is rushed, and not enough time is given for them to fully grasp and digest the materials presented in class. They claim that if class slows down and allows them time to understand and grasp what they currently learn, they would enjoy mathematics better. Meanwhile, some of these students also use time as an excuse. When they fall behind, it requires them to put in extra time and effort to succeed. However, many students would rather spend time on things other than mathematics. In order to remove themselves from the negative emotions associated with falling behind and failure in mathematics, these students blame the pace of the class and claim that there is no way to catch up.

Mathematics as My Own Method

Sometimes mathematics teachers show the class one or two methods to solving a problem but do not allow students the time to explore other alternatives due to time constraints.

Although these methods of solving the problem presented by the teacher may be the most efficient and easy to understand, they do not provide students with the chance to explore and understand the topics. Therefore, students often believe the teacher's solution is the only way to solve the problem and they have to follow this specific method in order to get the correct answer (Schoenfeld, 1988; Garofalo, 1989). Students often end up not fully understanding the concepts, although many can do the questions and perform fairly well on tests and quizzes. On the other hand, there are those who need to fully understand the concepts before they can do the questions related to the topic. Diane is one of these students. When she was enrolled in the principles of mathematics class, she found class overwhelming, felt lost and had no idea how to do the assignments. The more teachers tried to explain things, the worse it became for her. She believes that she could have understood it more if she was allowed to play with the mathematics, and ask questions when she needed help.

D: ... This mathematics class is pretty easy. Other mathematics classes, it's kinda like, I go there, and then they talk, and I'm just like, oh, okay... they write a bunch of numbers on the board, and I go... oh, okay... and I go home, and I forget about it... like, whatever...

D: Like, I could figure things out, but I get confused when people tell me different things kinda thing.

In the essentials of mathematics class, Diane is given a lot of time to explore a concept because the curriculum is not as packed as principles of mathematics. She is also encouraged to think outside the box and is not bound to solve problems using one single method. It allows Diane to work with her friends, help each other out, and explain to one another the various possible methods to solve the problems, which helps everyone in their understanding. Mathematics feels less overwhelming and more understandable.

Diane's feelings towards mathematics remain the same when she works with her tutor because her tutor gives her time to explore and understand the questions, and allows her to work out the answers in her own way.

D: I found tutoring, when I get tutors, basically we just get someone next to us, and we did the work and when we have questions, we ask right? I found that like, a lot easier to do than mathematics class. It's just like, you figure it out, but you can't, you can ask, and they teach you how to do it. And then it's like, really simple I guess. It feels simpler, but not really.

R: It's not right?

D: Yea, it's the same thing, but it feels simpler.

When there is only her tutor and herself, she is not afraid to make mistakes and ask questions because she is not being judged by her peers. No one is going to ask why she does not understand and why she needs so much time. She feels safe to try new things and is not afraid to take risks.

When students are allowed to explore mathematics, they often find mathematics fun and interesting. They enjoy the process and pick up the ownership of their learning. In a slope measurement exercise, students were asked to measure the slope of a flight of stairs in school and the sidewalk outside school given only a 10" ruler. Mia's group was creative in approaching the task. Instead of measuring each step of the stairs, Mia's group compared the height of the stairs to her height and measured the overall run. The group understood the concept of slope, and enjoyed the task. The exploration frees mathematics from rules and restrictions since the group were not bound to do mathematics in a particular method. As Mia suggests, mathematics becomes an adventure.

M: Oh yea. I like it. It's really challenging. ... You gotta play around with the stuff too, like problem solving, you gotta play around with the numbers, try to solve, and then um... The slope thing was kinda hard too, but then once you get it, you just go on it... like a roll.

When students are allowed to explore and spend time on mathematics, they are often able to find their own way to solve mathematics problems. Their understanding deepens as they make discoveries, and they pick up the ownership of learning mathematics. On the other hand, when students are restricted to solving mathematics problems using specific methods, they stop exploring and look for rules to follow. It also removes the ownership of learning from them.

Mathematics as Computation

In general, the students I interviewed define mathematics as numbers, computation, equations, and formulae, which is similar to the misconceptions pointed out by many researchers (Garofalo, 1989; Mtetwa and Garafalo, 1989; Crawford et al., 1994; Hekimoglu and Kittrell, 2010). Students' mathematics knowledge and experience are very limited to their classroom experiences. For example, John and Fiona define mathematics as numbers calculations that involve lots of numbers.

R: Okay, let's backtrack a little bit. What do you mean by math?

J: Lots of numbers.

F: Math is calculating lots of numbers.

Similarly, Diane believes that mathematics involves numbers and formulae, where she plugs numbers into a formula to determine the answer.

D: It's just a formula, cuz it's just what mathematics kinda is. It's a formula, you plug in numbers, you solve it right? So...

R: What about the other stuff we do in class? Like the puzzles, is that math?

D: No, I don't really count that as math. I mean, it's like, mathematics related strategic kinda thing, cuz people refer to logic as mathematics kinda thing, right? But I don't really include that as math, cuz it's not a bunch of numbers, right?

It is unfortunate that Diane defines mathematics with a narrow definition. Similarly, Elle believes that mathematics means numbers, equations, and “finding an answer using numbers”. This is another typical misconception many students hold towards mathematics (Schoenfeld, 1989; Spangler, 1992; Chinn, 2009; Hekimoglu and Kittrell, 2010).

R: What is your definition of math?

E: Numbers, the first that comes to my mind is numbers.

R: Okay.

E: Numbers, and like equations, like numbers, and things like that.

R: So, simply numbers and equations?

E: Ahuh.

R: Anything else?

E: When I think of math, I just think of finding an answer using numbers.

Both Diane and Elle believe that mathematics has little relevance outside the classroom. They feel that the mathematics they learnt in the principles of mathematics class is divorced from reality.

D: You know, like English, of course you are gonna use it everyday right? You are talking right? And you know that you are gonna use it. Mathematics you, oh, when am I ever gonna use math? Well I know addition subtraction, I know how to do like, you know, simple taxes and stuff.

E: It doesn't really relate to me, like I can't use it, really. I'm not really like, other than calculating clothing tax, like, I'm not... I dunno, I just haven't like, seen, other than calculating taxes, buying cars and stuff like that. I just haven't seen the need for it yet.

Similarly, Caroline defines mathematics as numbers, but also relates mathematics to failure.

R: So how do you define math? Like, to you?

C: Ugly. I have phobia of numbers.

R: Is mathematics just numbers then?

C: Well, for me lately it has been.

R: Lately?

C: I mean, I mean the past two years. It was always numbers in grade, grade 10, and 11. Grade 11, oh my gosh, failed grade 11.

It is interesting that Caroline calls mathematics ugly. If mathematics is ugly to Caroline, it could be pretty to someone else. Caroline's definition of mathematics is based on her recent negative experiences with mathematics, which in turn is based on the mathematics classroom. The grade 10 and 11 mathematics curriculums involve a lot of numbers and computation, which can be "ugly" to students such as Caroline. Since she experiences mathematics mostly in the classroom, her definition is narrow and negative.

Students' experiences with mathematics contribute to their definition of mathematics. Positive experiences lead to positive definitions, and vice versa. The students I interviewed were only able to provide a narrow definition of mathematics due to their limited experience with mathematics. Students experience mathematics mostly in the classroom. If a teacher focuses on the mathematics curriculum, his/her students' definition of mathematics is curriculum based. As the teacher provides his/her students with mathematics experience outside the curriculum, their definition of mathematics broadens.

Mathematics as a Self Fulfilling Prophecy

"Whether you think you can or you think you can't, you're right." Henry Ford

Many students feel defeated in mathematics. Because of their many negative experiences in mathematics, they equate mathematics to difficulties and failures, and presume success is rare if not impossible. They believe they are mathematically incapable.

Caroline believes that she can never succeed in mathematics although she was successful at a younger age. She currently finds mathematics very difficult and believes that no matter how hard she tries, she will fail. She has a low sense of self-efficacy and hides from challenges. She focuses on her deficiencies rather than her capabilities, and does not believe she is mathematically capable. Her behaviors are in parallel with many researchers' descriptions of students with a low sense of self-efficacy (Schoenfeld, 1988; Mtetwa and Garafalo, 1989; Bandura, 1997). Caroline has already decided that she is going to fail mathematics before she begins.

C: No, I just don't like math, because it's like, it's, I think it's the way I got taught, like, it was just so complicated. And I didn't understand it, even when they try to teach me over again. I didn't get it. So, no matter how much I try, it still wouldn't go through my brain, so I dunno.

Caroline fails mathematics as she expects herself to. While Caroline believes she will never succeed, Andy and Kevin believe they are only successful because the essentials of mathematics curriculum is easy.

Andy thinks he has a lot of difficulties with mathematics. In reality, however, he is capable and does well in the essentials of mathematics class. Unfortunately, he does not believe in his abilities and attributes his success to the easy mathematics curriculum.

R: But you do fine in this class.

A: Do I?

R: I think so.

A: Oh because this class is designed for stupid people.

R: No...

A: So it's like really easy to pass.

Similarly, Kevin believes the easy curriculum is the sole reason he is successful in class. He does not believe in his abilities and considers the work he does in this class "grade 3 mathematics", and does not compare to the mathematics his friends do in the

principles of mathematics class. He believes that he is not capable compared to his friends who are enrolled in the principles of mathematics class.

K: This mathematics class, I think the mathematics we learn is like, grade 3 mathematics or something.

R: Really?

K: Yea. The mathematics like all the grade 11's are doing are much harder.

Besides Caroline, Andy, and Kevin, Vivian also focuses on her mathematics deficiencies rather than her abilities.

V: I hate [math] since grade one.

R: How come?

V: I dunno. I always am bad at math. And I always, in grade 3, I always had to do extra exercise everyday, 3 extra exercises for my math, cuz I am so bad. Like text exercises, like the text and you have to turn the exercises.

R: Like drill exercises?

V: Yup. I hate it.

Vivian expects herself to struggle with mathematics. Based on past experiences, she takes a long time to understand, and needs extra help and practice in order to grasp the mathematics taught in class. She believes mathematics is difficult, and she will not get it on the first try. As Wigfield and Meece (1988) point out, this behavior is typical in students who suffer from mathematics anxiety, they worry and believe they are defeated before they begin.

V: When we try to learn something, and some people, like, they see it on the first few and like, oh, look at that it's so easy. You have to do this and this and this. And when I see something, or when I hear an exercise, I first have to think about it, a long time, and I don't get it as fast.

Vivian finds success in the essentials of mathematics class. Similar to Andy and Kevin, this experience leads her to believe that she is only successful because the tasks are easy. She does not believe she has mastered difficult tasks, which is typical in

students with a low sense of self-efficacy (Bandura, 1997). Mathematics should be difficult.

V: Honestly I think I don't learn much [in this class]. ... [The stuff we do now] is so easy..... I mean, I'm totally bad at mathematics as well. But I think it's so easy. Like the smarties exercise, it was so easy. And I was thinking grade 11, we should do something more difficult.

Interestingly, Vivian does not always attribute her success to the easy materials. She only does that when the amount of success she experiences in this class is much more than what she expects. When Vivian experiences only a little bit of success but a lot of failure, she feels good about her success and believes that she is mathematically capable, because the amount of success and failure fall under her expectations. She believes she has mastered difficult tasks, and her self-efficacy rises. For example, when Vivian was enrolled in the grade 11 mathematics course in Germany, she did poorly on everything except for the geometry unit. Since she believes the mathematics course was difficult, mastering a task within the course means she is capable.

Vivian, Andy, and Kevin define mathematics as failure. They do not believe in their mathematics ability even though they experience success. Their sense of self-efficacy remains low. Fortunately, not everyone attributes their achievements to the easy course material. Some students believe in themselves when they do well.

When Steve was enrolled in the principles of mathematics course, he believed he was defeated before he began. He had low self-esteem, was frustrated and anxious, and felt that he did not know anything. Steve believed he would fail despite his effort. This is another typical trait in students with a low sense of self-efficacy (Wigfield and Meece, 1988). He saw mathematics as an opportunity for him to fail and embarrass himself

instead of a chance to learn and to succeed. At one point, mathematics was causing him so much grief he wanted to drop out of school.

R: Did you ever think of giving up when you were in regular math?

S: Oh yea. Tonnes of times, I said “mom, I wanna drop out of highschool”, “mom I hate math”, “mom I...” Like, I don’t want to be in highschool anymore cuz of math.

Steve felt that he was the outcast in the principles of mathematics class, the dumb kid who was holding back the class because he failed to keep up.

S: I remember I looked back on it, I felt upset, because I do not know the math. You know, it’s like I was borderline fail, and they were borderline A’s, or borderline A+’s sort of thing... so..... There were people in the group who were like “oh my gosh, you don’t understand this still”, like [the teacher] is still on this section when we should be 10 sections ahead. Then there some people who were, who could be going faster but we were doing better because we were going slower. And then there were people like us. If we were doing it at the pace we were [supposed to be] doing it, we’d be in the 15%’s, or 10%’s or stuff.

R: So that wasn’t a very good feeling, even though all your friends accept you...

S: Yea, it wasn’t a good feeling, knowing that I was the sole reason they were holding back the whole group that sort of thing. Um... yea.

After he switched to the essentials of mathematics class, Steve started to show more confidence and experience success. He believes he can do well and stopped labeling himself as the “dumb kid who does not know anything” although he still has to work hard to achieve his goals in mathematics. He pays more attention in class and starts to enjoy mathematics class. He does not feel as anxious and frustrated as he was in the principles of mathematics class. His shift in attitudes is related to his stronger sense of self-efficacy, as described by Op’t Eynde et al. (2006). Instead of hiding from mathematics, Steve is willing to take risks and give mathematics a try.

S: Um... when I got [to the essentials math] class, and we were doing algebra, I didn’t do great on that section even, but I think I did get it better, because like I was saying before, before when I was like that kid who didn’t know anything, I kind of, like, believe that too. [In my old class], there were

kids like perfect, like straight A's, and then there were kids where like B's, and then there was like me, maybe another kid or something like that. And we'd just be like, we'd be outcasts, the dumb people. And then [after I switched], I guess our competence was better, and you would have to listen, I would at least, actually listen, cuz I believe that I could actually do it. My self-confidence was high. And I thought that I was, well, I knew that I was one of the smartest kids in the class. And so because of that, I listened better, and I didn't labeled myself as a dumb-ass. It made a lot of difference.

Similar to Steve, Mia has been struggling with mathematics since a young age.

When she was enrolled in the principles of mathematics 9 class, she found mathematics difficult, even with one-on-one help. She thought she was incapable. She struggled and failed all three terms. It was a frustrating experience. Therefore, she joined the essentials of mathematics program in her grade 10 year. She finds success in the program. Unlike the students mentioned above, Mia does not feel she is successful because the material is easy. Rather, she feels that mathematics magically becomes easier and that she learns more efficiently in the essentials of mathematics program. Unlike when she was in principles of mathematics 9, she now believes in her abilities.

M: Ever since elementary school I've been struggling with math. But then, um, once I hit this essentials program, I think, like, I got to know more stuff.

R: Oh, what do you mean?

M: Like, I figure out how to do, how to solve all the problems, and, like, you know, do all the, like, equations out. In regular classes, it was kinda different, cuz they will give you the work, like they explain it once, and then they give you the work to do. And then I wouldn't understand how to do it even I got one-to-one help. But then in the essentials, I find it a bit, like, totally different. Like it's more, I feel like, more, um, information I get, how to do stuff.

In general, the curriculum from the essentials of mathematics stream is easier than the principles of mathematics stream. However, some topics overlap the principles of mathematics 9 and essentials mathematics 10 and 11 curriculum, including coordinate geometry, trigonometry, algebra, etc. Mia's success in essentials mathematics 10 and 11

could be a result of her learning the topics for the second time. However, it is more likely that she is successful because she believes in herself. As Mia experiences success in mathematics, her self-efficacy rises. She believes that she is smart now, but not when she was enrolled in the principles of mathematics 9 class.

R: Essentials 10 is not easy.

M: I found it easy.

R: With the sine, cosine stuff though. That's the regular 9 math.

M: Yea...

R: So what makes the difference?

M: I dunno, I, I just found it easier, a bit easier for me to do all the work.

Similar to Mia and Steve, Diane also felt overwhelmed in the principles of mathematics class, but is able to tolerate the essentials of mathematics class. Diane had negative experiences with the principles of mathematics program and believed mathematics is not for her. She felt defeated by mathematics. However, when she joins the essentials of mathematics 11 class, she experiences success, and begins to believe in herself. Just like Mia, Diane feels that mathematics becomes easier in the essentials classroom, although she admits it is the same mathematics.

R: But we do the same thing?

D: Yea... but, I guess it's just like, you know, the less you use to explain it, the easier it is to understand it kind of thing. I dunno if that makes sense.

R: What do you mean by that?

D: Cuz in regular mathematics class, right, when you teach division, you go into like, you know, like, all the steps, in like, blah blah blah... like, how to do it. Here, it's like really clear.

When students have struggled with mathematics since a young age, struggling and failing become the norm. They believe they are bad at mathematics. Poor performance is something they expect when dealing with mathematics. It is a self fulfilling prophecy. Students struggle and fail because they expect themselves to struggle and fail. This belief contributes to students' negative relationship with mathematics. They focus on their

weaknesses rather than their potentials (Schoenfeld, 1988; Mtetwa and Garafalo, 1989; Bandura, 1997), and do not believe they can succeed (Op't Eynde et al., 2006). As Bandura (1997) points out, students' performance fluctuates depending on their self-efficacy beliefs. As students' sense of self-efficacy lowers, so does their performance, because their sense of self-efficacy greatly influences how they approach a task and therefore their performance. When these students fail in mathematics, it further strengthens the belief that they will fail mathematics, and it destroys their self-esteem and their sense of self-efficacy. Therefore, mathematics, in this case, is not necessarily the cause of failures. Students relate mathematics to disappointments and struggles because they believe their mathematics performance is poor. On the other hand, as students master what they believe to be difficult tasks, their self-efficacy rises (Bandura, 1997). They feel better about themselves and their mathematics capability. They also become more confident and are more persistent when they face obstacles. As they begin to believe in their mathematics abilities, stop relating mathematics to struggles and failures, and their relationship with mathematics improves.

Mathematics as Successful Performances

Many students are performance goal oriented (Hannula, 2006). These believe the lack of success is a sign of incompetence, and often look for opportunities to demonstrate their abilities.

Vivian, Diane, and Mia are typical performance goal oriented students who enjoy mathematics when they are successful but hate it when they perform poorly. However, they do not actively seek opportunities to show off their talents. Vivian attributes her

success to external factors such as the curriculum when the amount of success falls outside of her expectations, but believes in her abilities if the amount is within expectations. She enjoys her achievements and relates these accomplishments to “getting it” and “understanding it”. She enjoys mathematics when she “gets it” and “knows what to do”, but hates it when she feels lost.

V: Yea. I don't understand. I always have, I always take so much time... to get it. Yea.

R: But do you find mathematics ever interesting at all?

V: Yup. Sometimes it's good. If you get it, then you know what to do, then it's fun, but that's not very usual (laugh), or not very often.

Similarly, Diane enjoys her “genius moments” in mathematics class when she “gets it”, but dislikes it when she does not know what to do. Mia loves mathematics when she experiences success, but hates mathematics when she gets stuck and feels lost.

M: Sometimes I like math. And when I get really really stuck I just feel like I hate math. I... it's an on and off kinda thing for me.

Other than these three students described here, Caroline and Steve are also performance goal oriented. However, they do not simply enjoy success and hate failures. They also actively seek opportunities to showcase their success.

Caroline considers a question dumb if she fails to answer it, and uses the phrase “dumb question” to hide the embarrassment. However, the question becomes a smart one if she knows the answer. She becomes super smart and shows off her skills to the people around her.

R: So what if you get it right? Would you call it a dumb question?

C: Oh if I got it right? Then I'm like, hey man, I'm super smart.

R: So then that's a smart question.

C: Yea.

Similarly, Steve looks for opportunities to show off his skills in mathematics class. However, he also avoids negative judgments, which I discuss in the next section. He shows his friends his solutions to problems, and tells people if he gets a good mark, even if it is only a worksheet. When I asked him what he would do if he can do all the “difficult” math, he said he would act like a hotshot, and show off his skills to everyone he knows.

S: If I knew how to do this. I’m probably all for it. Yea, well, honestly, if I wake up tomorrow, and know how to do that stuff, I’ll act like a hotshot, I would. Like I said before, today our society label you. That’s how people are labeled.

Elle and Kevin’s enjoyment of mathematics also depend on their success. They are both performance and ego-defensive goal oriented. Elle has low self-efficacy and believes that her chance of success in mathematics is very slim. In order to avoid negative judgments, she avoids challenges and shows low perseverance in the face of obstacles (Dweck, 1986; Hannula, 2006). When she struggles with things in general, she becomes frustrated and gives up easily.

R: Do you like mathematics in general?

E: Only when I get it. Only when I understand it.

R: Why is that?

E: Um... cuz I like, cuz I know I’m doing well in it and I understand it. I don’t like it when I know I’m struggling, and it’s frustrating and I’m like, no point. And I don’t like it.

Similarly, Kevin has low self-efficacy and gives up easily. However, he does not avoid mathematics like Elle. He feels that the lack of mathematical skills embarrass him and therefore believes he should know some mathematics and “stay in contact” with it.

From my observation, many students are performance goal oriented. They relate their enjoyment to their performance and success in mathematics. Therefore, their “love”

for mathematics often fluctuates. Typically speaking, when students experience success and attribute this success to their abilities, they enjoy mathematics and their relationship with mathematics improves. When students attribute their success to external factors such as the curriculum, they may still enjoy the feeling of success, but their relationship with mathematics does not improve because they do not believe in their mathematics abilities. When students experience constant failure, their relationship with mathematics deteriorates.

Mathematics as Sink High

Many students and parents consider the principles of mathematics class the “normal” mathematics class, and the enriched mathematics class the “smart” class. Unfortunately, that puts the essentials of mathematics class as the “dumb”, or “stupid” mathematics class. Since universities do not accept the essentials of mathematics class as an entry requirement, many students and parents alike believe that the essentials of mathematics class is a dead end. Although they understand that the essentials of mathematics program suit them better than the principles of mathematics program, students often refuse to be enrolled in essentials of mathematics classes. They would rather do poorly or fail in the principles of mathematics class than do well in the essentials of mathematics class.

Unlike typical ego defensive goals oriented students described by Dweck (1986) and Hannula (2006), Steve does not shy away from challenges in order to steer clear of failure and negative judgments. Rather, he refuses to be labeled as incapable by declining the essentials of mathematics program. He was afraid to be labeled as a dumb kid. It was a catch 22 because Steve was doing poorly in the principles of mathematics

class and felt that he was labeled as the dumb kid in class, but he also felt that he would be labeled as one if he is enrolled in the essentials of mathematics class.

S: It also suks that essentials mathematics can get you labeled as “not as good” sort of thing. And how there’s the thought of it always, when I was in regular math, oh essentials math, oh my gosh, life is over.

Steve feels that mathematics destroys him because others measure how smart he is based on which mathematics class he takes and the marks he gets. Although Steve feels that this is not fair, it is the reality he deals with on a daily basis.

S: I mean, you have to take a mathematics course because people think mathematics is the only way that you can be labeled as a smart person, or like, have brains. But like, it’s the stupidest, like, ... It’s obvious, like, I mean, you look at somebody and they are doing good in courses like, the one course that everyone “Oh, how’s your math?” “Oh, I’m getting A’s in English and stuff, but my mathematics is at 60%.” “Okay, you are not...” yea...

When Steve transferred out of the principles of mathematics class in the middle of the year, his friends asked loads of questions. Steve felt that he was leaving class because he was not smart enough to be in the “normal” mathematics class, and that hurt him.

S: I wasn’t happy, so basically it was a hard decision, like it was kinda an embarrassing decision.

R: Why embarrassing?

S: Cuz I was in Montessori at the time, leaving the program, cuz I had to, it was kinda like, why are you leaving? Oh, because I am not smart enough.

R: But it’s not about how smart you are.

S: It wasn’t. I never actually said that, but then that’s what I felt. And that’s why it was harsh.

Eventually, Steve switched out of the principles of mathematics class into the essentials of mathematics program because he was not receiving the support he needs. He started to believe in himself, experiences success, and enjoys mathematics much more than before, as I have discussed in “Mathematics as a Self Fulfilling Prophecy”.

Along with Steve, Kevin also avoids negative judgments. He believes that although mathematics is not applicable in his life, he should still learn and know some mathematics. He is extrinsically motivated. He wants to learn mathematics in order to avoid looking bad in front of his friends because he lacks mathematics skills.

K: Yea I don't like them but we still have to do them though right?

R: But if you have a choice...

K: Oh if I have a choice? Well yes. Because we need to learn more.

R: But you said the angle stuff is not useful.

K: It's not useful but, better to know it.

R: Why?

K: I dunno, cuz you won't look stupid when someone asks you.

Steve and Kevin defend their egos by avoiding negative judgments from their peers. While Steve refused the essentials of mathematics class at first to avoid being labeled as a dumb kid, Kevin does not want to be embarrassed because he lacks mathematics skills. Both of them feel that they are judged by others based on their achievements in mathematics. Therefore, they look for ways to protect their ego. Steve transferred into the essentials of mathematics program and labels himself as the smarter kid in class, and Kevin wants to learn mathematics so that he has some mathematics skills.

Mathematics as One Answer

Students work on many numeracy tasks¹⁰ in my mathematics classes. When I tell students that there is more than one possible answer to a numeracy task, many would

¹⁰ In general, these numeracy tasks have no single correct answer and may or may not relate to the curriculum. Students often work together, apply their mathematical knowledge, and do some research outside class in order to do finish these questions. See Appendix C for an example of a numeracy task.

look puzzled. Many students believe mathematics to be black and white with no gray areas. Therefore, it is impossible to have more than one answer to a question.

For example, Elle strongly believes the goal to any mathematics problem is to determine the answer. She finds that while she works hard and tries various methods, only the answer counts at the end. The process does not matter. There is only one answer to a mathematics problem, which is presented in the form of numbers. Elle defines mathematics as “use the numbers, find the answer”.

E: When I think of math, I just think of finding an answer using numbers. . . . I dunno, math’s just . . . find the number. Use the numbers, find the answer . . . It’s like, mathematics and numbers, and like, there’s always just one answer and like, there’s never like, a “what if”, or like “but”, just one answer.

The format of the assessment tools may be a contributor to Elle’s misconception. Elle finds that she is often given multiple choice questions in review packages and on tests. Since these questions give her a point if she gets the correct answer and no point if she gets it wrong, the process of finding the answer does not matter.

Elle hates the idea of a single answer in mathematics. She feels that mathematics, unlike English, has no room for exploration or an alternative answer. There is no “what if”, or “but” in mathematics. Mathematics is too black and white, and gives no room for negotiation. She feels that if she cannot determine the answer, she will fail.

E: If you don’t find [the answer], you are screwed. It’s not like English, like “but”, “if”, ...

Similar to Elle, Steve was extremely frustrated and overwhelmed when he was enrolled in the principles of mathematics class because there was too much focus on the answer. He lacked understanding, and struggled to memorize the “tricks” his tutor gave him to determine the correct answer.

- S: Every now and then I have tutors so they would, now and then one of them would come up with a really good trick that I could actually use and get the answer right but...
- R: But that's not really understanding...
- S: No. Yea, a trick, but I never actually understand the reason of what stuff was. And even today I still don't get like, the numbers and stuff, like, and the letters...
- R: That really suks...
- S: Yea, and, it's really frustrating cuz, like, I was just like, screw this, I'm outta here.

Other than Elle and Steve, Vivian also believes that mathematics is answer oriented. According to her, mathematics is fun when she gets the correct answer. When she gets it wrong and has no clue what is going on, however, mathematics is not so much fun.

John and Fiona made similar comments. They believe mathematics is primarily answer oriented and finding the answer is the key to becoming successful in mathematics.

- J: Math's just crazy sometimes.
- F: Cuz you don't know the answer.
- R: And that's when you don't like it.
- F: Yea. Yea.

Many students focus on finding the answer instead of the process, and believe that there is only one answer to a problem. This misconception of "one single correct answer" drives many away, because many believe unable to find the correct answer means failure. Students' narrow experiences in mathematics have contributed greatly to this misconception, because sometimes the mathematics classroom puts too much focus on the answer, and not enough focus on the process.

Mathematics as Elementary and Secondary

A couple of students whom I interviewed told me that they love mathematics until they hit grade 8. There seems to be a huge difference between elementary and secondary mathematics. For example, Andy feels that elementary school mathematics is rather simple and is meant for students to understand and to succeed. However, secondary school mathematics is much more complicated, because it requires application and the ability to link together various mathematics concepts. Therefore, he believes secondary school mathematics is notably more difficult compared to elementary school mathematics. He compares elementary mathematics to a simple puzzle with only a few puzzle pieces, and secondary mathematics to a large puzzle with many complicated pieces that are related to each other in many ways. Andy also feels that he is left alone to figure out the relationships between these puzzle pieces.

A: In grade 7, you know in elementary school, I would get a C+ average, so it wasn't too bad, right?

R: Is there a difference between elementary mathematics and highschool math?

A: [pause] Yea. Cuz highschool is a lot more complicated.

R: What do you mean by more complicated?

A: The stuff in elementary is very simple and basic right? They are meant for you to understand. But in highschool you have to think beyond and you have to like, you still have to use the basic steps, and put together with the other basic steps that you learned.

R: So more like linking concepts together.

A: Yea. Like in elementary school there are a couple of puzzle pieces and you put them together. But when you get to highschool it's like, all puzzle and you have to put them together. And you have to use the knowledge that you've learned in your previous years. And I know a lot of kids here who actually forget the stuff they've learned in the previous years.

Students often experience difficulties when they are asked to apply or combine their knowledge to solve mathematics problems because they forget what they have learned. They may also fail to apply their skills because they did not fully understand the

material in the first place. For example, the difficulty in mathematics often arises when students learn fractions operation. In fraction addition and subtraction, for example, students are required to use multiplication to find a common denominator before they can add or subtract. After students have finished adding or subtracting, they need to be able to divide in order to reduce the fraction into its lowest terms. This can all happens in a “simple” fraction addition or subtraction question involving only two terms. Now imagine a long fraction order of operations question. If students fail to link all they have learned previously to what they do now, or if they forget what they have learned previously, they can fail badly.

Similarly, Diane experienced some success in elementary school, but suffers from failure now. She admits she has a weak foundation in mathematics, and does not actively seek help, especially when she was in the principles of mathematics program.

R: Can you tell me a little bit about you and math? Relationship wise.

D: It's not good. We're kinda like off and on, more off than on.

R: More off than on, so there are some on time?

D: Like in elementary school, but after elementary school, I kinda like went downhill in math.

Andy and Diane are not the only ones who claim there is a difference between elementary and secondary mathematics. I have heard many students complain about secondary school mathematics. Many of these students used to love mathematics in elementary school, but find secondary school mathematics to be a big turn off. Diane was not able to fully articulate what contributes to the difference between elementary and secondary school mathematics during the interview. However, listening to her story led me to believe that in her case, the difference between elementary and secondary mathematics is closely related to the curriculum, the pace of the class, her inability to

apply her mathematics knowledge due to her weak foundation in mathematics, and the restriction of solving problems using specific methods.

Mathematics as Avoidance Behaviors

I have noticed that many students actively avoid mathematics. Some of them leave mathematics to the last thing to do, others simply do not want to have anything to do with math. For example, Elle actively avoids mathematics. She would even give up her dreams and “scale down” what she wants in order to steer clear of mathematics. She has low perseverance, and gives up easily when she gets stuck.

R: What if you absolutely need the “useless math” in order to go into the college that you want?

E: I may have to scale down what I want.

As discussed in “mathematics as building blocks”, Elle feels that there are too many gaps in her mathematics education, and these gaps are preventing her from becoming successful. Therefore, she gives up and avoids mathematics.

E: ... I went and got tested, so then, when they come back, since I’ve missed some obvious things, even if I wanted to do it, I couldn’t do it, cuz I don’t even know half of fractions.

R: So there are all these gaps and holes you need to fill, before you can do the...

E: The more advanced stuff.

Giving up in mathematics prevents Elle from feeling incapable and incompetent. It also removes her from the negative emotions associated with mathematics. Instead of trying hard and failing mathematics, Elle steers clear of mathematics. If she does not do mathematics, she will never fail mathematics because of her incapability. And when she does fail math, it’s because she hasn’t tried yet, not because of her incompetence.

Problem solved.

Andy solves his problem with mathematics similarly. In Andy's case, he leaves mathematics to the last thing to do. When he finally has to deal with mathematics, he gives up and does not bother with it. He acknowledges that he has been experiencing trouble with mathematics since a young age, but believes that he is capable at mathematics if he tries. He claims that he has never failed mathematics badly, when he fails mathematics, he is always a few percents shy from passing. However, he knows deep down that he has trouble with mathematics. Since the two beliefs contradict each other, Andy chooses not to face mathematics so that he won't contradict himself.

A: [long pause] Mathematics is something that I go to school with, and struggle with. I've never really failed hard, like every time I failed I was in the forties, like high forties right, but it was always the last thing that I would do, out of like all the homework. And if I kept it for the last, like screw it, I'm not going to do it.

R: Why do you think you would leave it for the last minute?

A: Because it was the one with most, it was the most difficult out of, like, all the subjects. And I knew it would take the most time.

R: Therefore you leave it to the last.

A: Yea.

Andy also lacks perseverance. Similar to Elle, he gives up easily on mathematics when he gets stuck. He acknowledges that mathematics requires a lot of work and unless he is willing to put in the effort, he is not going to succeed. Since he does not want to put in the effort, he sweeps mathematics under the carpet so he does not need to face it.

Similar to Elle, Andy believes that he only fails because he hasn't put in the effort, not because he is incompetent.

Caroline is another student who actively avoids mathematics. However, she does not avoid it because of the amount of work. Caroline hides from mathematics to prevent possible embarrassments and feeling dumb.

C: I avoid it because I know I'm not good at math, so then I'm saving myself from embarrassment. That's why I avoid mathematics questions cuz if I get it wrong, and I, you know, it's embarrassing. People ask you, they expect a good answer right?

C: Yea. When I get something I feel good, but when I don't get it, I feel dumb. That's why I don't want to try doing the work.

R: Okay. So when you don't get it you feel dumb. Then you don't want to try, cuz you feel like kinda pointless?

C: Yup. Even if I try doing it, and I don't get it, then I give up.

Instead of confronting their difficulties in mathematics, Elle, Andy, and Caroline choose to avoid mathematics and shift the responsibility away from their mathematics abilities. They believe that if they don't try, they won't fail because of their incompetence. It is a temporary solution, but it satisfies their immediate need.

Mathematics as Chores

Students are often forced to take mathematics courses because they serve as graduation requirements. When students do not see any connection between mathematics and their lives but are forced to take mathematics courses, mathematics becomes a hurdle keeping them from their dreams.

Andy describes mathematics as “numbers on paper, where you sit down and do work”. He finds mathematics “tedious”, and compares mathematics to “chores”.

Mathematics is boring, and he would rather be “doing things”.

A: ... If you don't have an interest in it, than you won't wanna do it right? I don't really have an interest in it. Like, I would rather be doing things.

R: Do you like math?

A: [pause] not really. [pause] no.

R: Why is that?

A: Cuz... I don't find it enjoying. I don't need towards that area of academics. So. It's just me, some individuals may like it right? But I don't.

Andy does not hate seatwork, but it is not something that he chooses to do either. He does not have an interest in mathematics and finds it boring, especially when mathematics restricts him to sit down and work.

A: Well I don't have a grudge on it or anything. It's just something that, it's not like "wow", mathematics class. It's just something like oh yea... I have this. After this, this is over. So yea... and your class is only an hour and 15 minutes. Let it be done.

R: Now if you have a choice, would you take a mathematics course?

A: If I have a choice? And I don't need it in post secondary? No.

Vivian is another student who finds mathematics involves too much seat work. Since she is weak at math, she hires a tutor for extra help. She also does drill exercises, which she hates but believes will help her to do better in mathematics. These exercises are similar to the chores Andy describes. They are "numbers of paper, where you sit down and do work", but do not necessarily help with understanding.

V: I dunno. I always am bad at math. And I always, in grade 3, I always had to do extra exercise everyday, 3 extra exercises for my math, cuz I am so bad. Like text exercises, like the text and you have to turn the exercises.

R: Like drill exercises?

V: Yup. I hate it.

Similar to Andy, Steve sees mathematics as a barrier between him and his secondary school diploma. Steve does not see the connection between the mathematics he learns in class and his daily life. Just like Andy, Steve takes mathematics courses to satisfy his graduation requirements. Mathematics, in this case, is the hurdle that keeps Steve, Andy, and many others from graduation and from their dreams.

Mathematics as Lack of Connections

Finding a connection between what students learn and what they enjoy is crucial to effective learning. Without a connection, students hardly find what they learn meaningful. For example, Diane has determined mathematics has very little, if anything, to do with her dreams of becoming an artist. While she agrees that mathematics can be useful to those who need it, she does not care for mathematics because she does not need it. She feels detached from mathematics and fails to see how mathematics relates and connects to her. Therefore, she is not motivated to improve her relationship with mathematics.

D: Well... like, not that math suks, but, I know mathematics is useful, like society or whatever, but I don't care for it, probably cuz of my career choice.

R: What do you mean by that?

D: Like... I don't feel like it's useful to me because of what I wanna do in the future. Like, you know, some people wanna be chemist, or like, architects, or whatever, they need mathematics right? Artist, it's just, you know...

Diane believes that one of the things that contribute to her detachment from mathematics is the mathematics curriculum. Diane feels that the principles of mathematics curriculum is abstract and detached from reality. For example, she believes there is no applications in algebra and trigonometry in her life because she only sees these mathematics in textbooks and on worksheets. She lacks the connection and feels that what she learns in class is meaningless.

Diane believes while the principles of mathematics curriculum consists of abstract and theoretical math, the essentials of mathematics curriculum is more practical, and includes mathematics that she can use in her daily life. She finds a connection and sees the potential of applying the mathematics she learns.

R: What do you mean by actual math?

D: Like, numbers and stuff. On the sheet, like, worksheet stuff.
R: But you do mathematics in the house project.
D: Yea, but it doesn't feel like math. You know what I mean, cuz like...
R: You like it better?
D: Yea, I like it better. Cuz people get used to like, sitting down, doing worksheets, right? But doing something like that, you are actually using the math. You see how it's being used. You feel like it's more useful and you want to learn it kinda thing. ... So like, when we are learning things like algebra, it's just, what are we gonna use it for, right? Or like, trigonometry, like, when am I ever gonna do this, right? It's just that if you are not going to go into a career like that, people are like, it's so useless right? When you are doing something like the house, you just like, oh, I see it now right? Like, architects use this for like, houses and stuff. Besides, it's a fun project anyway.

While Diane does not care for mathematics because she cannot see any use of it in her life, Andy shares a similar concern. He feels that the secondary school mathematics curriculum involves too much abstract mathematics that he cannot use and does not relate to. He needs mathematics to be hands on and practical in order to be enjoyable. He finds mathematics abstract, and defines mathematics as equations, trigonometry, geometry, and things that he cannot touch and use in life. The lack of connection causes Andy to "shut it" and give up when he experiences difficulties with mathematics.

R: Tell me a little bit about your relationship with math.
A: Um... Detached.
R: What do you mean?
A: I don't really have one with it. I know how to do additions, subtractions, multiplications, and the other one, ... division.
R: Why do you think you are so detached?
A: Um... I dunno. When you have trouble with it, you kinda, just shut it. Yea.

Andy calls the work he does in the essentials of mathematics class practical or unconventional mathematics because this mathematics does not involve many worksheets and equations. He finds this kind of mathematics tolerable, sometimes even likeable, because he is able to use and apply the mathematics he learns.

R: What about the stuff we do in this class? Do you consider it math?

- A: Yea. It's more practical mathematics to me. It's something that you can actually, like when you are teaching it's stuff that you can use later on in life, right? Like all the insurance things and all the taxes and everything we did. Like seriously why do we need to know learn those crap, pentagon crap, like those mathematics right? Like in my life when am I ever gonna use that? So a lot of people see it like, if you don't, like, they don't see practicality in it, why would you do it?
- R: So sometimes mathematics is just too distant, like, not useful.
- A: Yea. This class is a lot more practical.
- R: Does that make a difference in how you dislike math?
- A: Yea. Cuz if it's practical you would actually wanna learn it. Cuz you are like, oh, I can use it later on.
- R: But you still don't like it.
- A: I would say I like this mathematics class more than any other mathematics classes I had cuz it's useful.

Diane and Andy's comments are similar to Hume's comments on the Vancouver Sun (Hume, 2009).

If mathematics is ultimately the language of relationships, we never seem to get beyond the grammar and basic punctuation in the classroom. We reward students with innate aptitudes and marginalize those without at a time when adolescents are most self-conscious and their self-esteem is most vulnerable to a sense of public humiliation.

Imagine teaching English literature ... by requiring students to memorize the Oxford Unabridged Dictionary, grading them only on their ability to correctly spell the words they are required to memorize and on whether they can parse the sentences. Imagine teaching Romeo and Juliet by counting Shakespeare's use of bilabial fricatives and ignoring the big themes of passion, pride, love, jealousy and betrayal with which teenage readers most identify.

Many students believe that the secondary school mathematics curriculum is very abstract. Diane and Andy are not the only ones who fail to find the link between the mathematics they learn in principles of mathematics what they enjoy doing in life. Elle and Steve express a similar concern. Elle believes that she does not need to know the mathematics she learned in principles of mathematics because she does not see this mathematics outside the mathematics classroom. On the other hand, she finds essentials of mathematics useful, because she believes that she will need it in her future.

E: It doesn't really relate to me, like I can't use it, really. I'm not really like, other than calculating clothing tax, like, I'm not... I dunno, I just haven't like, seen, other than calculating taxes, buying cars and stuff like that. I just haven't seen the need for it yet.

R: What about the stuff we do in class?

E: The stuff we do in class include stuff that I need to know later on. But I feel that like, regular math, some of those things are not needed.

R: What do you mean by regular math?

E: I mean like, um, principles of math, I can't see how some of the stuff are gonna help me when I am older... Essentials is a lot easier, cuz it covers the basics, and then you review them, and then I know most of it, and also we get stuff like, calculating getting a car, which is good for the future, and like taxes and stuff, that all helps.

Similarly, Steve finds essentials of mathematics enjoyable and useful because he can apply what he learns in his life. He feels the need for the mathematics curriculum to change, because the mathematics he was learning in principles of mathematics is unnecessary and useless.

S: It's just, just so shitty. So shitty.

R: Is it shitty because it's useless?

S: Yea. It's so useless. Lots of it, like, if there's someone who wants to be an artist, and they want to go to UBC arts, why the hell do you have to take a mathematics course?

S: I like math, like I like essentials math, because it's more mathematics I'm gonna use in my everyday life after highschool. You know like how to, like what we are doing right now, like products and stuff... Because what if one day, I have a little business, and I wanna sell stuff. And I need to know how to manage my money, and I need to know this. And, for example, when I was building the house, one day maybe we'll have to fix or décor... or build the place, like design a place to live, or something like that, on a blueprint. And, find someone to make it. And you know you can't just like, if you didn't learn how to do that, you like, okay, I'm gonna draw this in the bathroom and it end up to be three feet large, or something. Yay! I have a three square feet bathroom! Yay! But, everything I've learnt in mathematics essentials are stuff that I've already used.

Steve finds the mathematics taught in principles of mathematics class meaningless and useless, but feels that he is forced to take these mathematics courses in order to

satisfy his graduation and university entrance requirements. He believes that many jobs, including good paying jobs, do not require a lot of mathematics.

S: Yea... Like if you want to be a teacher, or a rocket scientist, like, I obviously don't know many jobs that will use square roots and stuff. Teaching is a big one, and I dunno, like can you name any jobs where you actually on a regular basis use like trigonometry?

S: I honestly almost think unless you are gonna go into like, um, I mean, say you wanna be a writer, say you wanna be a news journal writer, and... to go do that you have to go to university, and to go to university you'll need mathematics credit, I almost say like, they should make mathematics essentials the necessary one to take. I had um... doing um... regular mathematics but um ... it's like somewhat useless, unless, like I said, you are gonna use it for a profession. ... Compare to how many jobs, like, even good paying jobs, like, you don't need to have math. Like, honestly, even a lawyer, one of the highest paying jobs you can get, is like, you don't necessarily need to know math. You need to know basic mathematics probably, like, you need to know [the things you learn in] essentials math, and your grade 8 and 9, maybe, but you need social skills. Honestly I think I have strong social skills and not so strong mathematics skills, and I can do lots of stuff better than someone who get straight A's in math.

Steve believes that the amount of mathematics each person needs to know varies, and they should have a choice to how much mathematics they need based on what they want to do in life. He believes while everyone should know some mathematics, not everyone needs to know the mathematics taught in the principles of mathematics stream, including algebra and trigonometry. Since Steve works part-time at a restaurant, he finds adding, multiplying, and converting between grams and pounds more useful than any theoretical mathematics concepts he has learned in the principles of mathematics class. He feels that if he can focus on only the mathematics he'll use, he will enjoy mathematics much better.

R: If you do only the useful stuff, do you think you'd have a better relationship with math?

S: Yea. Definitely. Yea... There is addition, that is extremely useful. If you want to be a drug dealer, you know how to add numbers, and make sure, you

gotta know what pounds are, what grams are, and you gotta know what stuff and everything. Not even just a drug dealer, say you are going to grocery shopping, and it says two dollars for a pound of strawberries. And you didn't know what that was and you just take the whole case, and then they'll be like 300 dollars, sir. But it says two dollars. This is two dollars. That's per pound sir. I've used pounds more in a week than I've used any other stupid mathematics concepts I've ever learned.

Steve used to have tutors who would work with him often when he was enrolled in the principles of mathematics class. When one of the tutors told his parents that mathematics is not for him, Steve held on to his tutor's comment like a shield. Steve had finally found "proof" that he and mathematics are not a good match, the excuse for him to quit.

S: This one tutor said if you want to keep spending money on this, he said, [Steve] is an unbelievably smart kid. I've seen people like this, and he doesn't understand this, and it's gonna ruin his life, if he keeps on doing this.

Many students dislike mathematics because they only experience mathematics inside the classroom. They hold many misconceptions about mathematics and often regard what they learn in class as meaningless bits and pieces of information, and fail to relate and connect to the curriculum. Students tend to enjoy mathematics when they can relate what they learn to their interests. Davis (1992) and Kaput (1989) made the following comments regarding the mathematics curriculum in general:

With the best of intentions, we have created a curriculum of mathematics that has been severed from the real world. It consists of meaningless bits and pieces, and we ask students to learn it as a large collection of meaningless bits and pieces. (Davis, 1992, p. 730)

Few now deny that school mathematics as experienced by most students is compartmentalized into meaningless pieces that are isolated from one another and from the students' wider world. (Kaput, 1989, p. 99)

When the questions "When will I use it?" and "Why are we learning this?" come up in class, it often means there is a gap between the classroom and students' lives.

(Garofalo, 1989; Mtetwa and Garafalo, 1989; Crawford et al., 1994; Hekimoglu and Kittrell, 2010). We can break away from these misconceptions by connecting mathematics to something students are interested in.

The connection between students and mathematics does not necessarily be a useful one. For example, the Fibonacci sequence is fascinating and we see it everywhere in nature and in architecture. It may not be the most useful thing in students' lives, but many find it fascinating because it provides a connection.

John finds enjoyment in mathematics when he connects with mathematics. The connection makes mathematics tolerable and enjoyable. John has weak mathematics skills, but works hard and strives for success. He hates problem solving, especially those with lots of numbers and equations. However, he enjoys the measurement unit in the curriculum where he designs and builds a scaled model of his dream house. Although there are a lot of calculations with numbers and equations, John enjoys it because he finds the connection between mathematics and design.

J: I hate problem solving.

R: What kind of problem solving? I mean, we do a lot of problem solving stuff in class.

J: Yea, but like more... more... not like... cuz in the Philippines, we have like, different kind of problem solving stuff. I can't figure out the..... given the equation. But like here, we do different, like different methods. Like, lots of fun here.

R: What makes it fun?

J: Like, the houses.

R: But the houses have lots of numbers, and building the house is a big problem solv...

J: It's okay. It's like, I dunno. It's just fun.

R: What's so good about it? What makes it different? Cuz they both have numbers in it, houses and the problem solving stuff you were talking about.

J: It's more style.

R: What do you mean? More...

J: Like, I can relate. Like, cuz, I love fashion. Like, style.

John finds enjoyment in mathematics when he finds a connection. The connection makes mathematics tolerable and enjoyable. Many students are not interested in mathematics because they don't see how mathematics connects to their interests in life. Therefore, what students do in mathematics classes become boring and meaningless.

Mathematics as Methods of Delivery

In a traditional mathematics classroom, students are often "told" mathematics (Corey and Bower, 2005). They are passive learners of mathematics. In a typical secondary or post secondary mathematics classroom, mathematics teachers preach mathematics while students listen and take notes. Students are often not encouraged to think outside the box or attempt mathematics problems using their own methods. Students rarely do projects, research, or group work that involves active participation. They lack motivation, and unfortunately, there are not enough stimuli to capture students' interest.

Andy and Caroline both believe that their mathematics teacher makes a big difference in their mathematics education. In the past, they used their mathematics teacher as a scapegoat to defend their lack of success. Although this sounds like an excuse, there may be some truth to it, because the method of delivery plays an important role in students' learning.

A: Like in grade 8, like, I failed it, like I don't wanna play the blame game but, [X] wasn't that great of a teacher. And then I had him in grade 10, and I failed too. But in grade 9 math, I had no problems at all, because [Y] was my teacher. So. yea.

Caroline uses her mathematics teacher to defend her ego. Caroline believes that throughout her mathematics education, she always had the worst mathematics teachers possible, and they have prevented her from succeeding in mathematics.

C: Honestly, I don't think there are good mathematics teachers at this school.

R: Honestly?

C: Yes.

R: So it's the mathematics teacher's fault that you don't like math?

C: NO no no. It's the mathematics teachers' fault that I'm not good at math.

She argues that in one of her mathematics class, all she did was questions and exercises. There was no explanation, discussion, and relation between the curriculum and life. In another mathematics class, she found the teacher boring, because he talked all the time and the only class activity was note-taking. There was a lack of interaction between her teacher and the class. Therefore, she put her head down on the desk and fell asleep, stopped trying, and failed the course.

C: All he did was talk, the whole class and I just slept. It was so boring.

R: What would work for you then, in a class?

C: Maybe if we did like group project stuff, and work together, or something.

We didn't even work together. We just did stuff, and he explained to use the whole time in class. He was talking. I fell asleep.

Similarly, Vivian experiences mathematics class as note taking, practice exercises, and homework. Rarely do mathematics classes involve projects and moving around.

V: [In a typical mathematics class], we get homework every class. And usually when class starts, we check homework, and if there are any questions, we go over it. And our teacher explains that to us. And after that, it depends. Usually he introduces us to a new topic, or tells us what [today's class] is about. And then we practice. Or, we usually write it down in our notebook. We copy it, the whole board, and then we do exercises, sometimes we do group work, or working in groups. And yea, we practice, then we get our homework, and then yea, that's it.

In this particular mathematics class, however, Vivian finds mathematics "fun" because she does a lot of group projects and there is a lot of moving around. The lack of

notes, traditional practice exercises, and homework are definitely unusual to her. She enjoys this “atypical” approach to mathematics and the activities. She finds a lot of success in class, but attributes her success to the easy course materials, as discussed in “mathematics as a self fulfilling prophecy”.

Mia is another student who enjoys the class activities although she finds them challenging. She compares mathematics class to an adventure and believes this particular method of delivery suits her needs.

M: ... It's like you gotta move around, and do other stuff. Like, other boring pages would be like, sit at a table, and write, while as you, it's like an adventure kinda thing.

The delivery of the curriculum plays an important role on students' learning. If we are able to capture students' interest, teaching and learning become much easier and efficient (Mitchell, 1997).

Mathematics as Physical Objects

Other than group projects, we also build three-dimensional puzzles in class. Andy enjoys these puzzles, even though there is no direct linkage between these puzzles and what he does on a daily basis. Unlike equations and numbers, they are physical objects that he can touch and pick up. He also finds writing instructions tolerable, because it is a way of communication that is understandable by most.

A: I guess it's so fun to do [the puzzles] physically, right? When it's on pen and paper, when the things are already there, it's different. I dunno. Like, when it exists, when it's there, I guess people would find it more fun. It's like, oh, this is real, it's not... not...

R: Not just numbers..

A: Yea. Like it exists. Like I can pick it up and hold it in my hand.

These puzzles capture Andy's interests and engage him in class. Although they do not necessarily further his mathematical knowledge, they help him see mathematics as more than numbers and equations.

Summary

These fourteen themes emerged from the interviews contribute to the student participants' relationships with mathematics. Of all the students interviewed, everyone's relationship with mathematics is affected by more than one theme. In other words, there is no single reason to students' negative relationships with mathematics. Everyone is also affected by a different set of themes, because each student's experiences with mathematics are unique. These particular experiences contribute to their relationships with mathematics. Table 2 is a summary matrix that shows the relationships between the student participants and the emerged themes.

Table 2 *Student Participants and the Emerged Themes*

	Vivian	Andy	Kevin	Mia	Diane	Steve	Elle	Caroline	John	Fiona
Mathematics as										
Building Blocks	✓	✓			✓		✓	✓		
A Race Against Time	✓				✓	✓	✓	✓		✓
My Own Method				✓	✓					
Computation					✓		✓	✓	✓	✓
Self Fulfilling Prophecy	✓	✓	✓	✓	✓	✓		✓		
Successful Performances	✓		✓	✓	✓	✓	✓	✓		
Sink High			✓			✓				
One Answer	✓					✓	✓		✓	✓
Elementary and Secondary		✓			✓					
Avoidance Behaviors		✓					✓	✓		
Chores	✓	✓				✓				
Lack of Connections		✓			✓	✓	✓		✓	
Methods of Delivery	✓	✓		✓				✓		
Physical Objects		✓								

Interactions of the Themes

The themes discussed above are not isolated from each other. Some of these themes overlap each other significantly, for example, “mathematics as building blocks” and “mathematics as a race against time”. Since mathematics follows a building block model, students experience difficulties in mathematics when they miss a step or a concept. Many also feel that the fast pace of mathematics lessons does not allow them sufficient time to fully grasp the materials taught in class, which contributes to their “holes” in their education.

Another group of themes that significantly overlap each other is “mathematics as a self fulfilling prophecy”, “mathematics as successful performances”, and “mathematics as avoidance behaviors”. Students’ self-efficacy is related to their choice of goals and

abilities. For example, Vivian, Kevin, Mia (while enrolled in the principles of mathematics 9), Diane (while enrolled in the principles of principles of mathematics 10), Steve (while enrolled in the principles of mathematics 10), and Elle, are performance goal oriented students who believe they have low mathematics abilities. These students also have low self-efficacy. Also, Andy, Elle and Caroline are students who display avoidance behaviors with low self-efficacy. The interactions between self-efficacy and goal orientations can be found in other research. Research suggests that low ability students who are performance goals oriented and students who are ego defensive goals oriented tend to have low self-efficacy (Bell and Kozlowski, 2002; Taye and Zhou, 2009).

These interactions between the themes suggest that there is no single contributor to students' negative experiences with mathematics. In the next chapter, I offer a more detailed discussion of these themes and their implications on "math suks".

Chapter 6 Summary, Discussion, and Conclusion

“Math suks” is a catch phrase commonly used in the mathematics classroom, from students who are struggling with mathematics to students who are high achievers. It is a personal and emotional expression that carries many different meanings. In general, “math suks” represents students’ negative experiences and their reactions to these experiences. In this chapter, I offer a discussion and summary on the themes discussed in chapter 4. These fourteen themes are based on students’ experiences and can be classified into three major categories, students’ views and definitions of mathematics, students’ views and beliefs about themselves, and students’ goals and expectations of mathematics.

Students’ Views and Definitions of Mathematics

Some students use “math suks” to describe the holes and gaps in their experiences with mathematics. These students feel that these holes have held back their mathematics education. They do not follow what they are currently learning because of these gaps. Some believe that there is no way for them to catch up and fill these holes in their education even if they want to. They feel defeated and left behind. Many students believe the fast pace of the lessons contributes to these holes. They find that mathematics class moves too fast and does not allow them sufficient time to fully understand the materials before moving on to the next topic. As a result, they fall behind, the cycle repeats, and more holes are created in their education.

Students develop their definitions of mathematics through their experiences, which are often limited to the classroom. Many have expressed that their mathematics classroom experiences consist of mostly lectures and seatwork, and lack explorations and group work. Some complained that they are not given time to explore and “play” with mathematics. Rather, they are told mathematics, because they are often given specific instructions to solve mathematics problems.

From my observations, students’ beliefs about mathematics contain many misconceptions, such as mathematics is numbers and formula, and is detached from reality. Some students also find mathematics answer oriented, and believe the goal of mathematics is to determine the answer, and there is only one answer to a question. Their view of mathematics is narrow and biased because of their negative experiences in the classroom and the lack of positive reinforcements in their mathematics education. Many students also find mathematics boring because they do not see mathematics outside the classroom or in the things they enjoy. As a result, many do not care about mathematics and feel they do not need it in life. These misconceptions contribute to their definitions of mathematics and “math suks”.

Many students have expressed the feeling that their relationship with mathematics deteriorates as they grow up. The number of negative experiences multiplies but positive experiences decreases. While this may be a result of students’ misconceptions about mathematics, the fast pace of mathematics class and the gaps students have in their mathematics education contribute to this deterioration. As students fall behind, many experience struggles and failures instead of success, and the cycle continues. These students respond to these negative experiences with “math suks”.

Students' Views and Beliefs about Themselves

While students' mathematics education may be a factor to "math suks", students also play a part in their own feelings of "math suks". Many students are performance goal oriented. They are proud of their success but are ashamed of their failure (Hannula 2006). As mentioned before, many students' mathematics experiences are limited to their classroom. Therefore, these students judge their mathematical abilities based on their classroom experiences. This judgment contributes to the development of their self-efficacy. Some have always done poorly in mathematics. They have a low sense of self-efficacy and expect failure before they begin. These students do not believe in themselves, as failure is deeply rooted. On the other hand, some have found success at an early age, usually elementary school, but suffer from failure now. The secondary school mathematics curriculum covers a lot more material compare to the elementary curriculum and requires students to apply their mathematical knowledge to what they currently learn. Unfortunately, many have trouble because they lack understanding and forget what they have learned in their prior mathematics classes. They also find that not enough time is spent reviewing concepts they forget. Due to the amount of failures they experience, many students stopped believing in themselves. They feel that mathematics has crushed their self-efficacy and believe "math suks" because they suk at math.

While these students have low success rate and do not believe in themselves, there are those who experience success but still do not think they are capable. Similar to those who experience a large amount of failures, these students also suffer from low self-efficacy. They attribute their success to the easy curriculum rather than their abilities.

Similarly, they believe “math suks” because they assume they are bad at math.

Interestingly, one of the student participants ascribes her success to the curriculum or herself depending on the amount of success. When the amount of success she experiences falls within the expected range, she gives credit to her ability. However, when the amount of success is beyond the expected range, she attributes the success to the easy curriculum. Similar to the other students, she has low self-efficacy. Finally, there are those who believe in themselves when they find success. Their self-efficacy slowly rises along with their performance, and they become more confident at mathematics.

Some students refer the essentials of mathematics program to stupid mathematics. It implies that the essentials stream is design for people who are dumb. This stereotype makes it difficult for students to choose the correct mathematics stream that suits their needs. The essentials of mathematics classes typically provide more support for students who have weak mathematics skills. Unfortunately, many who will benefit from the program refuse to be enrolled in it because of the stereotype. They believe their success is measured based on their mathematics abilities, and the essentials of mathematics program implies low mathematics skills. They do poorly in the principles of mathematics program and feel that they are labeled as incapable individuals, but refuse to enroll in the essentials of mathematics class for the same reason. They are caught in the dilemma and express their negative emotions towards the situation using “math suks”.

Students' Goals and Expectations of Mathematics

“Math suks” is also a reaction to obstacles and failures. Students use it to shift their responsibility and the cause of their failure away from themselves to mathematics or the classroom teacher. This reaction can be observed through avoidance behaviors. It is a method for students to release their frustration and remove their negative emotions associated with their difficulties in mathematics. Students who exhibit avoidance behaviors tend to be ego-defensive. They hide from challenges and give up easily when they face obstacles in order to avoid negative judgments and feeling incompetence (Hannula, 2006). One of the students from the interview is even willing to give up her dreams in order to avoid mathematics. She avoids mathematics because she has low self-efficacy and feels defeated in mathematics. On the other hand, some students experienced success at a young age and believe they are mathematically capable. When they experience failure, they blame external factors such as their teachers and remove themselves from mathematics. In both cases, they avoid mathematics to steer clear of failures.

Unfortunately, students are not always successful in avoiding mathematics. They are forced to stay in classes because they need these courses to satisfy their secondary school graduation requirements. Mathematics becomes chores – unpleasant but mandatory. Very often, these students simply want to pass the course, receive the credits they need and not have to deal with mathematics anymore. Therefore, students hold a negative attitude towards mathematics and express these feelings using “math suks”.

Sometimes students also use “math suks” to express their lack of connections with mathematics. Some students feel that mathematics does not relate to their interests, their

goals, and their daily lives. For example, one of the student participants dreams to become an artist and believes mathematics has nothing to do with her goals. A few other students find that basic computations are sufficient to get them through their day. Other student participants find that “math suks” because mathematics fail to capture their interest as they have only experienced mathematics as computation. They claim that mathematics class involves too much seat work and lack engaging activities. As a result, they are disengaged from the lesson. Some students put their heads down and sleep during class. As they miss the lesson, they fall behind and fail to keep up.

Whether mathematics fails to capture students’ interest or mathematics lacks connections to their interests and lives, these students feel detached from mathematics. Since they are forced to “stay connected” with mathematics, they express their negative feelings using “math suks”.

So, Does Math Suk?

Mathematics does not suk. Students often feel that “math suks” because of their negative experiences with mathematics and mathematics class. Since students’ experiences contribute to “math suks”, we can steer students away from this negativity by providing them with positive experiences. One of the things students from the interviews suggested is to allow them to “play” with mathematics instead of giving them the full instructions or solutions. Playing with mathematics gives them the chance to explore and make discoveries. It also put the ownership of learning back to the students. From my experience, students often like to figure out a problem themselves. They may want a hint, but definitely not the full solution. In order for this to happen, however, they

need time. As mentioned before, many feel that mathematics class moves too fast and they are not given enough time to understand the materials. Interestingly, I realize that giving students time to “play” does not use up more class time. I found that if I show them the full solution without giving them time to “play”, I would eventually need to re-enforce their learning. If I give them class time to “play”, however, they seem to remember the material much better.

Students from the interviews also suggested that relating mathematics to their interests helps them experience mathematics positively. I notice that students spend more time and effort on their learning if the material is relevant to them. Since their world as teenagers are different from mine as an adult, I target their interests and needs in order to make mathematics applicable in their lives. I also find the use of physical objects help students see mathematics in their reality and break the misconceptions of mathematics is numbers and equations, because these are objects that students and pick up.

Negative experiences lead to negative definitions of mathematics. Therefore, I believe if we feed students enough positive experiences, they will eventually be able to see mathematics in a more positive manner, and steer them away from “math suks”.

This research made me pay closer attention to what I do in class. During this project, I had a “math suks” experience. It was eye-opening because I have always believed mathematics to be fascinating and interesting. In one of the lessons, students worked on finding the roots to quadratic equations, and I showed them one of the problems from the homework questions. When I looked at my work afterwards, I had a sense of satisfaction. However, I also realized that “mathematics really suks”. The mathematics I showed the class has no implications and applications in my life, and I

thought to myself, “Who cares about this stuff?” It was an emotional and frustrating experience.

This project has allowed me to gain a deeper meaning of “math suks”. This understanding helps me become an effective mathematics teacher by presenting and promoting mathematics in a positive manner. As my understanding of “math suks” grows, I pay attention to the factors that may contribute to “math suks” in my classroom and remove these factors the best I can. I present mathematics in a positive and attractive manner in the hopes of steering students away from this negative attitude.

Mathematics itself does not suk. However, the way we present mathematics to our students may need some change. As teachers, we need to provide our students with positive learning experiences, bring meaning to the mathematics we teach, and make the connection between mathematics and students’ lives. After all, who wants to attend mathematics class when math suks?

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Appendix A Introduction Activity

The following is an introduction activity that I assign to all students at the beginning of the year. This provides me with a better understanding of the relationships with mathematics, and their goals and expectations in mathematics class.

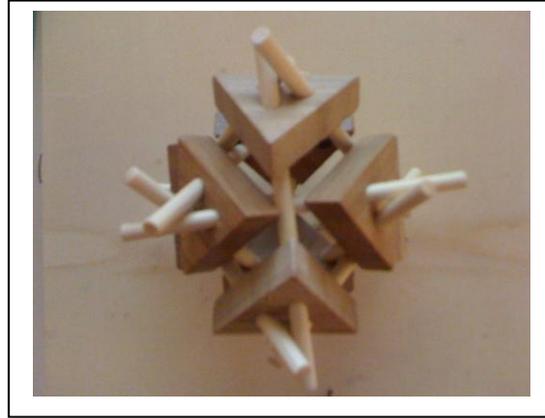
STUDENT PORTFOLIO

In this introductory lesson, you will create a portfolio about yourself. First, fold the paper in half, creating 4 pages. Use the pages to answer do the following tasks.

Page 1	<ul style="list-style-type: none">• Put your name, date, and block on page 1.• What do you look like in mathematics class? What do you do in mathematics class? What are your roles in mathematics class? Be creative.
Page 2	<ul style="list-style-type: none">• Tell me four interesting things about you.
Page 3	<ul style="list-style-type: none">• Tell me four things that you remember from your prior mathematics classes.
Page 4	<ul style="list-style-type: none">• Tell me four things that you would like to do or see happen in this year's mathematics class.

Appendix B Three-Dimensional Puzzle

The following is an example of the three-dimensional puzzles students work on during mathematics class. In this puzzle, students need to put eight triangle pieces and eleven sticks together to form a three-dimensional shape. Some students call this shape “the two pyramids stuck together”. After they are done, they need to write or draw instructions to show others how to do it. The following are two pictures of this puzzle. The one on the left contains all the pieces in the puzzle, the one on the right is the finished product.



Appendix C Numeracy Task

The following is a sample of the numeracy tasks students do in my class. This numeracy task does not relate directly to the curriculum. I used this as a precursor to the measurement unit because this task gives students a sense of spatial orientation. The task also encourages students to think outside the box and work together as a team. Some students may also need to do some research because their knowledge with golf is limited.

NINE HOLE GOLF COURSE

Prince George is getting a new 9-hole golf course. It is going to be built on a treed lot just outside of town. Your task is to come up with a layout for the golf course. There are a few things that the owners of the golf course would like you to keep in mind:

- there must be two par-3 holes, five par-4 holes, and two par-5 holes
- a par-3 must be between 150 and 200 metres in length
- a par-4 must be between 250 and 400 metres in length
- a par-5 must be between 400 and 500 metres in length and must have a bend in it.
- all fairways are between 75 and 100 metres wide
- you must start and finish in the same place
- there can never be two par-3 holes or two par-5 holes in a row
- there is a pond in the middle of the property that you need to work around.
- you must include a clubhouse and a parking lot

To help you with your design and layout you have been provided with a scaled map of the property (every square is 50m x 50m). Present your final design on a copy of this map. Number the holes and indicate where the tee boxes are (with the letter T) and where the greens are (with the letter G). Also indicate where trees are going to be left (with the letter X).

