A Case Study of Social Justice Mathematics:
The Experiences of Secondary Students and Preservice Teachers
in Mathematics Teaching And Learning

By

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ABSTRACT

The purpose of this case study was to describe the experiences of secondary students and preservice mathematics teachers in the teaching and learning of social justice mathematics (SJM). Specifically, participants’ experiences in making connections among the mathematics curricula and the real world, perceptions about mathematics, and responses to an integrated curriculum approach were described.

Students participated in SJM activities designed by preservice teacher participants: one component of a pre-existing extracurricular Social Issues Club at a high school in Southeastern Ontario. Mathematics activities, led by the researcher or one of the preservice teacher participants, were designed to complement the social justice issues that were being explored by the members of the Social Issues Club. Data were obtained through observations, questionnaires, both focus group and individual interviews, written reflections, and artifacts.

Results demonstrated that preservice teacher participants had unique professional and educational encounters prior to SJM that they connected to their SJM experience. Subsequent to this experience, preservice teachers suggested limited ideas about integrating curriculum into their future teaching practice beyond the content and contexts made familiar to them through SJM. With limited exposure to examples of curriculum integration identified by preservice teachers as a barrier, results suggest that preservice teachers need more opportunities to learn about and engage in mathematics curriculum integration.

Students showed an expanded view of connections between mathematics and the real world through their descriptions of the various ways in which SJM had helped them to apply mathematics concepts and understand the issues they were exploring. They enjoyed SJM’s
collaborative mathematics learning approach and valued the opportunity to discuss the social issues about which they were concerned.

Although the preservice teachers were confident about what they thought to be topics of interest for secondary students, there was a disconnect between students’ choices of contexts for mathematics learning and the beginning teachers’ assumptions about students’ interest. This finding suggests that there is a need to support preservice teachers to understand students’ interests in mathematics learning and that students’ opinion needs to be solicited. In addition, participants’ visions about enhancing mathematics teaching and learning through collaboration and providing students with autonomy allowed suggestions for the practice of mathematics teaching.
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CHAPTER 1

INTRODUCTION

Mathematics instruction is often based on a knowledge transmission approach since the subject has a long tradition of focus on procedures and algorithms. This results in an image of mathematics as a rule-bound and decontextualized body of knowledge. In contrast, the National Council of Teachers of Mathematics (NCTM) states that mathematics learning should involve the process of actively constructing new knowledge from prior knowledge and experience (NCTM, 2000). The NCTM (2000) encourages teachers to employ approaches that construct mathematics learning on the foundation of the knowledge and experiences students acquire through everyday life. Similarly, the Ontario Secondary Mathematics Curriculum policy documents mandate the “active involvement of students in building new knowledge from prior knowledge and experience” (Ontario Ministry of Education, 2007, p. 3) to prepare students for their future roles in society (Ontario Ministry of Education, 2005). According to Doll (1989, 1993), curriculum that involves refining the learner’s experience is described as a process of transformation.

To understand the transformation of learning experiences within the parameters of mathematics pedagogy, this study described secondary school students’ and preservice teachers’ experiences when mathematics teaching and learning was immersed in a pre-existing, non-mathematics extracurricular setting at a local high school. This extracurricular setting, known as the Social Issues Club (pseudonym), engaged high school students in social justice projects. For the purpose of this research, a suite of mathematics-focused investigations was added to club activities and came to be known as Social Justice Mathematics (SJM). In collaboration with the researcher, preservice teachers designed and led activities for student club members in these
novel modules; thus, this study was designed to understand the lived experiences of teaching and learning mathematics within the created context of SJM.

**Autobiographical Signature**

I have always appreciated both the aesthetic and instrumental facets of mathematics and this passion led me to pursue an undergraduate degree in this field. Through my own mathematics learning and mathematics tutoring experiences, I became interested in mathematics teaching and learning in my senior undergraduate years; therefore, I decided to pursue a career in secondary school mathematics education. I was enrolled in a Global Education cohort during my teacher education program: a special focus course in which I became fascinated about the integration of mathematics and global issues in the classroom. From my classroom practice as a preservice teacher, my goal was to bring meaningful mathematics learning experiences to my students; however, I encountered many obstacles that limited my opportunities to teach mathematics using real-world contexts or inquiry approaches, the most significant being the mechanical teaching approaches that I regularly observed and the resistance of a number of supervising classroom teachers to permit me to try non-traditional instructional approaches.

Another obstacle was that curriculum integration models, standard in my Global Education course, were not a focus of my Mathematics Curriculum Methods course. I had few concrete examples on which to build lessons and I struggled to find resources to create authentic activities that related mathematics to global issues and vice versa. As a result, I felt that I graduated as an Ontario Certified Teacher with more questions than answers in terms of meaningful, integrative mathematics teaching.

My pursuit of a Masters degree in Education stemmed from the desire to gain a better understanding about ways to enhance the mathematics learning experiences of students.
Although there are multiple subject areas with which to integrate mathematics to create meaningful mathematics learning experiences for students (Nolan, 2009), I decided to integrate mathematics and social justice issues rather than other topics due to my professional background and personal interests. While my experience as a preservice teacher provided anecdotal data for me to understand this model of integration as a graduate student, I aimed to gain insights into the integration of mathematics and social justice issues using empirical methods.

**Rationale for the Study**

Although some researchers suggest that there is increasing interest in integrating mathematics and social justice issues (Nolan, 2009), there remains misunderstanding about efforts to combine these two particular subject areas (Nolan, 2009): one important factor that was a catalyst for this study. The rationale for conducting this study is presented through the consideration of pedagogical goals for using social justice issues as a context for mathematics instruction; the dearth of Canadian research on the topic; and, the limited availability of models of curriculum integration in these fields.

**Pedagogical Goals**

Through his research, Gutstein (2006a) identified two different pedagogical outcomes for integrating mathematics and social justice issues. The first, a predominant focus in his research, was teaching mathematics *for* social justice, an approach in which the emphasis is on using mathematics as a tool to foster students’ sense of social equity and empowerment (Gutstein, 2003, 2006b, 2011). The principle of teaching mathematics for social justice was that “students themselves are ultimately part of the solution to injustices” (Gutstein, 2003, p. 39). Conversely, the second goal identified by Gutstein (2003, 2006b, 2011) was to use social justice issues as a
context for teaching mathematics content and processes by connecting skills and concepts to everyday life.

Researchers have emphasized students’ development of social citizenship, social awareness, and social agency as principal benefits arising from the integration of mathematics and social justice issues (Brelias, 2009; Esmonde & Caswell, 2010; Gutstein, 2003, 2006b, 2011; Lim, 2008; Turner et al., 2009). Studies have shown that when mathematics is used as the vehicle to teach about issues related to social inequity, students were prompted to challenge injustice and feel a sense of personal involvement in social change (Gutstein, 2011). In addition, empirical evidence has shown that teaching mathematics through the lens of social justice benefits minority or marginalized students, especially when knowledge of mathematics, local community issues, and personal circumstances intersect and support one another (Turner et al., 2009). Utilizing mathematics as an instrument to quantify particular factors within social injustice was a common approach used in these studies.

With so much focus being given to the use of mathematics as a tool to drive the development of socially responsible learners, limited empirical research has been conducted to describe the ways in which greater mathematical understanding can be achieved by connection to the real world using the context of social justice issues. There appears to be a gap in the literature that examines mathematics learning experiences that employ social justice issues as a vehicle to achieve mathematics learning objectives. Although there are findings that are related to students’ positive perceptions and conceptions towards mathematics when it is integrated with social justice issues (Brelias, 2009; Gutstein, 2003; Lim, 2008), a limited body of research has focused on students’ experiences in learning mathematics content through such contexts.
Thus, this study was designed to examine mathematics teaching and learning experiences through the lens of social justice issues, and is not concerned with teaching mathematics for social justice. In this study, mathematics was used as a tool to illustrate and illuminate social justice issues, and social justice issues were used as the context through which rich mathematics learning experiences were designed and implemented.

**The Canadian Context**

Many of the studies that have examined mathematics and social justice were conducted in Mexican-American communities that were selected purposefully because the focus of the research was to determine the impact of such curricula on student participants who were marginalized cultural minorities (Gutstein, 2003, 2006a, 2006b, 2011; Turner et al., 2009). It appeared that one of the primary aims of such studies was to empower marginalized students to understand and break away from social inequities. Because research about integrating mathematics teaching, learning, and social justice has been conducted in such specialized environments in the American context, there is a need both for Canadian studies and research with more general student populations to fill gaps in the literature. My study brings insights into the integration of mathematics and social justice issues for Canadian classrooms.

**Curriculum Integration**

The Ontario Ministry of Education (2007) encourages mathematics learning to be embedded “in the solving of problems based on real-life situations” (p. 4). The mathematics curriculum document provides suggestions of contexts for rich mathematics learning experience. Drawing from related subject areas, teachers are encouraged to allow students to connect mathematical concepts and thinking to other disciplines such as “computer science, business,
There are formal models of making connections in terms of curriculum integration. For example, the Ontario Ministry of Education (2007) suggested “involving quadratic functions arising from real-world applications” (p. 44) such as determining the maximum profit that a company can make, “collect[ing] data and graph[ing] the cooling curve representing the relationship between temperature and time for hot water cooling” (p. 49), and “using data . . . to determine if there was a period of time over which changes in the population of Canadians . . . could be modelled using a sinusoidal function” (p. 54). These examples are models of integration of mathematics with business, science, and geography; however, no specific models for linking mathematics with social justice issues are included in the official documents used by classroom teachers.

To combine mathematics and social justice issues, this study used the “Shared” curriculum integration model of Fogarty and Stoehr (2008), which is appropriate for two disciplines that share “overlapping concepts or ideas” (Fogarty & Stoehr, 2008, p. 26). Because previous studies have shown that mathematics could be used as a tool to analyze statistical data about social issues such as the population of death row inmates and whether or not race was a factor in their incarceration (Brelias, 2009); the difference in employment rates between genders (Brelias, 2009); and the issue of gender inequality in the population of those infected by HIV/AIDS (Gutstein, 2011), these overlapping ideas appeared to integrate curriculum using the Shared model. The Shared model of integration also allows two disciplines to “embrace a single idea simultaneously” (Fogarty & Stoehr, 2008, p. 33). Because this model allows the integration
of ideas from two domains (in this case mathematics and social justice), the shared curriculum integration model seemed to be the most appropriate choice.

**Purpose of the Study**

The purpose of this research was to address a gap in the literature by describing the experiences of preservice teachers and secondary students when mathematics was taught through the context of social justice issues within an extracurricular learning environment. To achieve this goal, the following research questions framed the study:

1. How do preservice teachers and secondary students describe their experiences in connecting (a) mathematics and the real world and (b) SJM and their formal mathematics teaching and learning experiences?

2. What are preservice teachers’ and secondary students’ perceptions of mathematics in response to SJM?

**Conceptual Framework**

According to Doll (1989), a curriculum theorist, the dichotomy of objective reality and subjective experience tends to drive curriculum away from becoming transformative. Traditional theories of learning consider teachers as authority figures and learners as the passive recipients of knowledge (Doll, 1989). The notion of transmission of objective knowledge regards the process of learning using a stimulus-response model or knowledge filtering model (Davis, Sumara, & Luce-Kapler, 2000) with the emphasis placed on student mastery of subject content (Miller, 1993). If pedagogy focuses solely on the transmission model of instruction, then teaching and learning is based on the belief that knowledge is an entity that is passed from one person to another (Davis et al., 2000). Doll (1993) described this process as “knowing teacher informing unknowing students” (p. 4). Because the transmission approaches to teaching are mechanical in
nature, Doll (1993) argued that no transformation of experience can take place when such an approach is employed.

By redefining learning as the student’s reorganization and reconstruction of experience, Doll (1993) brought into focus the process of learning instead of the measurement of learning outcomes. Rather than viewing curriculum as a predetermined, linear, and measured path designed to be experienced in lock-step fashion by all learners, Doll (1993) described the curriculum itself as a passage through which transformation of experience will emerge. Central to the transformation model is the notion that learners are “active creators of knowledge” (Doll, 1993, p. 8), which is a phrase originally coined by von Glasersfeld in his constructivism framework (Ernest, 1993). Doll (1993) further asserts that learners should not be “passive receivers of preordained truths” (p. 8). Not only should students have an active role in learning, but according to Doll (1993), teachers should take an active role in designing the learning opportunities that would bring about such change. According to the transformation model of curriculum, teachers are much more than implementers of a predesigned curriculum: their role is to create a classroom community in which the students’ lived experiences become the curriculum to be studied and understood (Doll, 1993). Similarly, Miller (1987) asserted that the transformation model of pedagogy is necessary because student “growth involves reconstruction of experience and knowledge, which helps in refining and controlling future experiences” (p. 121).

**Rationale for Conceptual Framework**

Mathematical knowing is interwoven into our bodily experiences and shared through social interaction and cultural tools to make sense of the world in which we live (Davis & Simmt, 2006); however, the traditional teaching approach in mathematics appears to be oriented
around teacher-instruction, which concentrates heavily on the transmission model (Borasi, 1994). From Doll’s (1989, 1993) perspective, the focus on transmission of mathematics content diminishes the potential of learners’ transformation in response to learning experiences.

Because I believe that mathematics instruction needs to move beyond the teaching of predetermined objective facts, I chose Doll’s (1989, 1993) notion of transformation as the conceptual framework to frame this study. I recognize that there are other frameworks that discuss the notion of transformation such as Mezirow’s (1978, 1997) transformative learning theory and Freire’s (1970) social-emancipatory transformation. Although both Mezirow (1978, 1997) and Freire (1970) discussed transformation as a change in the learner’s perspective, both frameworks focused on transformation as understanding reality and gaining a sense of agency to shape the world. On the other hand, Doll’s (1989, 1993) notion of transformation emphasizes the experience of a learner in connection to the curriculum. Because this study sought to understand participants’ experiences with regards to mathematics teaching and learning in the curriculum integration of mathematics and social justice, Doll’s (1989, 1993) definition was best suited for this research.

**Definition**

Transformation is a marked change in form, nature, or appearance (Oxford University Press, 2012). For the purposes of this study, transformation was defined as “a change in view, in perspective” and “one’s relationship to nature, to life, to the environment, [and] to learning” through the “reorganization” of experience (Doll, 1989, p. 249). Change is regarded as a positive event rather than being “handled in a controlled, incremental way” (Doll, 1989, p. 249).

To describe the teaching and learning experiences of each group of participants, this working definition of transformation was used to bound this study. Doll (1989) argued that
transformation was one of the three main components of the foundation of a post-modern curriculum and also used the phrase “transformative change” (p. 249) to describe the impact of a post-modern curriculum in moving beyond traditional learning models.

Overview of the Thesis

This thesis is comprised of five chapters: Introduction, Literature Review, Methodology, Presentation of Data, and Discussion. In this chapter, I introduced my study and presented the personal background and professional issues that were the catalysts for this research. Chapter 2 presents and critiques three major areas within the relevant literature: real-world mathematics, mathematics teaching and learning through the context of social justice issues, and informal mathematics learning experiences in extracurricular activities. In Chapter 3, I describe the methodology that was used in this study. I present the rationale for the case study approach and describe participant selection, data collection modalities, and data analysis methods. I also discuss the trustworthiness and the limitations of my study. The presentation of data and summary of findings are presented in the fourth chapter. Chapter 5 is a discussion that situates findings within the literature and considers the implications of my findings on research and practice. Finally, I make closing remarks regarding the significance of this study.
CHAPTER 2

LITERATURE REVIEW

In this chapter, I discuss the literature related to teachers’ and students’ experiences in mathematics teaching and learning when integrated with social justice issues. Topics of the literature review include connecting classroom mathematics to the real-world, connecting mathematics education to social justice issues, and informal, extracurricular mathematics education. As I present findings from prior studies, I connect these findings to the conceptual framework of this study to bring clarity to my research.

Real-world Experiences in Mathematics Education

While pure or theoretical mathematicians might argue that there does not exist such a thing as “real-world” mathematics, mathematics educators often struggle to define this term and find examples of applied or practical mathematics when students question the relevance of mathematics curriculum to their everyday lives (Garii & Okumu, 2008).

Positivist mathematicians believe that mathematics is constructed as a human endeavour and the source of this construction is humankind’s natural curiosity (Brelias, 2009). By examining the history of mathematics, it becomes evident that many fundamental concepts, formulae, and theorems were developed from questions posed about the reality of the world. “Mathematics has existed for as long as humans have sought patterns to make sense of the world in which they live . . . [and] with time, different cultures began developing more sophisticated mathematics that reflected their social and political needs” (Bateiha, 2010, p. 3). Because of this, mathematicians tend to avoid defining real-world mathematics. They believe that (a) the developed ideas will eventually have an application in the future if there is no immediate application (Garii & Okumu, 2008), and (b) the fact that ideas are constructed “just because”
gives aesthetic value of mathematics (Brelias, 2009). The definition of real-world mathematics, which has been widely explored by mathematics educators, is extremely complex (Greer, 1997). According to Greer (1997), one of the difficulties in defining real-world mathematics was situating social and cultural contexts within word problems posed to mathematics students.

Secondary school teachers often encounter the questions “When am I ever going to use this?” (Otten, 2011, p. 20) and “Why do we need to learn this?” (Otten, 2011, p. 20) in their mathematics classroom. Otten (2011) posits that secondary mathematics teachers often combat such questions by informing students about real-world situations in which one would use mathematics: professions that require a foundation in mathematics, mathematics that underlies technology, and future mathematics learning that students will experience. Other teachers hold and share with learners their belief that mathematics concepts do not necessarily need an immediate real-world connection.

According to Brelias (2009), traditional mathematics applications in the classroom merely represent attempts to connect mathematics and the real world. While mathematics educators strive to bridge content to real-life applications to engage students in mathematics learning, some argue that attempting to find and connect the subject to the real world could mislead students into believing that there is always a real-life application for any given mathematics concept. This attempt to attach every concept to real life may result in problems and applications that are contrived, leading students to feel a further detachment of mathematics to the real world (Otten, 2011). Similarly, Boaler (1993) argued that contexts that are intended to provide a real-world dimension to classroom mathematics tend to distance the subject further from real life because these problems tend to be fabricated and overly-simplified for students to
follow a specific algorithm in determining the solution. Thus, these problems rarely connect to those encountered in life and merely represent “real world associations” (Boaler, 1993, p. 14).

Currently, there is no fixed definition of the term “real-world” within the discipline of mathematics. Studies have shown that educators recognize and make use of various categories of real-world connections and researchers have expressed their concerns regarding the observed misunderstanding of real-world connections in mathematics pedagogy. Some mathematics educators posit that students should learn that mathematics is a process that involves abstracting relevant information from reality and employing mathematical modelling to use available information and is not merely a calculated outcome at the end of a problem (Maasz & O’Donoghue, 2011). This suggests that it may be efficacious for educators to take into consideration the complexity of reality when importing real-world problems into the classrooms (Maasz & O’Donoghue, 2011). Authentic real-world problems often may have more than one correct solution depending on different points of view (Maasz & O’Donoghue, 2011) while traditional, and often contrived, classroom problems designed to be “real-world” tend not to reflect this characteristic. Although a principal goal of linking the subject with the real-world is to promote student engagement (Gainsburg, 2008), some connections are superficially applied, for example, matching specific algorithms to specific problem categories: known as “instrumental understanding” of mathematics (Skemp, 1976/2006). This particular approach could further perpetuate the notion of mathematics as a rule-bounded subject.

As suggested by mathematics education researchers, arriving at a definition of the term is complex because the meaning of real-world connections varies among individuals (Boaler, 1993). The way real-world connections are designed in standard mathematical application problems could be more relevant to adults’ rather than secondary mathematics learners’ use of
mathematics in their everyday lives. Because this could deter students from making meaningful connections, Boaler (1993) directed the need to consider “whose world” when attempting to comprehend the meaning of real-world mathematics. Furthermore, Boaler (1993) suggested that students should be given the opportunity to construct their own contexts in mathematics learning.

Garii and Okumu (2008) and Otten (2011) recommended that the focus of mathematics education should be shifted from content to process and that mathematics learners should be educated about the value of the subject in terms of the thought processes they are required to use to solve mathematics problems. Such processes are key to “problem solving, reasoning, justifying, representing, [and] working in deductive systems” (Otten, 2011, p. 23), all of which are valuable in one’s understanding of reality. Making real-world connections does not refer only to applying mathematics in the real-world, but also sense-making about reality (Gravemeijer & Doorman, 1999; Van den Heuvel-Panhuizen, 2003). For example, Gutstein (2003) showed that beyond using mathematics as a tool to solve problems in the context of social justice issues, secondary students reached an understanding of reality about social injustices by examining issues through a mathematical lens. The notion of real-world mathematics in the absence of equivalent consideration of thought processes and the role that these processes play in sense-making about authentic situations can lead to superficial links between the subject and the real-world (Gainsburg, 2008; Garii & Okumu, 2008; & Otten, 2011).

Gainsburg (2008) stated that in the current mathematics literature, the following categories delineate those applications that represent real-world connections:

- simple analogies (e.g., relating negative numbers to subzero temperatures);
- classic ‘word problems’ (e.g., Two trains leave the same station...);
- the analysis of real data (e.g., finding the mean and median heights of classmates);
• discussions of mathematics in society (e.g., media misuses of statistics to sway public opinion);
• ‘hands-on’ representations of mathematics concepts (e.g., models of regular solids, dice);
and,
• mathematically modeling real phenomena (e.g., writing a formula to express temperature as an approximate function of the day of the year). (p. 200)

Despite this categorization, Gainsburg (2008) indicated that there are still misunderstandings about what real-world mathematics entails and the ways in which real-world mathematics can be integrated into mathematics teaching and learning. Because there is no consensus about the definition of real-world mathematics and there is growing concern about the ways in which real-world mathematics can be incorporated into a mathematics program, there is a need to understand how real-world mathematics is defined for both theoretical and practical reasons. In this section of the review literature that is pertinent to my study, major empirical studies that examined various definitions of real-world mathematics will be presented.

**Real-world Connections in Secondary Mathematics**

In a qualitative investigation about teachers’ perceived definition of “real-world” connections in mathematics education, Gainsburg (2008) categorized the real-world applications that secondary mathematics teachers included in their lessons. Real world examples used by teachers were examined through classroom observations and individual interviews with teachers to determine the factors that influence their use of authentic connections in their instruction. Surveys, in which teachers self-reported and described their recent real-world connections, were given to 62 middle school and secondary school teachers from California. Of the 62 survey participants, 19 agreed to be observed in their mathematics classrooms and five teachers from
this pool were selected based on their self-reported significant use of real-world connections in their lessons. The following categories were used to organize classroom observations made by the researcher: (a) the nature of the connection, (b) the way mathematics content was connected to the real-world, (c) the way the teacher expected students to engage in the connection, and (d) the way the teacher made the connection authentic (Gainsburg, 2008). Subsequent to the observations, semi-structured, audio-recorded interviews were conducted with each of the five participants to determine the following: (a) the purpose of the connection, (b) dilemmas in making the connection, (c) the source of the connection, (d) their perceived quality of the connection, and (e) the frequency they make these connections during their teaching practice (Gainsburg, 2008).

Based on the survey and observations, Gainsburg (2008) formed categories, which included format, features, context, mathematics concepts, and purpose of the connection, to describe the nature of the real-world connections. The types of format self-reported by teachers in the survey included student-solved word problems, planned example or reference in teacher presentation, project/lab, manipulative/illustrative model, spontaneous example or reference in teacher presentation, student input, and student-discovered connection. Among these types, student-solved word problems, planned examples or references, and project/lab were commonly used by the surveyed teachers. Through qualitative analysis, features of the connection made by teachers were examined. The types of features varied among real reference artifacts, relation to students’ personal situation, student-generated real data, teacher-provided real data, physical product, and real audience. The contexts in which the real-world connection was made tended to be structural or interior designs, shopping or pricing, and banking or budgeting. Some use was made of contexts such as sports, games, household items, maps, physics, students’ habits, work
and salary, art, and TV shows. When asked about the frequency of making real-world connections, making these connections daily, weekly, and monthly were most commonly reported. Teachers also reported that their own ideas and experiences were the major source of their connection. While the purpose of closing the gap between school content and the real-world was to engage students and to simplify mathematics concepts for students to aid student comprehension, teachers encountered many constraints in spite of their good intentions (Gainsburg, 2008). Participating teachers felt that time constraints, limited resources, lack of real-world emphasis on standardized tests, and classroom management were the primary impediments that they faced in making real-world connections.

The survey data in Gainsburg’s (2008) study were obtained from a small sample size, which cannot be extrapolated to represent the general population of secondary mathematics teachers. This could be deemed a limitation of Gainsburg’s (2008) study. In addition, the data were obtained as teachers’ self-reported data, which is a secondary data source. Thus, the data from the survey cannot be generalized to characterize the ways in which mathematics teachers bring real-world mathematics into their classrooms. Despite these limitations, this study has provided a framework to portray the nature of real-world connections in mathematics education, advancing the understanding of real-world connections in the context of mathematics and clarifying the way real-world mathematics is defined.

**Preservice Teachers’ Perceptions of Real-world Mathematics**

In a longitudinal study conducted by Wubbels, Korthagen, and Broekman (1997) to investigate preservice teachers’ views of mathematics in The Netherlands, data were collected from eight participants during the four years of their enrollment in a teacher education program. Through questionnaires, interviews, and video recordings of supervision conferences, the
researchers found that secondary school mathematics preservice teachers defined the connection of mathematics to real life as “using the mathematical results in the real world, or translating the mathematical results back to real-life problems” (p. 11).

In a more recent study, teachers’ recognition of real-world mathematics was examined (Garii & Okumu, 2008). Twenty-eight participating teachers enrolled in a Master of Education program, were asked to record their mathematical encounters over a seven-day period. Participants were then asked to report these encounters, which included the recognition, practice, and use of mathematics in their everyday lives. Using data from the activity, Garii and Okumu (2008) described the types of mathematics recognized in these teachers’ daily lives, the types that were not recognized, and the implications of teachers’ mathematics recognition for teacher education.

Analysis of data allowed the researchers to generate the following categories based on the mathematical encounters teachers reported: (a) Non-mathematics, which involved number recognition such as dialling a phone number; (b) Counting and Calculations, which included counting, algorithms, and budgeting; (c) Estimating and Planning, which included comparisons, decision making, logistics, and spatial relationships; and (d) Embedded Mathematics, which included the mathematics involved in technology and pattern recognition (Garii & Okumu, 2008). Garii and Okumu (2008) reported that 8.6% of the recorded encounters belonged in the category of Non-mathematics while the remaining 91.4% encounters corresponded to the other three categories. Within those encounters, 74.3% belonged in Counting and Calculations, 24.7% belonged in Estimation and Planning, and 0.9% belonged in Embedded Mathematics.

These findings indicated that mathematics teachers tend to recognize what Garii and Okumu (2008) defined as explicit mathematics. “Activities that required [the] use of
mathematical strategizing beyond the simple recognition of numbers” (Garii & Okumu, 2008, p. 297) were considered as explicit mathematical encounters. Given that so few participants recognized Embedded Mathematics in this study, the authors suggested that the participating teachers tended not to realize a deeper and more complex use of mathematics, resulting in a disconnect among mathematics curriculum and the ways in which the subject is used and understood outside of the classroom (Garii & Okumu, 2008). Based on their data, the researchers expressed concerns about a possible focus on teaching algorithmic-based problem solving that did not involve higher-order mathematical thinking, and a transfer of superficial mathematical concepts to students. Although the participants were not representative of the general population of mathematics teachers, the researchers argued that educators need to be supported in their teaching practice to move beyond the superficial connection of mathematics to the real-world.

**Summary of Real-world Experiences in Mathematics Education**

Empirical evidence indicates that secondary mathematics teachers connected mathematics taught in classrooms to the real world by using various formats, contexts, and mathematics concepts (Gainsburg, 2008). Studies show that mathematics teachers commonly create word problems, instruction examples, and projects that involve real reference artifacts, students’ personal situations, and real data (Gainsburg, 2008). Results from Gainsburg’s (2008) study provide an understanding about the characteristics of the way teachers connect mathematics and the real world.

Wubbels et al. (1997) found that preservice teachers defined connecting mathematics to the real world with the notion of “using mathematical results in the real world, or translating the mathematical results back to real-life problems” (p. 11). Garii and Okumu (2008) found that preservice and inservice teachers recognized that mathematics is used in everyday life through
counting, making calculations, budgeting, estimating, comparisons, and decision making. The researchers also reported that the participants tended not to recognize the complex and authentic ways in which mathematics is embedded in the real world, limiting their examples to mere numerical calculations.

These studies show that there remains an incomplete understanding about real-world mathematics and the ways in which mathematics can be connected to the real world in the classroom (Gainsburg, 2008; Garii & Okumu, 2008).

**Real-world Mathematics in the Context of This Study**

Bounded by Doll’s (1989, 1993) notion of transformation, this study considered real-world mathematics as being valuable in helping learners to examine, evaluate, and reflect upon issues related to their personal reality. In the realm of mathematics education, the transformation afforded by learning experiences not only entails applying mathematical knowledge to the real world, but also the ability to analyze and interpret real issues by using mathematical principles and processes. For the purposes of this study, social issues became the real world context in which mathematics content and tasks were embedded. The transformation framework allowed this researcher to describe not only the ways in which students and preservice teachers apply mathematical knowledge by using the context of social issues, but also the ways in which they use mathematical inquiry to recognize, analyze, and challenge these social issues. The use of social issues as a context for this research was supported by Garii and Okumu (2008), whose study suggested that there were benefits associated with teaching implicit mathematical concepts through an analysis of social issues rather than falling back on the explicit and immediate connections made possible by applications of mathematics to explicit daily applications like
money. Other issues pertaining to the integration of mathematics and social justice will be discussed in the next section of the literature review.

**Connecting Mathematics and Social Justice Issues**

Socially-just teaching is a practice that is defined as “a teacher’s effort to transform policies and enact pedagogies that improve the learning and life opportunities of typically underserved students, while equipping and empowering them to work for a more socially just society themselves” (Chubbuck & Zembylas, 2008, p. 274). Educators have valued the integration of social issues and subject content in their classrooms since seminal research showed benefits in various contexts (Lim, 2008; Pedretti, 2009).

Mathematics teaching and learning through the context of social justice issues is not a novel concept. According to Brueckner (1933), one of the major goals of education is to provide learners with the opportunity to understand social order and its progression. Since mathematics content is connected to social issues through its quantitative roots, Brueckner (1933) suggested the importance of implementing topics such as financial literacy, national defence, economic organization, distribution of wealth, and improvement of labour conditions in mathematics courses. Many recent studies still emphasize this focus as a major goal of education (Esmonde & Caswell, 2010; Gutstein, 2003, 2006b, 2007; Lim, 2008; Turner et al., 2009).

The current study examined the experiences of students and preservice teachers in the teaching and learning of mathematics through the context of social issues. Thus, this literature review is organized into two sections: students’ experiences in learning mathematics through social justice and teachers’ experiences in teaching mathematics through social justice. This part of the literature review will be concluded by bringing the relevant literature into the context of
this study. Because limited research has been conducted in this area, this literature review will discuss the most off-cited researchers.

Students’ Experience in Learning Social Justice Mathematics

The literature surrounding students’ experiences in learning social justice mathematics (SJM) will be organized into the following sections: reading and writing the world with mathematics, students’ perspectives about mathematics, and authentic contexts.

Reading and writing the world with mathematics. Gutstein (2003, 2011) examined students’ experience using the objectives of reading the world with mathematics and writing the world with mathematics. These objectives respectively refer to (a) the use of mathematics to develop social consciousness and an understanding of social inequities, and (b) the draw on mathematical knowledge to examine and determine solutions to real-life problems (Gutstein, 2003, 2011).

During Gutstein’s (2011) study, his role was that of a practitioner-researcher who taught 21, Grade 12 college preparation mathematics students from a low-income community. A similar two-year study was conducted by Gutstein (2003) as he played the role of a Grade 7 teacher, who became the Grade 8 teacher for the same group of 26 students in an elementary school located in a Mexican-American community in a midwestern city of the United States. Both studies involved the goal of empowering students who are experiencing the immediate consequences of particular social issues, by integrating data about these issues into their mathematics classes. Similar data collection methods were used in both studies: observations, artifacts from students’ work, and student questionnaires. In Gutstein’s (2011) study, student interviews and focus groups were added.
In the Grade 12 mathematics classroom, social justice topics included election fairness, gentrification, immigration and deportation, HIV/AIDS, criminalization, and sexism (Gutstein, 2011). Teaching mathematics in the context of these topics allowed Gutstein (2011) to observe that it is the context of social justice issues, rather than the mathematics content, that drove the curriculum. For instance, the context of social issues such as fairness in the election process drove students to pose their own questions about fraud in election results. Their questions then led to exploration of binomial and normal distributions to understand whether the irregularities in the election outcomes were just coincidence.

Overall, Gutstein (2011) observed that students used mathematics to explore themes including race, class, and gender which interact with social issues. Documenting the interactions in his classroom and surveying students in an open-ended questionnaire at the end of the course, Gutstein (2011) concluded that the student-selected topics supported his students in developing the skills to “read and write the world with mathematics.” In terms of “reading the world” with mathematics, students demonstrated their use of mathematics to understand social inequities (Gutstein, 2011). This was found in students’ participation in the activities as they formulated questions, made conclusions from data, and discussed social phenomena to explain their findings (Gutstein, 2011). In terms of “writing the world”, students showed a sense of responsibility in remediating social inequities as they expressed in a student survey the need to take part in “combat[ting] against oppression and injustice in our communities and in the world” (Gutstein, 2011, p. 36). In this study, students appeared to have learned to use mathematics to make judgements about the real world (Gutstein, 2011).

Similar to the experiences of his Grade 12 students, the 26 Grade 7 and 8 students in the study conducted by Gutstein (2003) were engaged in classroom activities and projects that
required students to analyze data on a specific social issue: the inequity in distribution of global resources. Students experienced in-class simulations, during which students were given the number of people and the total wealth of each continent and were asked to distribute themselves proportionally to an area of the classroom. Students were then given cookies to represent proportional equivalence to the amount of global wealth belonging to each continent. The mathematics in the activity involved content and skills from the data management strand (e.g., calculating averages), proportional reasoning (e.g., equivalent ratios), and number sense (e.g., calculating percentages) (Gutstein, 2003).

Through triangulation of data from reflection journals, participant observations, open-ended surveys, and document analysis of students’ work and test scores, results suggested that students gradually gained the ability to connect mathematical ideas to real-world social issues (Gutstein, 2003). For example, students showed an understanding of the proportional relationships between the classroom representation and the actual situation of resource distribution. Furthermore, because the activity allowed students to explore wealth allocation among continents, Gutstein (2003) found that one of the students extended her inquiry to the inequity within a continent.

Data collected from students’ work indicated students’ ability to “construct their own solution methods on non-routine problems” (Gutstein, 2003, p. 54). This was found in students demonstrating a variety of ways to problem-solve, as well as communicating their problem-solving strategies by using mathematical reasoning. For example, in a non-routine algebra problem, one of the students showed a unique solution and provided logical reasoning to support his problem-solving method, which was never introduced to the student by the researcher. Another example of a non-routine problem was the challenge for students to determine areas of
countries using a classroom world map. Students were given the opportunity to work in small
groups. Each of the six groups estimated the areas of the countries by using unique strategies,
leading Gutstein (2003) to conclude that students showed greater competence in the skills of
mathematical reasoning and problem solving as a result of the context of the non-routine
problem (Gutstein, 2003).

Students’ perspectives about mathematics. In Gutstein’s (2003) study, of the 25 Grade
8 student respondents on a survey, all but three students appeared to have changed their views
about mathematics when it was taught through the context of social justice issues. Although not
all students had expanded their personal interest in mathematics, students still expressed new
perspectives about viewing mathematics as a valuable tool for problem solving (Gutstein, 2003).
Students indicated that they viewed mathematics not to be confined to the classroom, but to be a
meaningful part of everyday life all around the world (Gutstein, 2003). After the study, students
reported that they regarded mathematics to be a subject that was broader than just numerical
calculations and 23 of the 25 of the middle-school participants said that they gained new positive
attitudes towards mathematics and recognized the connections among mathematics and the real-
world because of their experience. Although the number of respondents to the survey was small
because the study was conducted in the context of Gutstein’s (2003) class, the multiple data
sources and the two-year length of his study contributed trustworthiness to these findings.

Brelias (2009) reported similar outcomes in her recent doctoral dissertation: an
investigation of the use of socially relevant mathematics applications in two Grade 12
mathematics classes from two separate urban high schools in the midwestern United States. The
mathematics courses, Statistics and Mathematical Modelling, were selected based on the
inclusion of mathematics applications that involved social issues in the curricula. Specifically,
the study focused on investigating the nature of the inquiry in social justice mathematics and students’ views of using mathematics as a tool for social inquiry.

Brelias (2009) collected data from 40 hours of classroom observations, interviews with each of the two teachers, 60 individual student interviews, and document analysis that included curricular materials and students’ work. The mathematics content of the courses was connected to social issues through the following socially relevant applications: the death penalty, social security, distribution of income, environmental pollution, scarcity of resources such as health vaccines, and equity in school funding. Through these contexts, students were asked to generate a hypothesis prior to working with numerical data, use mathematics to investigate the issue, explore the implications of their findings, and discuss possible explanations for their findings. For example, on the topic of the death penalty, an open-ended question was posed by the teacher that required students to formulate a problem associated with the topic. Students began to discuss equity issues associated with the death penalty and generated hypotheses about racial discrimination being related to execution rates. Students then participated in mathematical activities that involved experimental distribution of chi square, theoretical probability, and experimental probability to test their hypotheses. From Brelias’ (2009) observations, students concluded that racial bias was found to be associated with death penalty execution.

Using data from observations and interviews, Brelias (2009) reported that such activities allowed students to choose specific mathematical tools to explore social inquiry. When looking into social justice issues, the problems formulated by the teacher and the students allowed students to explore different ways to represent situations mathematically. Furthermore, findings indicated that drawing conclusions from their hypotheses testing was not always simple. For example, in one of the statistical analysis activities, students explored equity issues in
employment and experienced a conflict because opposite conclusions surfaced from their mathematical work. Thus, the researcher asserted that these applications allowed the integration of “ambiguity, complexity, and uncertainty” (Brelias, 2009, p. 256), which tend to be characteristics of problems in real-life. By having these characteristics reflected in the investigations, Brelias (2009) found that students’ common misconception that mathematics is “certain, objective, neutral, and value-free” (p. 256) was challenged.

Referring to the activity of questioning the equity of the death penalty, students felt that the issue was too complex to be objectified and answered by challenging whether there is fairness in execution. This example suggested that students’ recognized that mathematics is not necessarily a definitive tool for answering moral and ethical questions. The researcher concluded that students recognized the limitations of mathematics as an inquiry tool for investigating social issues. These limitations include the oversimplification of the issue, objectification of human beings, irrelevance for moral and ethical questions, and inadequacy in explaining social problems (Brelias, 2009). Despite recognizing these limitations, students felt that mathematics is valuable in initiating investigations about social justice issues. These results showed that students learned the value of mathematics as a tool in uncovering social inequalities, which could lead to social change (Brelias, 2009).

From observation data, Brelias (2009) drew rich findings regarding the nature of students’ participation in activities that integrated mathematics with social justice issues. It is necessary to point out that both Grade 12 mathematics courses in Brelias’ (2009) study were mathematics elective courses designed for senior high school students. Thus, participants in the study might have shared similar interests and appreciation for mathematics prior to learning mathematics by investigating social issues.
Another limitation was that one of data sources in this study was students’ work collected as artifacts for analysis. The researcher acknowledged that limited completion of class work and homework became an issue in the data collection process; thus, results based on students’ participation were supported mainly by the researcher’s observations and were underrepresented by student-produced data.

**Authentic contexts.** Turner et al. (2009) conducted a two-year study in an afterschool mathematics club, which provided elementary Mexican-American students, who are visible minorities, the opportunity to learn mathematics as they investigated social issues relevant to their local community and personal situations. Approximately 20 Grade 3 through Grade 6 students were engaged in two extracurricular projects in the study. The first involved students in creating surveys, tabulating data, and interpreting data using fractions and percentages to describe the perspectives of community members on the national issue of immigration. The other project involved students in rebuilding a community park that was lost to a disaster. Using geometry and measurements, the student participants measured perimeter and area and calculated proportional relationships to create scale drawings of their new park design. Because these topics were based on issues in schools and in the local community, and students’ interests and needs, Turner et al. (2009) suggested that such a context for mathematics learning was authentic to students.

From video-recorded data of club sessions, observation data of the club sessions, and individual semi-structured interviews with students, Turner et al. (2009) reported that the extracurricular mathematics learning opportunity had allowed students and their families to play the role of experts due to their unique experiences of marginalization and understandings of social injustices (Turner et al., 2009). Findings indicated that students’ informal knowledge
about the community and classical knowledge learned from the school curriculum were integrated. For example, in the immigration project, students wished to understand community members’ perspectives on immigration. It was this desire that drove the design of a survey, thus, providing a context for mathematical activity. Similarly, informal knowledge about the community was integrated with students’ classroom mathematical knowledge in the park rebuilding project. Turner et al. (2009) found that students’ previous experience in the community park played a role in their decision on an appropriate scale for their park design drawings. From these examples, the researcher concluded that the integration of multiple knowledge bases in such authentic activities empowered students to engage in mathematical investigations and understanding of social injustices. Turner et al. (2009) stated that “a consequence of grounding mathematical investigations in authentic situations is that the situation or issue often drives the mathematical activity... [which is] potentially a transformative aspect of the work” (p. 150).

As recognized by Turner et al. (2009), this study was conducted in the context of an elementary school, which tends to be an environment in which cross-curricular integration is common. Thus, findings from this study cannot represent such extracurricular activities in other settings such as secondary schools.

**Summary of students’ experiences.** In this section, I discussed findings from recent studies that sought to understand students’ experiences when mathematics was integrated with social justice issues. These findings indicated that students were able to “read and write the world” using mathematics and gain new perspectives about mathematics because linking mathematics and social justice issues provided authentic contexts for mathematics learning.

From studies conducted by Gutstein (2003, 2011), both Grade 8 (Gutstein, 2003) and
Grade 12 (Gutstein, 2011) students showed that they were able to use mathematics to understand social issues and to determine solutions to those social problems. The Grade 8 students also expressed their interest in and new perspectives about mathematics as a valuable tool at the end of the study (Gutstein, 2003). Similarly, Brelias (2009) reported that the high school students in her study regarded mathematics as a valuable instrument to investigate and understand social justice issues.

In a study that involved elementary students in extracurricular projects, Turner et al. (2009) found that the integration of mathematics and local issues provided a rich context for students to use their mathematical knowledge and knowledge about the local community, suggesting that such learning opportunities provided authentic contexts that could drive mathematical activity.

In the next section, I will discuss findings that described teachers’ experiences in teaching social justice mathematics.

**Teachers’ Experience in Teaching Social Justice Mathematics**

The literature surrounding the experiences of teachers and preservice teachers in teaching SJM will be organized into the following sections: conception of social justice mathematics, overcoming misconceptions about mathematics, professional development, and difficulty in finding balance.

**Conception of social justice mathematics.** A graduate course was designed for secondary teachers to explore teaching mathematics for social justice in a study conducted by Bartell (2006). Eight secondary mathematics teachers designed, implemented, observed, and revised their social justice mathematics lessons through the course. Attending the course once a week for two and a half hours over a 15-week period, these teachers were engaged in discussions
based on assigned readings, written and verbal reflections on the readings, and collaborative
design of lessons that integrated mathematics and social issues. The purpose of this study was to
determine teachers’ conceptions of teaching mathematics for social justice as they evolved over
the duration of the course. By gathering data from class discussions, teachers’ reflections based
on the readings, and individual interviews at the beginning and at the end of the course, Bartell
(2006) was able to identify themes about the ways in which the teachers’ conceptions changed
during the course.

At the beginning of the course, Bartell (2006) found that three of the teachers disregarded
critical thinking as a skill that is necessary to assess social justice issues. Their definition of
teaching mathematics for social justice was limited to relating the subject to society and various
cultures for learners. These teachers appeared to have neglected the aspects of allowing students
to understand social issues critically and take action to remediate these issues. Thus, Bartell
(2006) commented that the teachers in her study generally did not acknowledge critical thinking
and action-taking as an integral component of teaching mathematics for social justice; however, as
teachers participated in the course, they began to expand their conception of critical thinking,
which remained consistent through the course (Bartell, 2006). Four of the eight teachers began to
appreciate that action-taking was one of the goals of integrating mathematics and social justice.
In addition, Bartell reported that two teachers broadened their definitions to include notions of
raising students’ awareness about social inequities and the use of mathematics to investigate
injustices they may encounter or have encountered.

When teachers were given the opportunity to design lessons collaboratively and
implement these lessons in their own secondary classrooms, Bartell (2006) emphasized a major
outcome of such activities based on observations: teacher participants self-reported that they
were able to recognize conceptions of social justice mathematics within their own teaching practice and from their students’ responses. An example that indicated the emergence of this theme was in a lesson designed by the teachers to investigate “prison populations and school achievement” (Bartell, 2006, p. 3). Teachers reported that their students responded by recognizing the importance of education as a key factor in rates of crime and incarceration. During their course meeting, teachers recognized that identifying the root of the social problem was a key goal of teaching mathematics for social justice.

In another lesson design study that integrated proportional reasoning with an examination of the impact of the gap between minimum and living wage, teachers encouraged students to seek out possible solutions for inequities related to wage discrepancy. Bartell (2006) concluded that after this lesson design experience, the teacher participants demonstrated a stronger understanding of action-taking as an instructional role for integrating mathematics and social justice issues.

Through peer discussions during the course and reflections on their experiences after using the collaborative teaching units in their own classroom, participating teachers broadened their conceptions of teaching mathematics for social justice. They recognized that mathematics can be used as a tool for social inquiry, social justice mathematics can raise students’ awareness of social issues, and social justice mathematics can empower students to take action on social issues (Bartell, 2006).

In addition to the benefits of social justice mathematics for illuminating aspects of social problems, the teachers in the study conducted by Bartell (2006) appeared to understand its contribution to mathematics learning. In their discussions, teacher participants also addressed the traditional role of mathematics as a gate-keeping subject and felt that it was important for
teachers to help students overcome difficulties in mathematics learning. Findings from observations of the course meetings indicated that teaching mathematics for social justice also meant challenging the traditional role of mathematics in the education system—by teaching meaningful mathematics through the context of social justice issues, participating teachers felt that students may have more opportunities to develop mathematically (Bartell, 2006).

Similar findings emerged from a case study that involved preservice elementary teachers in a social justice mathematics course. Echoing the findings of other researchers and opinions of mathematics educators, Bateiha (2010) suggested that the lack of relevance of classroom mathematics is an issue that may impede student achievements. This issue could stem from preservice teachers’ limited experience with curriculum integration and the design of social justice mathematics units as a part of their formal mathematics teacher education (Bateiha, 2010). To test her hypothesis, Bateiha (2010) studied the impact of an elementary preservice mathematics course that was taught through the context of social justice issues. Triangulating data collected from multiple modalities including field notes, reflective journal, preservice teachers’ journals, preservice teachers’ mathematics work, online discussions, and midterm conferences, Bateiha (2010) found three major themes related to participants’ course experience: (a) enjoyment of learning mathematics for social justice, (b) a critical perception of mathematics, and (c) a critical perception of social issues and their connection to mathematics.

Bateiha (2010) reported that 14 out of 19 preservice teachers expressed negative attitudes such as fear, anxiety, and dread towards mathematics learning at the beginning of the course; however, at the end of the semester, all 19 participants indicated that they held positive attitudes towards the subject. Preservice teachers attributed their changed attitude to positive course experiences, which focused on open-ended problem solving using student generated approaches,
not traditional, algorithmic procedures. Evidence indicated that preservice teachers gained a sense of enjoyment from their social justice mathematics learning experience. Such findings allowed Bateiha (2010) to conclude that there was a transformation in preservice teachers’ attitudes towards mathematics and mathematics learning.

According to Bateiha (2010), preservice teachers’ critical perception of mathematics was found to be another aspect that was transformed in response to the course experience. Initially, elementary preservice teachers regarded mathematics as a domain that is fragmented into computational procedures and rules for whole numbers, fractions, percentages, and exponents. At the end of the course, conceptual understanding of mathematics was one of the changes that participants had indicated. For example, one of the participants mentioned that as a learner, he/she “was taught repetitive procedures and had no clue as to what was behind the concept” (Bateiha, 2010, p. 137) and that this course provided “a very new way of solving math problems” (Bateiha, 2010, p. 137).

Consistent with participants’ self-reported transformation, Bateiha (2010) observed preservice teachers making connections among mathematics concepts and the real world, demonstrating a variety of representations in problem-solving, and showing conceptual understanding of specific procedures. They “developed questions outside the scope of mathematical objectives” (Bateiha, 2010, p. 137) and “justif[ied] and defend[ed] their solutions” (Bateiha, 2010, p. 138). For example, one of the preservice teachers recognized that “an odd number minus an odd number equals an even number” (Bateiha, 2010, p. 139) and a created a proof to justify this conjecture.

From students’ written reflections and the researcher’s observations, Bateiha (2010) also found critical perceptions of social issues as a transformation of perspective. Prior to the course,
some students indicated limited awareness of any social issues in their written journal. Similarly, observation made from class discussion of social issues such as health care reform allowed Bateiha (2010) to conclude that these preservice teachers lacked a deep understanding of the consequences of social inequities. For example, when discussing the issue of health care, students immediately established a “right” and “wrong” side of the issue based on their political interest without considering other factors, outcomes, and “alternative perspective to the two sides” (Bateiha, 2010, p. 153). After the debate activity on the health care issue, teacher participants reflected on the activity by discussing health insurance costs, the cost of health care per capita, and United States financial data. This led the researcher to conclude that participants’ views were transformed from “forming judgements about social issues [by] simply relying on emotion[s] and opinion[s]” (Bateiha, 2010, p. 155) and having dualistic views about fairness in social issues to using evidence to support their views during debates of social issues.

**Overcoming misconceptions about mathematics.** In addition to a change in the conceptions of social issues to move beyond such dualistic views, Bateiha (2010) asserted that observation data also indicated a change to preservice teachers’ view of mathematics. Participants learned to recognize that finding an incorrect answer or using the wrong procedure in mathematical problem solving are essential steps in mathematical growth. This shift suggested that the focus of learning has changed from the final outcome to the process of working with mathematics (Bateiha, 2010). When solving mathematical problems through the context of social justice, participants gained confidence in determining their own method of problem solving rather than relying on the demonstrated procedures (Bateiha, 2010). Through discussions, the researcher found that preservice teachers also preferred devising problem-solving strategies by themselves rather than being told to use a specific algorithm. The researcher concluded that these
findings were significant indicators of preservice teachers’ preference for mathematical procedures that promoted critical thinking, in contrast to the traditional approach that favours “memorizing and mimicking” (Bateiha, 2010, p. 124).

Bateiha’s (2010) case study was conducted by collecting data from multiple sources. Triangulation of data strengthened the trustworthiness of her findings. Bateiha’s (2010) study provided a rich understanding of the progression of preservice teachers’ conceptions of social justice issues and mathematics in a teacher education course that integrated the two topics.

**Professional development.** In contrast to the focus of preservice teachers’ conceptions and experiences in the study conducted by Bateiha (2010), Esmonde and Caswell (2010) facilitated monthly professional development sessions over one year for the purpose of understanding the experience of teachers in designing projects for teaching mathematics with a focus on social justice issues. In these sessions, educators, including five primary teachers, one graduate student studying mathematics education, one school principal, two preservice teachers from the researchers’ university, one teacher-librarian, one community support worker, and one mathematics consultant from a local school board collaborated on developing inquiry projects relating to social issues. These projects were then implemented in Toronto elementary schools that were identified, using provincial assessment data, as being below provincial literacy and numeracy standards. The goal of the study was to determine the way educators conceptualize the best way to teach mathematics for social justice in the development of these projects. To answer this research question, Esmonde and Caswell (2010) used the six principles of teaching for social justice developed by Cochran-Smith (2004) as a framework. The six principles are: (a) involving a community of learners, (b) building on students’ cultural knowledge and interest, (c) teaching skills to families and communities, (d) collaborating with families and communities, (e)
diversifying assessment, and (f) promoting activism (Esmonde & Caswell, 2010). The researchers emphasized that the principles were used as a framework to guide the understanding of educators’ professional development rather than to evaluate educators’ fulfillment in the project.

Data were obtained by video recording each professional development session and by collecting artifacts produced in the sessions. Esmonde and Caswell (2010) outlined three main projects that were developed: (a) the Water Project, in which students recorded and calculated their own family’s water consumption and advocated for water conservation; (b) the Language Project, in which students collected and displayed data on mother languages students spoke at their school to advocate for multiculturalism; and (c) a project that invited families to share their indigenous knowledge on learning numbers to create a kindergarten counting book.

The researchers found that multiple components of the projects aligned with all but one principle, which was to diversify forms of assessment. This principle was not observed in the projects because teachers focused mainly on the activities in the classroom. The projects had been designed for communities of learners: students working in groups, each responsible for a specific, designated task. In the Language Project and the counting book project, students’ cultural knowledge and interests were valued and were used as a basis of the projects. All projects had components of social activism, which addressed the socio-political aspects of teaching mathematics for social justice.

Because teachers used their knowledge about students’ cultural background and involved students from their own classrooms in designing the projects, the researchers saw a difference between their experience in such context and their experience in professional development settings that merely provide prepackaged materials with instructions imposed into their practice.
Unlike typical professional development sessions that are usually structured with a predetermined agenda, educators at various levels had the opportunity to contribute components to this project could both support numeracy achievement and stimulate social activism. For example, the Water Project was developed when teachers learned that some their Grade 5 students had shared the experience of not having drinkable water—in fact, one had supported his family by obtaining water in heavy jugs because clean water was not readily available to them. From their classroom interactions, teachers also learned that immigrant students had a sense of pride for the home country, which supported the development of the Language Project.

Based on observations of teachers’ involvement in integrating students’ background into the projects, Esmonde and Caswell (2010) concluded that this one-year project had allowed rich professional learning to take place. The collaboration of teachers in this study allowed the researchers to assert that the professional development gained by participants was more important than the developed resources (Esmonde & Caswell, 2010). The researchers claimed that the experiences these educators gained may stimulate them to continue collaborating with others in their profession and commit to the integration of social justice in mathematics education (Esmonde & Caswell, 2010).

**Difficulty in finding balance.** Because social justice mathematics integrates two disparate bodies of knowledge, one of the challenges for classroom teachers is to find the balance among mathematics content and social issues so that the integrity of each is upheld. In a study that involved 21 Grade 12 college preparation mathematics students in a low-socioeconomic status area of Chicago, mathematics was taught through student-selected social issues (Gutstein, 2011). These issues included HIV/AIDS, neighbourhood displacement, immigration, criminalization, and sexism. By integrating topics of interest identified by students into
mathematics lessons, the researcher led activities such as modelling the change of HIV/AIDS infection cases over time and calculating mortgages to investigate housing prices and neighbourhood displacement. Sources of data included video and audio recordings from 41 classes, researcher’s observations, researcher’s journal, student surveys, student focus groups, and students’ work.

The goal of the researcher in teaching mathematics for social justice is to encourage students to take part in socio-political change (Gutstein, 2011). As the practitioner-researcher who taught these students, Gutstein (2011) talked about his experience of the complicated and challenging aspects to navigate through both mathematics and social issues. If the lessons were placed on a spectrum with mathematics and social issues at either end of the extremes, then these lessons could be placed on various positions of the continuum more often than on the center, which represents the equal balance of both topics (Gutstein, 2011). Depending on the topic, students used mathematics to explain the social phenomenon. In other cases, students used social analysis to explain mathematics. For example, using graphs and data modelling, students sought to understand the changes of number of infections over a 35-year period. When students found that of the female HIV/AIDS diagnoses in Chicago in 2006, 80% were of African Americans, they discussed survival issues African American women experience that would lead to higher exposure to infections. From this scenario, Gutstein (2011) observed that students used social phenomena to explain numerical data.

Although multiple data sources provided triangulation for data analysis, findings were predominately from the perspective of the researcher because Gutstein’s (2011) role was that of both classroom teacher and researcher in this study. Furthermore, deeper understanding may have been achieved if Gutstein (2011) used the conceptual framework of models of curriculum
integration (Fogarty and Stoehr, 1995) to examine his experience in balancing mathematics and social justice issues. From Gutstein’s (2011) findings, it is suggested that designing integrated mathematics and social justice issue lessons in the classroom takes time and experience for both teachers and students.

**Summary of preservice teachers’ and teachers’ experiences.** In this section, findings that allowed insights into the experiences of teachers and preservice teachers were discussed. Being involved in the practice of teaching mathematics in the context of social justice, participants expanded their conceptions of social justice mathematics, were able to overcome their misconceptions about mathematics, experienced professional growth, and recognized the difficulty in balancing topics in mathematics with social issues.

Findings from a study conducted by Bartell (2006) indicated that secondary mathematics teachers showed an understanding of the goals of integrating mathematics and social justice issues. Similarly, when preservice elementary teachers were involved in a social justice mathematics course, Bateiha (2010) found that they were able to make connections between mathematics and the real world. Bateiha (2010) also found that the preservice teachers were able to overcome their misconception that mathematics learning is about memorizing procedures and achieving correct answers.

When mathematics was integrated with social justice issues through projects designed by elementary teachers as a professional development activity, Esmonde and Caswell (2010) found that these teachers demonstrated their knowledge about students’ cultural background when creating the projects. In such an opportunity, teachers experienced collaboration with colleagues and integration of their students’ background when designing these projects, which became a rich professional development experience.
Despite the benefits discussed in connecting mathematics and social justice issues, Gutstein (2011) also mentioned that he experienced difficulty in balancing both topics as a practitioner-researcher of his study. He reported that his class used both mathematical data to discuss social issues and social issues to explain data analyses that they performed. Thus, he found it challenging and asserted that time and experience would be required to teach mathematics in the context of social justice issues.

In the next section, experiences of both students and teachers will be discussed by presenting findings that related both in mathematics and social issues integration.

**Relating the Experiences of Students and Teachers**

Reagan, Pedulla, Jong, Cannady, and Cochran-Smith (2011) became interested in understanding the relationship between teachers’ practice and students’ achievement in the context of teaching mathematics for social justice. Their study involved 22 beginning elementary teachers and students in their classes from a single urban public school in New England. The 22 participants’ teaching practices were observed in their mathematics classrooms twice over four to six weeks. Observable items, which were teaching practices relevant to the principles of teaching mathematics for social justice, were created based on Cochran-Smith’s Teaching for Social Justice Observation Scale (TSJOS). Examples of items included “the instructional strategies and activities respected students’ prior knowledge and preconceptions inherent therein,” “the lesson was designed to engage students as members of a learning community,” “connections with other content disciplines and/or real-world phenomena were explored and valued, and “students were actively involved in thought-provoking activity that often involved the critical assessment of procedures” (Reagan et al., 2011, p. 27). For each observable item, teachers were rated using the Reform Teaching Observation Protocol-Plus (RTOP+), which is a five-point scale ranging from
0 to 4. A score of 0 would indicate that no such teaching practice was observed and a score of 4 would indicate that the observable item was very descriptive in the lesson (Reagan et al., 2011).

To measure students’ achievement, district-developed, summative mathematics tests were administered to the students prior to and at the end of the unit in which their mathematics teachers were observed. Tests were scored by the classroom teachers and they reported the number of correct items out of the seven multiple-choice and three open response questions on the tests. Students’ achievements were represented by proportions of correct answers on the test.

Data analysis indicated that the mean score for all teacher participants was 2.23 with standard deviation 0.66. Teachers’ RTOP+ scores ranged from 1.16 to 3.18, indicating a moderate amount of observed practices that are related to the principles of teaching for social justice created by the researchers for the purpose of this study. The mean score for the observable items ranged from 1.16 to 2.80, with the lowest mean score in the item of connecting to real-world phenomena (Reagan et al., 2011). Similar to findings of studies discussed earlier, this outcome suggested that the novice teachers had difficulty in connecting mathematics to real life.

The researchers “calculated the classroom mean of the proportion of items answered correctly by each student in that class” (Regan et al., 2011, p. 29). Because not all participating teachers administered a pretest, nine classroom means were calculated from the pretests while 22 classroom means were calculated from the post-tests. In pretests, the mean of the nine classroom mean proportions was 0.41 and in post-tests, the mean of the 22 classroom means was 0.73 with standard deviation 0.13. This suggested that students “averaged 73% correct” (Reagan et al., 2011) on the post-test.
Reagan et al. (2011) stated that there were high variations in both teachers’ and students’ outcome measures. To determine the relationship between teaching practice and students’ achievement, the researchers correlated teachers’ TSJOS scores with students’ unit test scores. Correlation was computed to be $r = 0.44$ ($p < 0.05$). This figure indicates a positive, significant relationship between the practices of teaching mathematics for social justice and students’ mathematics achievement.

It is noteworthy that the comparison was based on mean unit test scores of different grade levels ranging from Grade 1 to Grade 6. Despite this limitation acknowledged by the researchers, Reagan et al. (2011) argued the importance of this study because investigations on social justice mathematics have been bounded to research on teachers’ and students’ experiences rather than their practice and achievement.

**Mathematics Learning in Extracurricular Environments**

Research has sought to describe the ways mathematics extracurricular activities may provide learning opportunities for students. By examining students’ learning experiences in such environments and investigating teachers’ understanding of teaching mathematics in non-traditional settings using non-traditional contexts, much has been learned about the potential benefits of mathematics-related extracurricular activities (Diez-Palomar, Varley, & Simic, 2006; Francisco & Maher, 2011; Mueller & Maher, 2009; Papanastasiou, 2004; Turner et al., 2009).

**Students’ Experiences in Extracurricular Mathematics Learning Opportunities**

In the discussion of students’ experiences in extracurricular mathematics learning opportunities, literature about this topic will be organized into the following sections: mathematics-integrated social justice projects, mathematical arguments and reasoning, and variables that contribute to successful mathematics clubs.
**Mathematics-integrated social justice projects.** Diez-Palomar et al. (2006) explored an afterschool mathematics club that had a social justice component. The goal for integrating mathematics and social justice in this extracurricular club setting was grounded in the belief that education can be a tool for social mobility and change, especially for students who are experiencing marginalization. The purpose of the study was to investigate the teaching and learning of mathematics in the club and to determine teaching approaches that support marginalized students. Twice a week throughout one school year, Grade 4 and Grade 5 students attended club sessions that were conducted by undergraduate, graduate, and post-doctoral student facilitators. Data was collected through video-recordings of the sessions and field notes made by participant-observers.

Diez-Palomar et al. (2006) found that when solving mathematics problems that were embedded in the real life experience of gardening, “such as measuring and evenly dividing up rows, calculating seed depth, and charting plan growth” (p. 2), students connected to their prior experiences and cultural background. For example, one of the students shared with the others her experience in seed planting when helping family members to farm in her native country. When solving mathematics problems, students shared alternative strategies, many of which were based on their indigenous knowledge (Diez-Palomar et al., 2006). For example, in one of the observed interactions between two students, one student showed the other the multiplication strategy from her prior knowledge when solving 48 x 5 together. Rather than the formal method that involved multiple digits in vertical columns, the student communicated using her native language, Spanish, and demonstrated the lattice method of multiplication to her peer.

The researchers reported that the mathematics club had allowed increased student engagement when mathematics learning is embedded in the context of social justice issues,
especially when these are issues that the students were experiencing. For example, one of the social justice mathematics activities was an immigration project that students designed to obtain input from other students about the issue of immigration and criminalizing illegal immigrants. This issue directly related to students who were new immigrants or children of immigrants. Furthermore, this afterschool learning opportunity allowed students’ to integrate their prior and native knowledge into their mathematical activities. Thus, Diez-Palomar et al. (2006) concluded that this learning opportunity could support students in counteracting barriers that hinder them from optimal achievements. Because video-recordings and observations were the only data collection methods, the researchers might benefit from additional sources of data.

**Mathematical arguments and reasoning.** In a Grade 6 afterschool program known as the Informal Mathematical Learning Project, Mueller and Maher (2009) investigated students’ mathematical reasoning and argumentation during a four week period. Each afterschool session, attended by 24 students, was held for about one hour. During the sessions, students were engaged in mathematical problem solving tasks that required them to use Cuisenaire rods. Examples of the tasks included: “If I gave the yellow rod the number name five, what number name would I give to the orange rod?” (Mueller & Maher, 2009, p. 17) and “If I call the blue rod one, I want each of you to find me a rod that would have a number name one-half” (Mueller & Maher, 2009, p. 17). Each of the tasks was designed in such a way that they allowed collaboration to create a variety of solutions through mathematical reasoning.

Eight of these students were selected for focus group interviews based on their below standard state exam score. Other data sources included observations, video-recordings, and students’ work. From the data collected, Mueller and Maher (2009) categorized students’

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1 Cuisenaire rods are a set of “10 coloured wooden or plastic rods that increase in length by increments of one centimetre” (Mueller & Maher, 2009, p. 15).
reasoning strategies during their collaborative problem solving in the informal mathematics learning environment in the following types: direct reasoning, reasoning by contradiction, reasoning by cases, and reasoning using upper and lower bounds. For example, in answering the question: “If I call the blue rod one, I want each of you to find me a rod that would have a number name one-half” (Mueller & Maher, 2009, p. 17), students created models using the rods, compared the rods, and discussed length equivalence to find the solution. Thus, Mueller and Maher (2009) concluded that it is natural for students to use different types of arguments and reasoning strategies in their mathematical problem solving processes. From their observation data, the researchers pointed out that when students made incorrect arguments, their flawed reasoning often contributed to meaningful mathematical understanding.

Mueller and Maher (2009) also reported that students discussed their ideas and challenged one another. For instance, during a task in which students were required to find “a rod named one-half when the blue rod is named one” (Mueller & Maher, 2009, p. 19), two students discussed the problem and placed rods adjacent to the blue rod. Together, the students found that the purple rod, which was 4 cm, was too short to be one-half of the blue rod, which was 9 cm. Similarly, they found that the yellow rod, which was 5 cm, was too long to be one-half of the blue rod. Thus, students decided no rod could be found to represent one-half of the blue rod. In another group of students, who were also solving this problem, one student explained to his group members that if they line up nine white rods, each being 1 cm in length, next to the blue rod, the nine white rods cannot be divided into two groups. Thus, the students understood that no rod could represent one-half when the blue rod is named one. Through these small group activities, the researchers asserted that collective mathematical understanding occurred.
As the project progressed over five sessions in a four-week period, student participants built a community around argument sharing and argument challenging (Mueller & Maher, 2009). Students’ discussions and interactions indicated that this learning environment enhanced not only students’ justification of their own solutions, but also their confidence in challenging solutions generated by their peers (Mueller & Maher, 2009).

Overall, the researchers concluded that this informal mathematics pedagogical setting nurtured students’ collaborative and individual learning. The need for extracurricular informal mathematics pedagogy is supported by this study as Mueller and Maher (2009) stated that “students’ success in justifying their ideas and in engaging in thoughtful mathematical activity can be underestimated by teachers” (p. 8). Despite providing insights into the role of informal mathematics learning environment on mathematical reasoning, a four week observation period posed a limitation in this study. Furthermore, focus group participants included only students who were underperforming in the state assessment exam. This selection criterion was not clarified by the researchers. The data collection from the student focus group could benefit from including a wide range of students.

The research on this type of informal mathematics learning opportunity brings implications to teaching practice as educators could apply teaching approaches successfully implemented in informal mathematics learning environments to the formal mathematics instruction.

**Variables that contribute to successful mathematics clubs.** In a study conducted by Papanastasiou (2004) to examine the variables that have played a role in the success of a middle school mathematics club, questionnaires were administered to 107 out of 163 student club members from Grade 5 to Grade 8 of a single urban school. These students attended a
mathematics club that was held weekly for an hour in the morning prior to the start of regular classes. Two middle school mathematics teachers were responsible for facilitating the sessions and snacks were provided at the club meetings. Every week, students participated in group contests and bingo, both of which consisted of completing numerical calculations. The third activity was Thinker Math, which consisted of filling in appropriate numbers into the blanks of a short paragraph that described a real-life scenario. Winners of the competitions were provided with candy prizes.

The survey included questions about variables that relate to student club members’ attendance. Questions were presented using Likert scales, with “1” representing strongly disagree and “4” representing strongly agree. From the data obtained, being with friends at the mathematics club was one of the most common reasons for attendance. Papanastasiou (2004) reported that the mean score on the likert scale was $3.69 \pm 0.50$ (mean and standard deviations) for this variable and that 71.0% of the students strongly agreed with this reason. The next most common characteristics that contributed to students’ attendance included the relaxed way of mathematics learning, being provided with food at the mathematics club, and working in a group. Thus, the researcher concluded that evidence has shown that students enjoy the group work aspects of extracurricular mathematics learning (Papanastasiou, 2004). Although research has shown that variables that contribute to a high rate of attendance at a math club include extrinsic factors such as socializing opportunities and food provision, Papanastasiou (2004) suggested that these extrinsic factors did not represent negative results. This was because the researcher found that these extrinsic factors did not hinder students from mathematics learning once students decided to attend.
Despite the large sample size, Papanastasiou (2004) stated that only descriptive statistics were performed with the data because only 107 out of 163 students completed the survey. Thus, “the ratio of students who had responded to the questionnaire to the students who did not respond to it was too unequal to be able to obtain any stable or unbiased results” (p. 164) from inferential statistical analysis. The researcher acknowledged this issue as a limitation of the study. With the questionnaire as the only instrument of data collection, student interviews or focus groups may contribute to richness of findings.

**Teachers’ Experiences in Extracurricular Mathematics Teaching**

In a parallel study conducted on the Informal Mathematical Learning Project, Francisco and Maher (2011) examined the way teachers attended to students’ mathematical reasoning. The Informal Mathematics Learning Project in this research was implemented for a year by nine facilitators. These facilitators included two elementary school teachers, four middle school teachers, and three mathematics education specialists who had experience working with classroom teachers. Similar to the study performed by Mueller and Maher (2009), 24 Grade 6 students were given mathematical tasks involving Cuisenaire rods such as “Find a rod X that is a/b as long as Rod Y” (Francisco & Maher, 2011, p. 53). Another mathematical problem students were required to solve as the following: “make as many different towers three cubes tall as is possible when selecting from three colours” (Francisco & Maher, 2011, p. 53). These tasks were designed to allow collaboration and involved mathematical topics such as algebra, fractions, counting, and probability. In small groups, students were asked to solve the problem and justify their solution using mathematical reasoning while the project facilitators made observations and video-recordings of the process. Subsequent to each session, teacher participants had debriefing meetings.
Analysis of data suggested that teachers’ learning from observations, examination of student work, and peer discussions could be organized into five themes: (a) identifying students’ misconceptions in mathematical conceptual understanding, (b) recognizing and understanding different types of reasoning strategies that students employed, (c) attending to students’ articulation of mathematical ideas, (d) realizing that students are able to make mathematical justifications when given the opportunity, and (e) learning that there are various conditions that support students’ growth of making mathematical arguments.

From observing students as they created solutions and communicating with students as they justified their reasoning, the researchers observed that, in this setting, teachers stepped back from their role as an authority figure. From this experience, teacher participants appeared to have learned that students need to be provided with appropriate settings to encourage the development of mathematical reasoning and recognized that students are able to construct meaningful mathematical arguments. Furthermore, the teachers recognized that mathematical proofs could be introduced informally through conversation rather than through written procedures, which led the researchers to conclude that a collaborative approach for learners to engage in mathematical arguments should be encouraged in the classroom.

**Summary of Mathematics Learning in Extracurricular Environments**

Many essential components must be in place to establish a meaningful extracurricular mathematics learning environment: allowing students to bring forth and share their prior experiences and native mathematical knowledge, supporting student collaboration that fosters constructive mathematical arguments, and providing a social environment and resources to encourage attendance. This literature review has shown that both students and teachers benefit from experiences in such learning environment. Students demonstrated multiple strategies in
problem solving and broadened their skills in mathematical reasoning. Teachers appeared to have learned from students’ misunderstandings of mathematical concepts and gained insights into the practice of mathematics teaching.

From the literature that was reported in this section, none other than the studies conducted by Diez-Palomar et al. (2006) and Turner et al. (2009) had situated mathematics learning in the context of social justice issues. Hence, there is a gap in the literature that addresses extracurricular mathematics learning opportunities that integrate mathematics and social justice issues. Similar to the studies performed by Diez-Palomar et al. (2006) and Turner et al. (2009), my research investigated mathematics pedagogy in the context of extracurricular social justice issues projects. Guided by the conceptual framework, I examined students’ and preservice teachers’ experiences in mathematics teaching and learning in a Social Justice Mathematics club at a local high school. Similar to the literature discussed above, my research brought insights into creating future extracurricular opportunities for mathematics learning or applying extracurricular mathematics pedagogical approaches in the formal classroom.

**Summary of the Literature Review**

This current study sought to address a gap in the literature by describing the experiences of students and preservice teachers involved in an extracurricular mathematics component that was integrated with the social justice issues underlying the projects that students of the Social Issues Club participated in. In this literature review, I have discussed empirical findings on the experience in connecting mathematics to the real world, in teaching and learning of social justice mathematics, and in mathematics learning opportunities in extracurricular environments.

Findings on teachers’ and preservice teachers’ experiences in connecting mathematics to the real world indicated that they held superficial understanding in this area of mathematics
teaching (Gainsburg, 2008; Garii & Okumu, 2008; Wubbels et al., 1997). In studies that allowed the integration of mathematics to social justice issues, this real-world context appeared to be beneficial to their understanding of social justice mathematics (Bartell, 2006) and the connection between mathematics and the real world (Bateiha, 2010). Similarly, students experienced authentic contexts for mathematics learning when the subject was taught in connection to social issues (Turner et al., 2009). In addition, students gained new perspectives about mathematics and were able to use mathematics as a tool to understand social phenomena (Gustein, 2003, 2011).

When involved in an extracurricular mathematics learning opportunity in the context of social justice issues, students of the cultural minority were able to connect mathematics activities to their prior experience of social injustices (Diez-Palomar et al., 2006). Furthermore, students shared the prior mathematics knowledge that they learned from their native countries.

Despite the benefits reported in the empirical studies discussed in this literature review, Gutstein (2011) argued that a social justice context does not “necessarily or miraculously transform” (p. 13) mathematics education and suggested that such an inference should not be made. Gutstein (2011) clarified that the end goal of his study was to prepare his students to analyze and challenge injustice in society through mathematics education. Because his students were already interested in learning mathematics prior to his study, Gutstein (2011) stated that the use of social context in his mathematics classroom was not to serve the purpose of engaging students in mathematics learning.

In conclusion, researchers have suggested that further research could allow deeper insights into the integration of mathematics and social justice issues. Thus, this current study describes the experiences of secondary students and preservice teachers when mathematics was taught in the context of social justice issues in an extracurricular environment.
CHAPTER 3

METHODOLOGY

This chapter outlines my research design and details the rationale for qualitative research – in particular, the choice for the case study approach used for this study. In this chapter, I will also expand on the implementation of the Social Justice Mathematics sessions, the context in which the sessions were conducted, and the background of the participants. Next, I will describe the methods of data collection and analysis. Finally, the trustworthiness of my study will be discussed.

Rationale for Qualitative Research

Because detailed and descriptive data obtained from conducting qualitative research is valuable in deepening our understanding of a phenomenon, qualitative methods were appropriate for this study (Patton, 2002), which sought to describe the teaching and learning experiences of participants involved in SJM. In addition, qualitative studies allow the researcher to be immersed “in the setting under study” (Patton, 2002, p. 4), in this case, the club setting in which the SJM activities occurred. Thus, a qualitative approach was appropriate for the purpose of this study.

Rationale for a Case Study Approach

The research methodology used in this study was qualitative case study research. Specifically, the case study was a single-case research design. According to Yin (2009), a single-case research design contains the following elements: a context, a case, and units of analysis. In sections that follow, I will present each of the elements in this case study.

The goal of this study was to describe the transformation of perspectives and experiences when mathematics was taught through the context of social justice issues. Particularly, the goal was to present the ways in which participants describe their experiences with mathematics
teaching and learning in the context of social justice issues. Therefore, a case study design was appropriate for this purpose because qualitative case study is used to “study the experiences of real cases operating in real situations” (Stake, 2006, p. 3). Other relevant situations proposed by Yin (2009) to be suitable for case study research include (a) the limited control that the researcher has over and access to actual behavioural events, and (b) the examination of contemporary events while relevant behaviours cannot be manipulated. Both of the above criteria were true for my study because the researcher was not a major facilitator during the intervention. In the sections below, I will provide further details about the case study design by providing the context, the case in this case study, the study proposition, and the units of analysis; thereby, justifying the appropriateness of using case study research in my study.

Context

The context of a case study provides data that is external to the case (Yin, 2009), which will be defined below. Because Yin (2009) emphasized the importance of distinguishing between data that is obtained from the phenomenon in the study and the data that is obtained from the context, it is essential for me to define and clarify the context and the case of my study. This study was conducted in the context of a secondary school in a suburban, middle-class demographic area in a mid-sized city in Southeastern Ontario.

Study Proposition

The role of the study proposition is to direct “attention to something that should be examined within the scope of the study [and]….where to look for relevant evidence” (Yin, 2009, p. 28) in case study research. The proposition of this study was the participants’ transformation of perspectives and experiences from the experience of mathematics teaching and learning in the context of social justice issues. Specifically, transformation of perspectives and experiences was
described by examining participants’ description of connection among mathematics and the real
world, connection among SJM and their formal mathematics teaching and learning experiences,
and their perceptions of mathematics in response to SJM.

Case

The definition of a case in case study research is a specific real-life phenomenon to
represent the abstraction (Yin, 2009). A case is a noun, a thing, or an entity (Stake, 2006); and is
also defined as a bounded integrated system, about which the researcher will decide what is and
is not included within the boundaries (Stake, 1995). “Being bounded [also] means being unique
according to place, time and participant characteristics” (McMillan & Schumacher, 2010, p.
344). The case was the Social Justice Mathematics (SJM) component being added to a pre-
existing, non-mathematics extracurricular setting known as the Social Issues Club (pseudonym)
in the context of a secondary school.

Units of Analysis

According to Yin (2009), the study proposition will guide the researcher in identifying
relevant data to be collected about the units of analysis. The units of analysis were secondary
students and preservice teachers who participated in the study.

Ethics Clearance

Ethical clearance was obtained from the Education Research Ethics Board (EREB),
General Research Ethics Board (GREB) at Queen’s University, and the local school board in
September, 2011 prior to the start of the recruitment process.
In this section, details on the process of creating Social Justice Mathematics sessions and the SJM environment will be presented. These will include context selection, participant selection and their background, designing SJM activities, and implementing SJM activities. Data collection methods will also be discussed.

**Context Selection**

A local, publically-funded district school board in Southeastern Ontario was selected for this study based on convenience sampling for geographical area. Information about each of the 11 secondary schools within the district was obtained from individual school websites. This included the school phone number, the principal’s name and contact information, and whether or not the school has a pre-existing extracurricular initiative relating to social issues or social action work. Although only three of the 11 high schools provided information about an extracurricular club focused on social justice on their website, all high schools were contacted in case online information was not complete or up to date. Each of the 11 schools was contacted according to the Secondary School Recruitment Script (Appendix A) via electronic mail. With no responses within a week, a second round of contact via telephone was directed to the three high schools with clubs related to social issues or social action work. Two of the three schools expressed interest in participating in the study. In one case, the principal requested an interview with me to gain a deeper understanding about the study. A few days after the meeting, the principal withdrew interest.

From the other school, I was directed by the principal to the teacher in charge of the extracurricular club. This teacher, Mr. Leggett (pseudonym), introduced me to the Social Issues Club by describing their current initiatives and projects. Because Mr. Leggett wished to include his student club members in the decision making process about whether or not to participate in
this study, he invited me to speak to the student club members about the research. I visited the Social Issues Club during its regular club meeting time and described my study to the students according to the Student Participant Recruitment Script (Appendix B). The Letter of Information (Appendix C) and Consent Form (Appendix D) were also distributed during this visit. The following week, I was informed by Mr. Leggett that eight student club members out of about 25 were interested in participating. Based on their collective decision, the second half of their regular club meeting hour was to be allocated for SJM.

At the time of this study, student club members were involved in social activism projects including sewing pillowcase dresses for girls and women in Haiti, supporting a local soup kitchen, planning soap drives for a local shelter, and contributing to a vow of silence initiative that symbolized the lack of voices of oppressed children. SJM sessions were held during the second half of the Social Issues Club’s weekly one-hour meetings. Sessions began in November, 2011 and ended in early February, 2012. Due to the nature of school activities, which included holidays, an examination period, and student club members’ commitment to other extracurricular events, the eight sessions were not implemented over eight consecutive weeks.

Sessions were held in a science classroom, with lab benches bordering the room and an area with tables and chairs in the middle. I usually arrived just five minutes prior to the start of the second half of the Social Issues Club’s weekly meeting. By the time that I arrived, about 25 regular student club members were usually finishing up a discussion led by one of the club leaders. To begin SJM sessions, either the club leader or the teacher supervisor, Mr. Leggett, would announce the completion of the regular Social Issues Club meeting. Mr. Leggett would then exit and participating students would join me and the preservice teacher leader, Kathy, for the second half of the club meeting. Non-participating students were dismissed or continued to
work on club tasks at the lab benches on the other side of the room. Due to commitments to academic responsibilities and other extracurricular events, the number of student participants present for SJM varied throughout the study ranging from three to six. On average, four students participated.

**Participant Selection**

Of the eight student club members who had shown interest in participating, only six returned their signed Consent Form. These six students became the student participants of the study.

Simultaneous to the context selection process, selection of preservice teachers was carried out. Preservice teachers were selected from Queen’s University based on purposeful sampling, which is the selection of participants based on the purpose of the study and resources (Patton, 2002). The criteria for selection included the following: (a) individuals who were either teacher candidates enrolled in the CURR 343 (Intermediate/Senior Mathematics curriculum course) or undergraduate students with an interest in pursuing mathematics teaching in the future and enrolled in either (i) MAT 010 (Fundamental Concepts in Mathematics for Elementary Teachers) or (ii) Concurrent Education at Queen’s University; and (b) individuals who were able to commit to research-related activities over the minimum of an eight-week period beginning November, 2011. Participating preservice teachers were informed that they would receive the book *Math That Matters: A Teacher Resource Linking Math and Social Justice* by David Stocker as compensation for committing to this study.

The recruitment of preservice teachers was carried out by introducing my research in the following settings of Queen’s University: (a) the two sections of CURR 343, (b) a Mathematics Education Seminar hosted by the Department of Mathematics and Statistics, (c) the Concurrent
Education Students Association Website, and (d) the section of PROF 310/311, Critical Issues and Policies course for third year Concurrent Education students. My research was introduced according to the Preservice Teacher Recruitment Script (Appendix E). In the class settings of CURR 343 and PROF 310/311, visits were made either at the beginning or at the end of class with permission given by the course instructors prior to the visit. In the setting of the Mathematics Education Seminar, which was held usually weekly or biweekly, permission was received from the faculty members from the Department of Mathematics and Statistics who were involved in organizing this regular event. Through this presentation, research was introduced to faculty members of the Department of Mathematics and Statistics and undergraduate students who attended the seminar. The recruitment information was posted on the Concurrent Education Students Association Website by contacting the president of the association.

Five preservice teachers contacted me and expressed interest in participating; however, only four met with me individually to discuss the study in further detail. During these meetings, participants received copies of the Letter of Information (Appendix F) and Consent Form (Appendix G). Consent forms were returned at a subsequent meeting to provide adequate time for the preservice teacher participants to make a decision to commit to the study. After two weeks, by which time only three of the four preservice teachers had returned their consent forms, the study began.

Participants’ Backgrounds

Secondary students. All six student participants were female. Carmen, Lena, and Tessa were in Grade 10 and Anita, Isabel, and Rachel were in Grade 12. In the past, all students had completed academic mathematics courses, which are one of the two types of mathematics courses that aim to “develop students’ knowledge and skills through the study of theory and
abstract problems [and] focus on the essential concepts of a subject” (Ontario Ministry of Education, 2005, p. 6) in the Ontario mathematics curriculum. All students were enrolled in a mathematics course during that semester, with the Grade 12 students taking mathematics courses in the university stream.

From students’ casual conversations and their comfortable interactions, all appeared to have established a good relationship with one another prior to participating in this study. One of the participating students was one of the leaders of the Social Issues Club.

In order to have information about the students’ background in mathematics learning experiences, a survey, Questionnaire 1 (Appendix H), was conducted during the first SJM session. The following table displays students’ feedback.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Somewhat Agree</th>
<th>Neither Agree nor Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoy learning mathematics.</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>I believe that mathematics is used in everyday life, in many ways, by many people.</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>I see a connection between mathematics and my life.</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>I believe that it is useful for me to learn mathematics.</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>I believe that mathematics is valuable</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>I enjoy using mathematics in the real world</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Overall, I enjoy learning mathematics in the classroom.</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I would like to learn mathematics as an extracurricular activity.</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Preservice teachers. For the purpose of this study, participants will be known as preservice teachers despite their varying background and experience as a teacher candidate or potential teacher candidate. Each of the three preservice teacher participants was at a different stage in their teacher education.
Enrolled in the Bachelor of Education program, the first preservice teacher participant was Kathy (pseudonym). Kathy had about four weeks of practicum experience at the onset of the study and about nine weeks of practicum experience by the end of the study. The practicum is a mandatory component of the Bachelor of Education program for preservice teachers to experience the practice of teaching in classroom environments under the supervision of a certified teacher.

During her undergraduate degree program, Kathy obtained seven full credits in mathematics. For her Bachelor of Education degree, she was pursuing mathematics as her first teaching subject and biology as her second. This meant that according to the teaching subject course requirements for admission into the Bachelor of Education program, Kathy held a minimum of five full-year courses from a university mathematics and statistics department and three full-year courses from a university biology department.

Due to Kathy’s availability, she assumed the role as the SJM session leader. She was responsible for facilitating the activities during the SJM sessions in addition to lesson planning with the other preservice participants. At the end of each SJM sessions, Kathy and I held a debriefing session about her observations and to capture her immediate reflections about teaching that particular session.

The second preservice teacher, Sandra (pseudonym), was in the third of the five-year Queen’s University Concurrent Education program. Sandra was enrolled in five arts and science courses per semester, one of the seven education course (PROF 310/311) at the time of the study, and was going to be completing a three-week practicum at the end of the year.

At the time of the study, Sandra had experience in lesson planning, classroom observation, and four weeks of teaching experience in Grade 9 and Grade 10 classrooms. Sandra
had 4.5 full credits in mathematics, her second teaching subject. Sandra’s first teaching subject was in biology. During the introductory meeting, in which she received the Letter of Information and Consent Form of the study, Sandra said that she was interested in participating because she felt that mathematics tends to be irrelevant to students’ lives. As we conversed casually about this, she spoke about a mathematical problem that asked students to determine the mass of an object hanging at the end of a spring. She used this example to express her opinion about the way mathematics applications lacked relevance to students.

Brian (pseudonym), who was an undergraduate student in the fourth year of an Honours Bachelor program, had completed 8.5 full credits in mathematics. During his participation in this study, he was enrolled in an undergraduate mathematics education course, MAT 010. This course, known as the Fundamental Concepts in Mathematics for Elementary Teachers, was designed for undergraduate students to be involved in a local mathematics enrichment program for intermediate students. In addition to classes, Brian had to complete a practicum component that required him to team-teach Grade 7 and 8 students in the enrichment program at a local school. At the time of the study, he had about five hours of teaching experience. Brian was also an applicant to various Faculties of Education to pursue his Bachelor of Education degree with a first teaching subject in mathematics and second in physics.

After providing Brian with further details about the study during our introductory meeting, he gave feedback about some of the preliminary ideas and topics suggested for use in the SJM. For example, in an activity designed for students to compare poverty and healthy eating choices, Brian suggested the inclusion of fast food prices since students can relate to the fast food culture.

Data Collection Methods
Data was collected using the following methods: (a) field notes, (b) student questionnaires, (c) student focus group, (d) preservice teachers’ reflection journals, (e) preservice teacher interviews, and (f) physical artifacts.

**Field notes.** As the researcher, field notes were generated throughout the study from participant-observations. Immersing in participant-observations, the researcher is not only a passive observer, but may also participate in the events in the case study situation (Yin, 2009). Using this observation approach, I was able to support the role of the preservice teacher as a session leader during the enactment of the activities and participate as required in the activities. According to Yin (2009), this observation method may benefit data collection by allowing the researcher to view insightful interpersonal behaviour and motives.

Because the purpose of the study was to describe the transformation of participants’ perspectives and experiences, observations were made by paying close attention to discussions about mathematics and mathematics teaching and learning. In this study, field notes helped in refining the questions for the student focus group and preservice teacher interviews conducted at the end of the study. The field notes also allowed a thick description that provided “the reader all the information necessary to understand the case in all its uniqueness” (Patton, 2002, p. 450).

**Student questionnaires.** In this study, two questionnaires were administered to secondary student participants. In order to describe students’ perceptions about mathematics and the connection between mathematics and the real world at the beginning of the study, Questionnaire 1 (Appendix H) was administered in the first week of the implementation of the Social Justice Math session. Questionnaire 2 (Appendix I) was administered during the eighth and final session to describe students’ perceptions at the end of the study. Both questionnaires focused on the following inquiries: (a) students’ perception of connections between mathematics
and the real-world, (b) students’ perception of the value of mathematics as a body of knowledge, and (c) students’ experiences with formal and informal mathematics learning experience. Both questionnaires consisted of four questions asking for students’ demographic information, two questions with item options, eight 5-point Likert scale questions ranging from strongly agree to strongly disagree, and three open-ended questions. Likert scales were used in both questionnaires because the goal was to obtain information about students’ opinions and perceptions (Salkind, 2010). Open-ended questions were used because they allow “the researcher to understand and capture the points of view of other people” (Patton, 2002, p. 21).

**Student focus group.** At the end of the study, a one-hour focus group interview (Appendix J) was conducted with five participating students based on voluntary participation. The focus group was held at a library conference room of the secondary school in which this study was conducted. The purpose of the focus group was to understand students’ learning experiences in SJM and their perception of this type of mathematics learning opportunity. The focus group was conducted by the researcher, whose role was directive and active. Being directive and active allowed the researcher to exercise “considerable control over the direction of the interview by administering a structured and ordered set of items or by constantly keeping the group on track” (Morgan, 1993, p. 27).

The choice of a focus group interview for student participants was to “explicitly use group interactions as part of the data-gathering method” (Berg, 2009, p. 158), which might allow broader insights into both individual and collective experiences.

**Preservice teachers’ reflection journals.** In this study, preservice teachers were required to record their experiences and perceptions in reflection journals. To avoid fatigue of journal writing, which could contribute to less meaningful data, preservice teachers were
expected to generate jot notes in their reflection journals. Thus, reflection journals were used as a supplementary data source to stimulate discussions during the individual interviews at the end of the study. Two of the three preservice teacher participants, Kathy and Brian, submitted their journals at the end of the study. Point form notes were made by each of the two preservice teacher participants. Brian recorded his reflections on the collaborative lesson planning experience. Kathy recorded her reflections on leading SJM activities. Kathy and Brian each brought their reflection journals to their individual interviews, to which they had referred during the discussion.

**Preservice teacher interviews.** The purpose of conducting preservice teacher interviews (Appendix K) was to allow the participants to describe their potential transformation in response to experiences afforded by SJM. A one hour semi-structured interview was conducted by the researcher with each of the three participating preservice teachers at the end of the study. Each interview was held in a local library conference room.

“One of the most important sources of case study information is the interview” (Yin, 2009, p. 106). Because a case study interview is more likely to be fluid with guided conversations instead of rigid inquiries (Yin, 2009), semi-structured interviews, in which the researcher is permitted to probe beyond the standardized questions (Berg, 2009), were employed in this study.

**Physical Artifacts.** Samples of student-produced work, which included individual work and collaboratively-created work, were collected after each SJM session as physical artifacts. Students’ work included worksheets provided by Kathy and graphs created by students on chart paper. Similarly, drafts of lesson plans, resources, and materials for each SJM session developed
by the preservice teachers were collected as physical artifacts to gain a broader perspective on their experience of mathematics teaching.

Designing SJM Activities

The participating preservice teachers designed lesson plans in collaboration with the researcher and one another by using resources made available to them. Overall, the preservice teachers spent about five hours to create six activities that spanned the eight weeks of the study. At the first SJM activity preparation session, Kathy and Brian were present. At the second planning session, all of the preservice teacher participants were present. In the following sections, I will discuss the process of designing the SJM activities.

**Poverty and healthy eating.** I suggested the idea of connecting poverty and healthy eating to Kathy and Brian because the students in the Social Issues Club were involved in one of the local soup kitchen initiatives. Kathy and Brian also were given resources to work with including the 2010 local report known as the Deprivation Index (Appendix L). Because this activity was designed during the first meeting, I participated as required by prompting the preservice teachers to think about the activities that could be created using the data from the given resources. The pair of preservice teachers then decided on a graphing activity that would allow students to investigate the relationship between healthiness of foods and the cost per serving. Since healthiness of foods might be difficult to determine from food labels, Kathy suggested that the healthiness of foods should be rated by students. Thus, the activity was designed to begin with a challenge to allow students to assign a ‘health’ index to foods using a scale from one to 10. For this activity, students would then calculate the price per serving in groups and graph, on a single piece of chart paper, the student rated health index versus the cost per serving. With my prompts, Kathy and Brian also included a discussion at the end of the
activity for students to explore trends on the graphs and understand relevant data on Health by Income from the Deprivation Index report. (See Appendix M for the lesson plan of this activity).

**Different sources of income and affordable housing.** Another resource known as the Living Wage Report 2011 (Appendix N) was used by Kathy and Brian to discuss the various levels of poverty. This led to the idea of dividing students into three small groups to explore three income sources: Ontario Works\(^2\), Ontario Disability Support\(^3\), and Minimum Wage. Kathy and Brian then decided to challenge students first to estimate, then determine the cost of various living expenses using data from the report. They intended to use this activity to guide a discussion about poverty issues such as affordable housing. (See Appendix O for lesson plan of the activity)

**Food bank use increase.** With one of the projects of the Social Issues Club being the support of a local soup kitchen and recent media coverage about the increased number of individuals using the food bank, I suggested that the preservice teachers design an activity about this topic. Kathy and Brian found information on food bank use in the Deprivation Index report. When trying to understand the data themselves, Kathy and Brian brainstormed factors that affect the number of food bank users: economic recession, population changes, industrial changes, and immigration. In further discussion, Brian suggested that students should be given the opportunity to determine possible factors that affect food bank use. The pair became interested in the changes to the population of the community as a factor. Together, we arrived at the idea of constructing line graphs using two relationships: (a) number of food bank users over time and (b) population over time. Thus, Kathy and Brian decided to create two activities using these data: exploring

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\(^2\) Ontario Works is a form of temporary financial assistance for Ontario residents who have an immediate financial need. (City of Kingston Ontario, 2012)

\(^3\) Ontario Disability Support provides financial assistance for Ontario residents with disabilities who are in financial need for daily living expenses. (Ontario Ministry of Community and Social Services, 2012)
food bank use increase from the line graph and correlating food bank use with population growth. (See Appendices P and Q for the lesson plans of this activity)

Other topics discussed in the first session. Kathy and Brian also exchanged ideas on the social justice issues they had in mind, including prison expansion and carbon emission from vehicles. The two participants spoke about possible activities based on topics such as the cost per inmate, free education for inmates, community-based programs or programs for adolescent crime prevention, and comparison between the cost per inmate and the cost per person in crime prevention programs. Regarding carbon emission from vehicles, Kathy spoke about her interest in environmental initiatives and Brian spoke about his interest in fuel consumption of vehicles and electric vehicles. Because I had data on fuel consumption of vehicles available (Appendix R), Kathy and Brian briefly discussed possible mathematics activities that could be designed using that data such as graphing and modelling data. However, because of time constraints and limited relevance to current projects already underway by the Social Issues Club, these ideas were not fully developed into activities.

Haiti — women’s education and life expectancy. During the second meeting, in which all three preservice teacher participants were present, I provided data about women’s education and life expectancy for the general population in Haiti because of its relevance to the Social Issues Club’s pillowcase dresses project. In the pillowcase dresses project, student members of the Social Issues Club created dresses with pillow cases for girls in Haiti using simple sewing techniques. Thus, preservice teacher participants and I decided that allowing students to explore the impact of education for women in Haiti could illuminate one underlying issue related to their social action project that aimed to support girls.
Collaboratively, Kathy, Brian, and Sandra proposed exploring linear relations and extrapolation using the data (Appendix S). In addition, they included exploring the relationship between the two variables as part of this activity. They also arrived at the possibility of incorporating income as one of the variables. Another possible activity was comparing the life expectancy of Haitians to that of Canadians. However, because of limited time to obtain appropriate data, these were not included in the SJM activity.

**Implementing SJM Sessions in the Social Issues Club**

In the SJM sessions, Kathy, the preservice teacher leader provided students with mathematical activities that were related to their social activism projects. The schedule of the SJM sessions was adjusted by Kathy and I as required based on the activities of each session. For example, because of time constraints, the “Poverty and Healthy Eating” activity that took place during the first week and the “Haiti — Women’s Education and Life Expectancy” activity that took place during the sixth week was carried onto the subsequent session. Similarly, the “Fuel Consumption of Vehicles” activity was added based on students’ discussion about increasing fuel prices during the “Different Sources of Income and Affordable Housing” activity. Topics were covered in the schedule presented on Table 2.

Kathy engaged students in applying mathematics procedures in order to come to conclusions about the issue by providing opportunities for them to work individually, in pairs, or in a large group format. They discussed both mathematics content and social issues in response to Kathy’s prompts and questions. During Kathy’s absence in Week 6 and 7 and her late arrival in Week 8, I led the sessions according to the activities planned by the preservice teacher participants.
Table 2

Schedule of Social Justice Mathematics Sessions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>1 Poverty and Healthy Eating</td>
</tr>
<tr>
<td>Week 2</td>
<td>Poverty and Healthy Eating (Continued)</td>
</tr>
<tr>
<td>Week 3</td>
<td>2 Different Sources of Income and Affordable Housing</td>
</tr>
<tr>
<td>Week 4</td>
<td>3 Food Bank Use Increase</td>
</tr>
<tr>
<td>Week 5</td>
<td>4 Correlating Food Bank Use and Population Growth</td>
</tr>
<tr>
<td>Week 6</td>
<td>5 Fuel Consumption of Vehicles</td>
</tr>
<tr>
<td>Week 7</td>
<td>6 Haiti – Women’s Education and Life Expectancy</td>
</tr>
<tr>
<td>Week 8</td>
<td>Haiti – Women’s Education and Life Expectancy (Continued)</td>
</tr>
</tbody>
</table>

Organization of Data

Transcription

Prior to transcription, audio recordings of the three individual preservice teacher interviews and the student focus group were each listened to twice by the researcher. Next, all audio recordings were transcribed into a Microsoft Word text file, generating between 15 to 20 pages of interview transcript for each of the preservice teacher participants and 16 pages of focus group transcript. During the transcription process, pseudonyms were used to replace names of all the participants.

When reviewing the transcribed interviews, I recognized that several ideas expressed by the participants needed clarification or expansion. To seek additional explanatory data, Kathy and Sandra were contacted individually using e-mail with the section of the conversation attached for them. Their written responses were added to the transcribed data. The audio recordings were then listened to again while reading over the transcription to ensure accuracy of
converting digital audio data into text and to improve my familiarity with the data. After corrections were made during this process, the audio recordings were listened to again for the purpose of removing long pauses and verbal utterances such as “um,” “like,” “well,” and “you know.” The goal of this was to provide a more comprehensive text for the presentation of data. For member checking, each of the preservice teachers’ interview transcripts was sent back to the participant via electronic mail to verify the accuracy of the data.

**Converting Hard-Copy Data into Electronic Formats**

Handwritten responses from the open-ended questions in the student questionnaires and preservice teachers’ handwritten journal entries were converted into Microsoft Word text files. Field notes were also converted into Microsoft Word text files from handwritten notes taken during observations by the researcher. Conversions were done almost immediately within the same day of the observation to ensure accuracy in understanding the handwritten data. Each file was about two to four pages in length. To convert data into electronic formats, all hardcopy artifacts including students’ worksheets, calculations, and graphs were taken as digital photographs.

**Coding**

Data from field notes, interviews, focus group, and open-ended questions from questionnaires were coded. A preliminary coding process was done manually by highlighting the text on paper and writing notes in the margins of the pages. This approach allowed “bits”, which are “useful segments of data” (Kirby, Greaves, & Reid, 2006, p. 215) to be coded to identify related ideas. This was completed to familiarize myself with the data and to prepare the thinking process necessary to complete the coding process.
At this early stage of data analysis in which coding was performed, an inductive analysis approach was taken to allow findings to emerge out of the data through the researchers’ interaction with the data (Patton, 2002). Open coding (Corbin & Strauss, 1990) was performed using the qualitative data analysis software, NVivo 9, to identify codes that emerge from the reading and interpretation of transcripts. One of the preservice teachers’ interviews was also coded by the thesis supervisor using the open coding approach. Codes produced were compared to reduce my bias in interpreting the data and to enhance reliability of the coding process.

Data Analysis

Preliminary data analysis using field notes was performed during the process of data collection. Field notes were read to refine the questions of the focus group and interviews conducted at the end of the study. Observations recorded in the field notes provided specific interview questions that allowed me to probe deeper to understand the experiences of the participants. For example, specific questions about participants’ comments or a particular incident were added to gain a deeper understanding.

To look for patterns and themes about preservice teachers’ perceptions and experiences, field notes, interview transcripts, and preservice teachers’ journals were analyzed using an etic approach, which is labelling codes and patterns with “labels imposed by the researcher” (Patton, 2002, p. 454). Similarly, field notes, focus group transcripts, and students’ open-ended responses from the questionnaires were analyzed using an etic approach to look for students’ perceptions and experiences.

All data were analyzed using an approach of which the codes were derived directly and inductively from the raw data itself (Patton, 2002). Codes were inductively identified from the
data using the qualitative data analysis software, NVivo 9. The coding process was repeated once to help reduce my bias in data interpretation.

Codes were then sorted into categories by comparing, contrasting, mixing, and matching them (LeCompte, 2000). I began this process by reviewing all the codes, which were known as nodes using the terminology of NVivo 9. A Node Hierarchy was produced using NVivo 9 to place nodes underneath parent nodes, which were defined using NVivo 9 as a node that aggregates other nodes and have a higher hierarchy than the nodes placed into them. Thus, the parent nodes became the categories for the codes. Through this process, categories emerged. This process allowed me to “clump together items that are similar or go together” (LeCompte, 2000, p. 149). These categories became the patterns, which were inductively determined based on this sorting process (Patton, 2002).

Subsequent to creating patterns, I manually created a hardcopy map diagram (Appendix T) to assemble the patterns and the codes linked to each pattern. Then, “groups of related or linked patterns [were] taken together [to] build an overall description” (LeCompte, 2000, p. 151) relevant to the purpose of the study. This process allowed each of these groups to become a theme. The arrangement of patterns into themes was completed three times to help ensure relevance of the themes to the purpose of the study.

**Limitations**

**SJM Activities**

Most of the activities designed by the three preservice teacher participants involved modelling and interpreting data using graphs. Thus, the social justice issues explored in the Social Justice Club were predominately integrated with Data Management curriculum expectations from the Ontario Mathematics Curriculum.
Participants and Their Attendance

This study sample was only comprised of female student participants, which presented as a disadvantage because male students’ experiences in mathematics learning were not represented in the findings of this study. In addition, the participants consisted of only Grade 10 and Grade 12 students, which did not fully represent the demographic of a general secondary school setting.

Since the study took place in an extracurricular setting, where the number and nature of student participants cannot be controlled, the number of student participants attending the SJM sessions fluctuated throughout the eight weeks. Voluntary attendance and the nature of students’ involvement in regular school activities contributed to the absence of some students throughout the study period. Thus, difficulty arose when attendance numbers were low and the preservice teacher leader was required to make necessary changes to the planned activity.

In addition, the preservice teacher leader, Kathy, was also absent in two of the sessions, which led to difficulty in recording observations notes during those activities as I led the sessions.

Researcher’s Bias

Another limitation is the acknowledgement of my identity as a researcher. My background lies in mathematics education at the secondary school level as I have experience as a newly graduated mathematics intermediate/senior teacher prior to becoming a graduate student. The intersection of my identity as a mathematics educator and the researcher of this study could lead to bias in my data collection and analysis processes. In recognition of this limitation, I performed member checking and made use of an outsider of the research, my supervisor, to be involved in data interpretation.
Duration of the Study

Because the duration of the study was only eight, non-consecutive weeks with a total of four hours in SJM session meeting, the time frame could be a limitation to the richness in understanding participants’ experiences. To address this concern, multiple data sources were used in this study to provide triangulation of the data.

Trustworthiness

According to Yin (2009), one of the criteria to determine the trustworthiness of qualitative case studies is the identification of “correct operational measures for the concepts being studied” (p. 40). The researcher needs to obtain data from multiple sources of evidence and have collected data reviewed by key informants (Yin, 2009). In this study, multiple methods of data collection provided various sources of evidence. The multiple sources of evidence included field notes, student questionnaires, student focus groups, preservice teachers’ reflection journals, preservice teacher interviews, and physical artifacts. Member checking, in which the accuracy of the data collected was confirmed by participants, was also performed. In combination with member checking and triangulation of data from multiple sources, the use of multiple recording methods helped ensure reliability of the collected data. Audio recording devices and note-taking were both methods of documenting from interviews and focus groups. Data transcribed from audio recording devices were corroborated with hand-written notes. My supervisor was invited for data interpretation to minimize biases in the study.

Summary

In this chapter, the methodology used for this study, the rationale for qualitative research and choosing a case study approach, and the selection of context and participants were discussed. The setting of the study, which was the SJM session as an additional component to the pre-
existing Social Issues Club, was presented to provide details about the context of this research. Methods of data collection included observations, two student questionnaires (before and after the SJM session), a student focus group, individual interviews with preservice teacher participants, preservice teacher participants’ reflection journals, and physical artifacts. To look for emerging patterns and themes, data was transcribed and coded. Along with the detailed observations of each SJM activity, these patterns and themes will be presented in the next chapter.
CHAPTER 4

PRESENTATION OF DATA

The purpose of this study was to address a gap in the literature by describing the experiences and perceptions of the participants who were involved in an extracurricular opportunity to learn mathematics in the context of social justice issues. In this chapter, data collected in observations of the SJM sessions, preservice teachers’ individual interviews, preservice teachers’ reflection journals, students’ questionnaires, students’ focus group, and artifacts will be presented in detail. The descriptions of the enacted SJM activities will be presented first. Next, the participants’ experiences will be described. Preservice teacher’s experiences will be presented individually and students’ experiences will be presented as a group because each of the preservice teachers had a unique background and role while students shared a similar background. This chapter will end with a presentation of the analysis of data, which will include a comparison of the emergent themes and patterns between the two groups of participants.

All data in direct quotes will be referenced using a representation such as SRFN3, TSII, TKRJ, SAFG, SSQ1, or RFN3 in which SR (Student, Rachel), TS (Preservice Teacher Participant, Sandra), TK (Preservice Teacher Participant, Kathy), SA (Student, Anita), S (Anonymous Student) and R (Researcher) denotes the individual quoted. The notation of FN (field notes), II (individual interview), RJ (reflection journal), FG (focus group), and SQ (Student Questionnaire) conveys the source of the data.

Participants’ experiences will be described using the conceptual framework, which is Doll’s (1989) notion of transformation in view, perspective, and one’s relationship to learning through the reorganization of experience (Doll, 1989). Using the conceptual framework as a
guide, emphasis will be placed on participants’ reorganization and reconstruction of experience from the SJM learning opportunity in this study.

**Activities in Social Justice Mathematics**

The details of the SJM sessions are organized chronologically by session. Present at the SJM meetings were up to six students and Kathy, the preservice teacher whose role was to facilitate the activities as the session leader. When Kathy was absent during Week 7 and arrived late in Week 8, I played the role as the session leader in addition to the role as the participant-observer. The details are presented using data from the field notes that were made during the researcher’s observations of the lessons.

**Activity 1 - Poverty and Healthy Eating**

Isabel, Rachel, Tessa, Lena, Carmen, and Anita were present during this activity. Kathy distributed a sheet (Appendix U) to each student that contained various food items and their cost per package. Students organized themselves in pairs after Kathy invited the students to work in small groups to assign a health index (a number between one and 10, with 10 being the healthiest food item) and to determine the cost per serving for each of the food items. While rating food items, students discussed factors such as about sodium level, added sugar, and vitamins. Since only one pair of students completed the tasks before the session ended, this activity was carried forward to the next SJM session.

In the next session, all six students were present again. Kathy began the session by reminding the students about the instructions for the activity and the students immediately continued with their tasks. Students calculated the cost per serving of the foods and one student asked whether or not they were allowed to use calculators during the activities. Kathy responded
with “Yes,” and the students continued. As students finished up their computations (Appendix V, Figure V1), I prompted Kathy to introduce the next task.

Kathy invited the students to gather around a piece of chart paper and plot data for all the food items on a single graph. Each pair of students was given a different coloured marker to represent their data on the graph. As students moved around the room, Isabel mentioned that she had not plotted a graph since the completion of her Grade 12 Data Management course last semester. She took the initiative to draw the axes of the graph using a marker. By then, the rest of the students gathered around the chart paper and plotted their points, each representing a food item on the set of axes Health Index versus Cost per Serving (Appendix V, Figure V2).

Since the students worked in pairs on the previous task, one person from the pair read aloud the healthy index and the cost per serving of each food item while the other was responsible for plotting the point. When the scatter plot was completed, students stopped hovering over the chart paper with their markers and stepped back to take a look. Isabel mentioned that the graph could be described using data management terminologies. Kathy acknowledged her comment and took this opportunity to ask students about the trend of the graph. Rachel immediately said “correlation” (SRFN1, p. 2). Another student, whose name was not recorded in the field notes, then interjected and said “a positive correlation.” (SFN1, p. 2) Another noted that unhealthy food is generally cheaper.

Kathy pointed to the vertical axis, which was the Healthy Index rated by students, and mentioned that there was a large variance in the Healthy Index. From this, Kathy asked the students how they arrived at the rating of food items. Students replied collectively and their responses included the quantity of sugar, salt, and preservatives, and processing. The session leader gave each student a copy of the Health by Income data, which was represented as a bar
After a few moments of silence, Lena said that people who have more money can afford better food. Isabel referenced the bar graph from the Deprivation Index specifically and pointed out that the rate of asthma for the lower income population is substantially higher and that obesity rate is higher for the lower income population. When prompted to think about the reasons for this observation, students mentioned ideas including lower activity rate for individuals with lower income and the cost of exercise such as a gym membership. Rachel concluded that in general, people with a lower income tend to be occupied with more immediate priorities such as shelter instead of health. The session was interrupted by the bell and came to a close.

**Activity 2 - Different Sources of Income and Affordable Housing**

Isabel, Rachel, and Anita were absent during this activity because of other extracurricular commitments. With only Tessa, Lena, and Carmen present, Kathy asked the students to sit closer to one another and collaborate on estimating a specified list of monthly living expenses (Appendix W). One of the students asked whether the estimation should be made for an individual or per family. Kathy clarified that their estimations should be made for an individual. A few of the living expenses were public transportation, car payment, auto insurance, and gas for a car. As students worked on this task, Carmen asked why an individual would own a car and take the bus. Kathy replied that it depends on a person’s situation such as his/her commute to work by driving to a bus terminal and taking public transportation for the rest of the journey. Working with one another, students were verbalizing their logical thinking and mental calculations. For example, to estimate the monthly expense of auto insurance, students stated that the cost would depend on the number of people listed on the insurance policy, the colour of the
vehicle, and the age and gender of the driver. When attempting to determine the total monthly cost for gas, students discussed factors such as gas prices and fuel consumption of the vehicle.

Kathy provided students with prompts when they showed hesitation about stating estimations for unfamiliar expenses. For example, for estimating auto insurance, Kathy suggested that students think about the annual cost of auto insurance that their parents pay and then divide the amount to determine the monthly cost. Another expense in the list was clothing. When Lena came across this, she told us that clothing was not one of her frequent expenses. Thus, Carmen and Tessa helped with the estimation based on their personal experience. For the monthly expense of toiletries and supplies, students concluded that this cost would be greater for females. For the entertainment category, students included the cost of internet and cable television. The students brainstormed their estimations collectively but recorded their estimates individually on a worksheet. At the bottom of the worksheet was a blank space for the total of expenses. Carmen used her calculator to determine the sum as Lena read aloud the numbers to be added. Tessa, who appeared to be the quietest participant, waited for them to complete the calculation. Carmen obtained a total of $2200 and read it aloud for her peers to record.

The students then read the next blank row on their charts, which was “Amount Remaining at the End of the Month.” A student asked, “Doesn’t that depend on how much you earn?” (SFN2, p. 1) Kathy took this opportunity to introduce the sources of income that were planned for this activity. On another sheet that Kathy now provided were the monthly incomes of an individual receiving funds from the Ontario Works, or an Ontario Disability Benefits program, or earning a minimum wage. Students took a moment to read the numbers and immediately Carmen stated that the individual would be in debt for all cases.
Kathy instructed the students to fill in the last row on their first worksheet by concluding the amount remaining at the end of the month based on their expenses estimation. Using a calculator, Carmen calculated the amount remaining by subtracting the amount of income from the total expenses (Amount remaining = Total expenses – Income). Tessa noticed Carmen’s calculations and asked “Wait, isn’t it the other way around?” (STFN2, p. 2) By asking this question, Tessa implied that the correct calculations should be the following:
Amount remaining = Income – Total expenses. Carmen answered “It’s the same thing but just negative of that answer” (SCFN2, p. 2).

Next, Kathy asked students to determine the actual numerical value for each monthly expense by looking into the 2011 Living Wage Report for the local city, which had been provided to the students. Students flipped through the report booklet and found information about annual costs. They divided by 12 using their calculators to determine the monthly cost and recorded this in the second column of the first worksheet. Kathy asked whether their estimations were similar to the actual figures. Students responded with “kinda.” Next, Kathy noticed that the report provided expenses that were considered for a family of four and reminded students to read the information in detail before recording the numbers. Lena asked, “So we have to divide by four?” (SLFN2, p. 2) Kathy chuckled and apologized for not spotting their mistake of not dividing by four. When looking at the cost of utilities, students mentioned that the reported value of $82 per month did not make sense based on their estimated figure. Students looked through the report more closely to find more information about utilities expenses. I also facilitated and looked through the report with Kathy. We read the detail information and discovered that the cost of utilities referred to the cost of cable television, telephone, and internet, while water and electricity expenses fell into the rent category. From the estimation activity, students considered
utilities as water and electricity while including cable television, telephone, and internet expenses under the entertainment category. Students realized that entertainment expenses were not reported. Kathy led a brief discussion regarding the reason for not including entertainment expenses in the Living Wage Report, which might have been due to the large variation in the cost of entertainment. The activity came to a close at the end of this discussion.

Activity 3 - Food Bank Use Increase

Five students gathered as Kathy began the SJM session by distributing data on the use of the food bank from the 2010 Deprivation Index of the local city. The data was displayed in a bar graph and Kathy asked whether students saw a trend. Isabel said “an overall upward trend” (SIFN3, p. 1). Another student pointed out that “1994 was more than 2009” (SFN3, p. 1), referring to a greater usage of the food bank in 1994 than 2009. After a moment of lack of responses, Kathy prompted students to observe the fluctuations within the upward trend and she asked “Is the bar graph the easiest way to see this?” (TKFN3, p. 1) Carmen suggested that a line graph would be a better representation of the data. Kathy gave the students a piece of chart paper and some markers and asked students to construct a line graph to display the same information about food bank use. Everyone moved to the lab bench at the back of the room for space to lay out the large piece of chart paper. One student (name of this particular student was not recorded in the field notes) commented that the grid on the chart paper we provided was perfect for graphing. She was worried that the chart paper would be the regular lined paper, which would be difficult for the graphing task. Isabel took the leader role and began by drawing axes. Rachel went to the front of the room to obtain a metre stick for drawing lines. The students had an off-topic chat as Isabel drew the axes. Collectively, students decided to use the same scale for the axes as those on the bar graph. Lena asked “Wait, are we drawing a dotted graph?” (SFN3, p. 1)
Carmen replied, “Yes, we are drawing the dots, then connecting them” (SCFN3, p. 1). Lena appeared to be confused about the difference between a scatter plot and a line graph.

Kathy prompted students to plot different parts of the graph since there was a lot of data and little time remaining. Students divided themselves up and one of them said “We’ll start at this end” (SFN3, p. 2). During the plotting task, one of the students referenced the data plotted by others to the data on the bar graph to ensure the points were correctly marked. A few points were corrected. Tessa, who appeared to be a quiet participant in the activities, stood and watched the other students. Then, Isabel took an orange marker and connected the dots. She then asked another student to draw the trend line using a blue marker. Another student stepped in and drew it closely to the orange line. Kathy suggested that they could have used a different scale. One of the students responded “Ya, it would’ve been more obvious to see the fluctuations” (SFN3, p. 2). Students agreed. (See Appendix V, Figure V3)

Kathy posed the question: “What factors do you think contribute to this trend?” (TKFN3, p. 2) Inflation was mentioned and the students discussed the increase of the cost of food and other living expenses. One student pointed to the graph and said that she found it interesting that the gap was greatest between the years 2008 and 2009. Kathy then asked the students to think about possible explanations for that large gap. Rachel noted that 2008 was the year that many people in the United States became unemployed and this phenomenon affected Canada, contributing to an increase in the food bank access. At this point, Kathy did not refer to the notes written in the activity plan. She raised her own discussion questions based on students’ responses. The next question Kathy posed was “Could you predict the future using this graph?” (TKFN3, p. 2) Students predicted that the use of food banks would continue to increase and said that they had heard on the news that 2010 had been a year of high food bank use. “Housing
prices [are] another factor,” said Isabel (SIFN3, p. 2). Students then directed their attention to the peak on the graph at the year 1994. Isabel pointed to that section on the x-axis and said that “I think there were a lot of kids born in the early 90’s” (SIFN3, p. 2). Rachel then exclaimed, “That’s us!” (SRFN3, p. 2) and students laughed. Kathy asked the students how the increase in birth would contribute to the peak in food bank use. Students replied that it would take more to support a family. Kathy raised the notion of stigma. “Having children could be a factor for people to be willing to overcome that stigma of being poor and using the food bank because feeding their kids is more important” (TKFN3, p. 2). Students nodded and showed agreement. Since the data was on food bank use in the local city, Kathy questioned the students what they think would look different if the data was in the context of Ontario or of Canada. Isabel answered, “Canada’s immigration is a factor. I know my parents came around 1990” (SIFN3, p. 2). Carmen mentioned immigration could be a factor because “when people who are immigrants come to this country, they don’t have the same jobs” (SCFN3, p. 3). Isabel continued this conversation, “I heard from somewhere that one-third of people using the food bank are immigrants” (SIFN3, p. 3). The activity ended when the bell interrupted this conversation.

**Activity 4 - Correlating Food Bank Use and Population Growth**

Rachel, Isabel, Tessa, Lena, and Carmen were all present as soon as the session began. Kathy asked them whether they remembered the activity from the previous week. Isabel gave a direct answer using the context of last week’s activity: “food bank” (SIFN4, p. 1). Kathy informed students that in this related activity, they would delve into one of the factors that could have contributed to the use of food bank: population of the local city. Kathy displayed the line graph that had been created by students the previous week and distributed a photocopied page showing with the population of the local city between 1986 and 2006 in five year intervals.
The instruction given to students was to graph the population data on the same set of axes as the food bank use graph. Students were about to begin graphing, but there was a pause and some of the students exchanged looks. They appeared to have recognized the problem with the axes because the y-axis, representing the number of people, ranged from 2,000 to 12,000 at 1,000 people intervals. The new data that students were to graph ranged from 122,000 to 153,000 people. Students hesitated and said that they could not simply solve this problem by extending the y-axis from 12,000 to 153,000. Kathy stepped in and appeared to want to offer a suggestion as she said “What you guys can do is...” (TKFN4, p. 1); however, she changed her mind and decided to allow students to figure it out themselves as she said “Hmm...I’ll let you guys figure it out” (TKFN4, p. 1). One student recommended constructing a second y-axis on the right side of the graph, sharing the same x-axis. Students agreed and discussed the scale. “Should we go by 10’s?” asked Isabel, implying intervals of 10 thousands. After a short, collegial discussion, students decided to start the axis at 120,000 and increase by 2,000 people for every unit on the grid. At this time, the sixth student participant, Anita arrived and some off-topic chats about lunch began. Kathy explained the activity to Anita and asked the group “So how did you decide the scale?” (TKFN4, p. 1) One of the students answered that they used the range of the data given. Students shared the graphing task by passing around a green marker for each person to plot one of the 5 data points and the last student with the marker drew the curve (Appendix V, Figure V3). After the graph was completed, Kathy asked for students’ reactions to the visual display of the population data over the years. Isabel said that she noticed the “rate of change” (SIFN4, p. 2) was the greatest between 1986 and 1991. Kathy asked if there are any trends and whether or not students could predict using the trend. Rachel said “Well, this is a real-life application, so I think it will level off a little bit rather than keep increasing although the curve
keeps going up” (SRFN4, p. 2), referring to population curve. One student suggested immigration as a factor in population increase. Without referring to the notes of the planned activity, Kathy suggested that there are different resources for people in living in poverty to access. She explained that the data describing the number of people who use the food bank was not representative of the segment of the population living in poverty because not all individuals under the poverty line access the food bank. Rachel said, “Like Pauline’s Kitchen (pseudonym), where people can get a free meal once a week” (SRFN4, p. 2). Pauline’s Kitchen is a local soup kitchen that students from the Social Issues Club supported through fundraising in prior years. Kathy prompted students to find trends in the data and students noted the sharp increase between late 1980’s and early 1990’s in both curves. Because Isabel mentioned “rate of change” earlier, I asked students to determine the rates of change to compare the increase in both food bank use and population. Anita looked at the graph and placed her finger on the points of the graph at which she was interested in finding the rate of change. Isabel said “Rachel, find some derivatives!” (SIFN4, p. 2) Students calculated the rate of change between 1986 and 1991. Some students contributed by reading the data points aloud, while others provided the number sentence. Isabel took charge of recording the calculations and wrote:

\[
\text{rise} \over \text{run} = \frac{10000 - 3000}{5} = \frac{7000}{5}
\]

(Appendix V, Figure V3). Isabel spoke aloud to herself “What’s 7000 divided by 5?” (SIFN4, p. 3) One of the other students pulled out a calculator but by the time she obtained the answer on her calculator, Isabel had already mentally calculated the answer to be 1400 people per year. However, the calculations were incorrect because students read the inappropriate y-axis as they were determining the coordinates from the graph. This error was not identified during the
session. Students then decided to look at the rate of change at the end of the curve, which was the interval between the year 2001 and 2006. Again, students worked together and Isabel recorded:

\[
\frac{\text{rise}}{\text{run}} = \frac{152\,358 - 146\,838}{5} = \frac{5520}{5} = 1104 \text{ people/year}
\]

This calculation was correct because the values of the coordinates were obtained from the table of values rather than from the graph.

Because three of the students (Rachel, Anita, and Isabel) were in Grade 12, I asked the students why they chose to use the formula, \( \text{slope} = \frac{\text{rise}}{\text{run}} \), which was a formula learned from Grade 9, rather than the formula, \( \text{rate of change} = \frac{f(b)-f(a)}{b-a} \). Rachel said that it was easier for her to remember. Anita replied that slope and rate of change are the same ideas and was easier to understand. Isabel agreed and expressed with a little bit of humour, “It’s rise over run in my heart” (SI 4FN4, p. 4). To clarify, I asked if they preferred to remember “rise over run” because they understand that the slope and rate of change concepts being the same rather than memorizing the rate of change formula. The Grade 12 students agreed, but Lena, Carmen, and Tessa, who were in Grade 10, had no input. Rachel added that “Because letters are just letters” (SAF4N4, p. 4).

After this conversation, one student, whose name was not recorded in the field notes, asked whether the food bank use was recorded in units of individuals or families. Kathy replied by saying “That’s a very good question. Let’s see” (TKFN4, p. 4). She looked at the source of the food bank data, the Deprivation Index (Appendix L), and read aloud the written information:

According to an Ontario Association of Food Banks report, almost all of those who use food banks live in rental housing, with 65% in market rental housing and 34% assisted housing. A third of those who use food banks are new Canadians with over half having a
post-secondary degree. (Kingston Community Roundtable on Poverty Reduction, 2010, p. 5)

Students reacted with wide-eyes when Kathy read “over half having a post-secondary degree” (Kingston Community Roundtable on Poverty Reduction, 2010, p. 5). Although the statement “a third of those who use food banks are new Canadians with over half having a post-secondary degree” indicated that the food bank use would be recorded in units of individuals, Kathy was not aware and concluded that no indication was given about whether the data was recorded in units of number of individuals or number of families. Carmen responded to the “post-secondary” information and said “A number of people who use the food bank have mental issues, so it’s not their fault” (SCF4, p. 4). Everyone nodded. Next, Kathy asked, “So there are only a few minutes left. What’d you guys find?” (TKF4, p. 4) One of the students responded by stating “steeper rates of change at the 1986-1991 period, but the population and food bank use are not quite changing at the same rate” (SFN4, p. 4). Kathy pointed to the population curve and asked “What other factors can be graphed on this?” (TKF4, p. 4) One of the students answered “unemployment rate” (SFN4, p. 4). Other factors students thought of included size of family and disability. The bell interrupted the discussion. Students gathered their belongings and showed appreciation by saying “thank you”, “happy holidays” and “see you in January.” Isabel, who was the last one to exit, pointed at the year of 1994 on the food bank use curve and said “I still wonder why there’s a giant peak right there” (SIF4, p. 4).

Activity 5 - Fuel Consumption of Vehicles

When I arrived, Social Issues Club members were completing their regular club meeting. Isabel, Tessa, and Anita gathered together for the SJM component. We began the session by discussing administration issues such as examination schedules and possible dates for remaining
SJM meetings. Next, Kathy took the role of introducing the topic of this session: fuel consumption of vehicles. Kathy and I decided to include this topic because students came up with vehicle fuel consumption as one of the factors in their estimation of various living expenses in Activity 2. Kathy started by asking students whether or not they had a vehicle or a driver’s license. All three students replied no. “Why is it a good thing to know about fuel consumption?” (TKFN5, p. 1) was the next question Kathy posed. Answers included “gas is expensive” and that fuel consumption is “bad for the environment” (SFN5, p. 1). One of the students mentioned that fuel used in vehicles is not a sustainable form of energy. Kathy acknowledged that comment and gave each student a handout titled “How Lower Fuel Consumption Translates into Savings” (Appendix X), which displayed a bar graph on this data. Kathy asked “What is this graph showing us?” (TKFN5, p. 1) Isabel said, “Different cars have different fuel consumptions” (SIFN5, p. 1) and Anita said, “The car gets bigger” (SAFN5, p. 1). Then students discussed the idea that the larger the vehicle, the more fuel it will consume. Kathy asked the students “Is this a linear relationship?” (TKFN5, p. 1) Looking at the bar graph, Isabel and Anita said yes and Tessa nodded. Kathy asked students why they knew this to be a fact. Isabel responded by using a ruler to draw a line through the bar graph along the ends of the bars. The other two students agreed with her strategy. So, I asked the students to think about how we could verify that the data is in a linear relationship. Anita said, “we could graph each of the numbers” (SAFN5, p. 1). There was a brief silence, during which students appeared to be thinking. I prompted students to think about a more accurate way to determine a linear relationship. On their own sheets, students wrote the following: (4, 1000), (6, 1500), (8, 2000), (11, 2750), and (14, 3500) by identifying the information on the bar graph (Appendix V, Figure V4). These represented the coordinates of fuel consumption in litres per 100 kilometres and the annual savings assuming the cost of gas to be at
$1.25 per litre. At this point, students were working individually and silently. Isabel’s handout was scribbled with some calculations using first differences of the data, which was obtained by subtracting consecutive values. Anita and Tessa appeared to be doing mental calculations. One of the students asked if calculators were allowed. Once I said yes, she began entering numbers on her calculator. After a minute, a conclusion was offered when students stated that they found increments of $250. When expressing the unit, students said expense per litre and Kathy clarified that the figure represented $250 saved per L/100 km. I asked students to look at the values of the dependent variable, which was amount of money saved. Referring to the values, 1000, 1500, 2000, 2750, and 3500, I said, “If we look at the money saved, it isn’t increasing constantly” (R1FN5, p. 2). Isabel and Anita replied simultaneously that the independent variable was not increasing constantly either. Isabel explained that from (8, 2000) to (11, 2750), “the jump is three, and 2000 jumped to 2750” (SI5N5, p. 2), which corresponded to an increment of 250. The bell rang before there were further discussions on their findings. It was noted in the field notes that students did not use the language of slope or rate of change, nor did they mention the way they calculated slope in their explanations. Because of the time constraint, this activity ended and was not continued in the next session.

Activity 6 - Haiti – Women’s Education and Life Expectancy

This activity took two SJM sessions to complete. The first session was followed by the examination period; thus, the second session took place two weeks after the first. In the first session, four students were present. One of the students noted in the observations was Isabel. Kathy was absent for this session. Thus, I led the sessions and made quick observation notes simultaneously. I distributed a table containing data about the mean number of years in school for women in Haiti and the average life expectancy of the general population in that nation.
(Appendix Y). I began by asking students what they believed to be the factors that affect life expectancy. Students hesitated but eventually one student answered “health” and another mentioned the environmental conditions within which an individual lives. Referring to the data, one of the students stated that the number of years of education a person completes would be a factor as well. So I prompted students to think about the reasons that education could be a factor in one’s life expectancy. One student responded, “Because with education, they might learn to live in a way that would help them live longer” (SFN6, p. 1). Amongst themselves, students discussed sex education and learning about nutrition as areas that education would support. I asked students to think about this in terms of the Canadian context. Income was mentioned and the notion of income as a factor was expressed by relating it back to our previous activity on Poverty and Healthy Eating. I asked the students “What are we going to do with this data? What can we do with it to better understand life expectancy and education?” (RFN6, p. 1) As usual, chart paper and markers were present and I prompted students to represent this data visually. Students moved closer to one another and gathered around a piece of chart paper. One of them suggested drawing two vertical axes, each being Mean Years in School for Women and Life Expectancy, while the horizontal axis was to be the independent variable, the years from 1970 to 2009 (Appendix V, Figure V5). The other students agreed and started drawing lines to create the axes of the graph. Students spoke about colour-coding the data. One student said the “to go by five’s because she likes the number five” (SFN6, p. 1). By that, she was referring to plotting data in increments of five years to include the years 1970, 1975, and so on, up to 2005. On the tables, students highlighted the data they were going to plot. Another student counted the number of squares on the axis to decide the scale of the axes. One of the students directed a question to her peers: “How many five year intervals do we have?” (SFN6, p. 2) She then counted and
calculated mentally to determine the scale. After labelling the axes and plotting the data of Women’s Average Years of Schooling, students paused to look at it. I allowed students to study the graph. There was a moment of silence. One student said, “It looks like a straight line” (SFN6, p. 2) and another said, “It looks like a curve” (SFN6, p. 2). Because of this disagreement, I asked “Can we figure out if it is a linear increase or not?” (RFN6, p. 2) The same student who said the data followed a curved trend said “I think it’s increasing exponentially” (SFN6, p. 2). So, I asked, “Why do you think that?” (RFN6, p. 2) The student was unsure. She then pointed at the points, traced along them, and moved her arm to draw an exponential curve in the air just above the piece of chart paper. Other students appeared puzzled and expressed uncertainty about whether or not the graph would continue in a straight line or a curve. I posed the following question, “What is another way, other than looking at the visual, to determine if the trend is a linear or a curve? And, if a curve, what kind of curve?” (RFN6, p. 2) The students remained silent. I suggested the students to find the First Differences of the data. Students remained hesitant.

I wrote down a T-table the following:

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>32</td>
</tr>
</tbody>
</table>

I asked students what the First Differences are, two of the students replied aloud as I pointed from one row to another down the column: “2, 4, 8, 16” (SFN6, p. 2). The other two students
appeared to be following along quietly. I asked students what the Second Differences are, the
two students reiterated “2, 4, 8, 16” (SFN6, p. 2). I then asked the students what the Differences
would look like in a quadratic relation. Isabel said, “Okay, let’s look at let’s say $y = x^2$”
(SIFN6, p. 2) and imitated my T-table drawing:

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

She then wrote down the First Differences: “3, 5, 7, 9” (Appendix V, Figure V6) while other
students watched her. Then she wrote “2, 2, 2” as the Second Differences (Appendix V, Figure
V6). At this point, I asked them “What’s the difference between the Differences of a quadratic
and that of an exponential?” (RFN6, p. 3) One of the students looked and said “The First
Differences of a quadratic are odd numbers?” (SFN6, p. 3) I nodded and said “Yes, that’s true,
but let’s look at the Second Differences, notice how they are constant? In a linear relation, what’s
special about the First Differences” (RFN6, p. 3). In unison, students said “they are constant”
(SFN6, p. 3). Isabel spoke next, “Oh, in a linear relation, First Differences are constant. In a
quadratic relation, Second Differences are constant, and then 3, the third, and so on.” (SIFN6, p.
3). I then directed students to look at the exponential function represented in the T-table I drew
earlier and asked whether or not they noticed a pattern. One student responded that “it’ll continue
on as 2, 4, 8, 16 and it won’t go constant” (SFN6, p. 3). I said to the students, “So this would be
one way to tell if it’s an exponential increase or a quadratic increase, right? Now let’s look back at our data” (RFN6, p. 3).

Students looked at their sheets with Haiti’s data. Isabel calculated the First and Second Differences from the data they have highlighted on the table (Appendix V, Figure V7). The students followed along by watching and helping with calculations. They obtained the following First Differences values: 0.3, 0.4, 0.6, 0.6, 0.7, and 0.7 (Appendix V, Figure V7). The Second differences they found were 0.1, 0.2, 0, 0.1, and 0 (Appendix V, Figure V7). They paused for a moment and observed the numbers. I recommended that students calculate the Third Differences, which were determined to be 0.1, 0.2, 0.1, and 0.1. One of the students said that the Differences are now closer to being constant. I prompted them to think about whether this data could be modelled by an exponential function. Students all shook their heads, indicating “no, this data could not be modelled by an exponential function” as an answer. They then decided to graph the Life Expectancy data. Before they had the chance to begin, the bell rang and students were dismissed.

Activity 6 Continued

In this session, all six students were present. As students transitioned from the regular Social Issues Club activities to SJM session, Isabel, who was one of the leaders of the club, concluded the first component by stating “SoJo Math time!” (SIFN7, p. 1) Someone asked her “What’s SoJo Math?” and Isabel replied “Social Justice Math. We’ve been doing it for a couple of months and we look at numbers and issues, stuff related to the community” (SIFN7, p. 1). I was not previously informed about whether or not Kathy was going to absent for this session. Assuming she might have been running late, I began the session as the leader. As SJM participants gathered, I laid out the piece of chart paper containing the graph (Appendix V,
Figure V5) that the students had worked on in the last session and asked students what they remembered about the activity. Perhaps it was difficult to recall the last session from two weeks ago because students hesitated for a moment until one replied that they were looking into “the years of going to school and how long they would live” (SFN7, p. 1). Isabel added, “I remember doing some First Differences” (SIFN7, p. 1). I drew students’ attention to the graph they created in the last session and prompted them to complete the graph by plotting the Life Expectancy data. Students asked Isabel to draw the graph and she volunteered to complete it. The result was a curve representing the mean number of years for a woman’s education over time and a curve on the life expectancy of the Haitian population over time. A few students commented that both curves were increasing. At this point, Kathy entered the room and apologized for being late. Rather than facilitating as a leader, she observed our activity during this session as I continued the discussion with the students. I asked students whether they noticed a trend. One of the students mentioned that the curves were increasing together and were non-linear. Another student, who was present at the previous session added that she remembered that the First Differences had been calculated at the time and that the group had concluded that the curve was non-linear. A student who was absent from the previous session commented that “it looks like it’s exponential” (SFN7, p. 1). Isabel replied, “I don’t think it’s exponential. I think it’s quadratic because we calculated the First Differences last time” (SIFN7, p. 1). Next, I spoke about modelling data with equations after knowing the curve that it potentially follows. Isabel interjected and said, “Well, a quadratic is $x^2 + bx + c$” (SIFN7, p. 1), indicating the following $x^2 + bx + c$. After she stated that, the students appeared not to know what to do. So I explained to them that one of the ideas of finding equations to model data is so that predictions can be made. I asked them, “Do you think the curves will continue to increase?” (RFN7, p. 2)
Rachel responded, “Well, it’s not gonna increase forever and ever” (SRFN7, p. 2) and Carmen added, “Ya, there is a point where it will level off. People won’t live forever” (SCFN7, p. 2). Isabel changed the topic of the discussion by mentioning, “I think it’s interesting that the gaps between the points were really far (pointing at the 1970’s), and then they come closer (point at the 1980’s), and then they get further apart again (point at the 1990’s and the 2000’s)” (SIFN, p. 2). Students observed the sections Isabel pointed at as I acknowledged her comment. I personally did not know the reason that contributed to the gaps, so I said, “I wonder why that’s the case” (RFN7, p. 2).

After the appropriate interval, I suggested that “If we look at the relationship between the years of schooling and life expectancy, we can also look at the correlation of the data.” The students appeared confused. Finally, one student asked “how do we do that?” (SFN7, p. 2). I did not answer immediately and gave a moment for the students to think. Students did not know and began looking at me. Thus, I suggested that we graph the years of schooling on the x-axis and the life expectancy on the y-axis instead of the year on the x-axis, which was created on their current graph. A few students said “Ohhh.”

I took out a blank piece of chart paper and students grabbed the markers themselves. Anita drew the axes and looked at the first graph to determine the scale of the axes. I asked students to divide themselves up for the tasks. Students arranged themselves into pairs very quickly. One pair was responsible for plotting the data from the 1970’s. Another was responsible for plotting the data from the 1980’s and the third pair was in charge of plotting the data from the 1990’s. Students decided to divide the remaining data after depending on whichever pair completes the task first. The bell interrupted the activity. At that point, students finished most of the plotting. Although a discussion about the data was not time-permitted, students observed the
graph (Appendix V, Figure V5). Before being dismissed, they concluded that the relationship between years of women’s education and life expectancy were in a positive relationship.

Participants’ Experiences

To present participants’ experiences, this discussion is organized into one section for each of the three preservice teacher participants and one section for the student participants. Participants’ experiences are organized into themes and patterns that emerged from the findings.

Preservice Teacher Participants

Kathy’s self-reported influences on her experience. In this section, data related to Kathy’s self-reported influences on her experiences including her beliefs, intentions, barriers, and supports will be described. Kathy was a preservice teacher participant who was enrolled in the consecutive teacher education program and had secondary mathematics teaching practice during her practicum experience at the time the study was conducted. Her mathematics background included the completion of seven full credit undergraduate mathematics courses.

Kathy’s beliefs and intentions. Kathy shared beliefs about mathematics as a subject and mathematics teaching when discussing the real-world applications that were the basis of activities in SJM. She believed that the applicability of mathematical concepts varies by grade and that application is content-dependent. For example, “in Grade 9 and 10, a lot of [math] can be applied to the real world, but in Grade 11 and 12, it isn’t as much” (TKII, p. 1) and “if you are doing graphing, I think it’s easily relatable” (TKII, p. 1). She expressed that, unlike graphing, the “trig identity stuff like sine squared plus cos squared that equals one...I don’t know how I would relate that to something” (TKII, p. 10). Kathy often used the word “relatable” to describe finding applications of mathematics to the real-world. When discussing this, she stressed that it is important for a teacher to be aware of the difference between the students’ and the teachers’
worlds because teachers had very different experiences when they were students due to the rapid changes in the world. To emphasize this, Kathy believed that teachers cannot “use the same thing every year” (TKII, p. 9) and need to play the role of curriculum developer to connect mathematics to students’ lives. This notion can be seen in Kathy’s anecdote about her observation of a Grade 9 class learning graphing through arm’s length and height data:

They did the arm length and their height, but you could very easily incorporate something else. In no way are you straying from the curriculum. You’re simply using a different example. Your outcome is still the same. The students are graphing, interpolating and extrapolating data . . . I don’t think the curriculum has to be exactly what the textbook says. (TKII, p. 10)

To her, making mathematics “relatable” also meant relating to “something that [students] would use it in” (TKII, p. 1).

Kathy also believed that student engagement reflects relevance of the topic or the activity and teachers’ enthusiasm. She referred to engagement as leading students to “pay attention more” (TKII, p. 8) and being able to “eliminate classroom management issues” (TKII, p. 16). She spoke about engaging and connecting to students’ through “materials they’re interested in” (TKII, p. 7), “connecting to their interests and . . . to relevant things” (TKII I, p. 5), and “conveying that [she] thinks that there’s a value in learning [mathematics]” (TKII, p. 4).

Kathy stated that her intentions were to integrate topics for learning so that students could “learn the math and learn about issues that are happening in life” (TKII, p. 5). This related to her belief that “when you mingle the two to make connections, then [students] do better in both” (TKII, p. 8). Achievement, Kathy also believed was reflected in students’ positive experience
because “if something is personal, [students] put more effort into it and students excel in certain subjects” (TKII, p. 9).

During one of the SJM activity design meetings, Kathy suggested the comparison of the Haitian’s average life expectancy to that of the Canadian population. Because the activity involved looking for a relationship between women’s education and life expectancy for population of Haiti, Kathy recommended that a possible additional activity would be to determine the relationship between women’s education and life expectancy in the Canadian context. Moreover, Kathy stated that income and life expectancy could also be a topic for students to explore. Kathy mentioned that she aimed to present trends and relationships in data in order to relate mathematics to students.

**Barriers and supports in Kathy’s experiences.** Limited resources and time constraint were two barriers that Kathy faced when designing lessons that were based on meaningful real-world applications. She experienced difficulty in finding “the resources that connect to it” (TKII, p. 11). Creating applications that relate to students would “depend on how much time [she] had” (TKII, p. 11) because Kathy tended to dedicate time to “get the basics down of lesson planning” (TKII, p. 13) and “relearn” (TKII, p. 11) mathematics content. Although she expressed a sense of confidence in improving with more experience through classroom teaching practice, she raised the challenge of the absence of concrete examples on which to model lessons based on her formal teacher education program.

We (individuals in her mathematics curriculum course, CURR343) talk a lot about making it engaging with the students and making games, but [the CURR343 course instructors] don’t bring in the issues that we (SJM participants) talked about . . . . I don’t
think that we were taught how to incorporate different, mix of stuff . . . integrating different subjects and materials we haven’t learned. (TKII, p. 7)

Another barrier encountered is to “make sure you follow your curriculum” (TKII, p. 7). Kathy felt that the intended curriculum for formal classroom learning is “confined” (TKII, p. 13) and that her role as a teacher is restricted “to cover only certain things” (TKII, p. 13). In addition to this, Kathy showed a sense of conflict between adhering to “conventional lesson planning” (TKII, p. 13) and attempting various approaches in her practice because she viewed following the traditional approach as getting “stuck in a rut” (TKII, p. 13).

Although Kathy faced these challenges, she pointed out that the role of her associate teacher (AT) during her practicum made an impact in her experience. Kathy’s AT allowed her to explore and encouraged her to “go for it” because he believed that the practicum was her “opportunity to do whatever [she] want[ed]” (TKII, p. 6), such as the opportunity to explore the use of technology in a mathematics classroom.

Being involved in this study also supported her experience as a preservice teacher. “Seeing how students respond . . . makes me very eager to include it, to try my best to incorporate this, the social justice issues” (TKII, p. 8) was one of the supports Kathy referred to. “The positive results from students” in the SJM also acted as encouragement. Kathy regarded this experience as one in which she “learned lots of stuff [that she] never looked at it that way or thought of it that way” (TKII, p. 14).

**Kathy’s comparison between SJM and other educational experiences.** When describing her experience in leading SJM sessions and designing SJM activities, Kathy often spoke about them in relation to other experiences. In this section, Kathy’s comparison between SJM and other educational experiences will be described.
**Kathy’s role as a teacher.** “Having students do group work” (TKII, p. 5), allowing “investigation style learning” (TKII, p. 5), and allowing students to come to “their own conclusion” (TKII, p. 6) were all teaching approaches that Kathy experienced in her teaching practice and in the SJM activities. She also discussed the use of media such as online streaming videos to engage students, which was an approach that was not used in SJM. In regards to designing SJM activities, Kathy thought it was beneficial to collaborate with colleagues to “bounce ideas off of each other” and “generate so many more ideas” (TKII, p. 12). Kathy expressed her preference for collaboration by relating her SJM experience to the partnership with her AT to incorporate new teaching tools such as the interactive whiteboard into their classroom. “So we kind of learned [the SMART board] together, so it was nice” (TKII, p. 6).

Kathy mentioned that she participated in another professional development opportunity on the topic of “financial literacy” (TKII, p. 17), which reminded her of her SJM experience and the opportunity to: “incorporat[e] financial literacy into every subject . . . it really made me think about this (SJM) . . . and how to incorporate it into different subjects” (TKII, p. 17).

Lastly, Kathy related “venturing out” (TKII, p. 8) and “not stick[ing] to conventional lesson planning” (TKII, p. 13) as one of the teaching lessons from the SJM experience that she would carry with her into future practice.

It (the SJM experience) makes me more interested in trying new things and maybe venturing out a bit, away from just the things they put in the textbook . . . So maybe making up my own worksheets instead of just using textbook stuff or making up different activities, including these summative activities. (TKII, p. 8)

**Kathy’s perceived nature of applications and students’ experience.** Kathy felt that the SJM activities were relevant to students in a way that was community-based, globally-oriented,
and connected to real life since they were about “things that are happening around our community and around the world” (TKII, p. 7). By having activities of this nature, she sensed that they opened the door to a possibly deeper understanding of social issues. She commented:

When we are looking at stats . . . you might know that there’s an issue. So people using food bank, you know that there are people using it, but to what extent are people using it, to what extent do people need it. So figuring out those numbers, putting them into graphs . . . [to see] where patterns are and where issues are. I think it lets us compare a lot of stuff. (TKII, p. 2)

Kathy also said that she felt that SJM activities could have an impact on students’ lives by teaching “them how to use their skills that they learn in math and apply it to their everyday life” (TKII, p. 2) and she used the cost of gas and the healthy eating activities as examples to support her statement. Kathy thought “the healthy eating” (TKII, p. 2) activity was “very applicable to their (students’) lives” (TKII, p. 2) because “they eat this stuff” (TKFN9, p. 2) and that “students are interested in healthy eating” (TKII, p. 14). Topics that Kathy perceived as students’ interests were used in her own mathematics teaching to connect to students. She talked about including applications in her formal lessons such as the way a parabola models the trajectory of a basketball throw or a golf swing. She used sports as applications because “a lot of students were involved in the basketball team” (TKII, p. 2).

When discussing her perceptions of students’ experience in SJM, Kathy felt that this experience allowed students to learn how topics overlap and how they can apply the skills used in mathematics. “They are learning math but they are also learning other important things that students should learn about, like how we talked about the gas and the car insurance” (TKII, p. 2). She observed that students were able to acknowledge other factors in issues examined. When
estimating the amount of gas used each month in the activity of Different Sources of Income, she noticed that students considered the type of car as a factor.

Kathy had a general sense that “all of them (SJM students) enjoyed math” (TKII, p. 15) and had a pre-established sense of interest prior to participating in the study. From her perspective, unlike students she had taught in the formal classroom, the student participants of SJM required little prompting to complete the activities. She “felt that [she] could step back and they [could] still really be learning without me . . . prompting them as much” (TKII, p. 7). Kathy also discussed this experience with the other two preservice teacher participants during a meeting. She spoke about giving open-ended instructions and one incident in which students were to create a scatter plot. Students completed the task without specific instructions about the assignment of variables to the axes (TKFN9, p. 2). In addition, students were perceived to be able to arrive at their own conclusions. For example, Kathy observed that students concluded lowering certain expenses could be a solution for people living in poverty.

To Kathy, students in SJM learn the same mathematics content that they were expected to in the formal classroom; however, the context in which the content was delivered in SJM was different. This could be seen in her following statement:

Some of the activities that we did in Social Justice Math [were] . . . about [Southeastern Ontario]. It was about the last few years. It was very relevant to them; whereas, you can open a textbook and [do activities such as] little Sally did this and some made up thing.

(TKII, p. 5)

Related to this idea, Kathy perceived mathematics content learning through different contexts as one of the goals of SJM. She indicated that “a lot is just the material; the same general outcome
is achieved through the math,” referring “materials” to the context and “the math” as the “content” (TKII, p. 7).

**Kathy’s experience in giving students autonomy.** Kathy communicated her experiences of giving students the autonomy to their own learning in her classroom practice and in the SJM sessions. Having participated in the SJM sessions as the teacher, Kathy felt that she was a learner herself as well. She mentioned that she “was so impressed by what students said in our discussion” (TKII, p. 4) and that she “learned a lot from the students” (TKII, p. 15). From the SJM experience, she became “interested a lot more on their opinions because they have experienced different things in their lives and [she became] interested about what they know, what they think, and what they want to know” (TKII, p. 16). Using graphing activities as an example, Kathy spoke about her observations of students communicating with appropriate mathematical terminologies for graphing. When discussing students’ communication about social justice issues, Kathy said, “students are capable of learning these [issues] . . . and we don’t acknowledge that students are capable of talking about these issues and having in-depth opinions on them” (TKII, p. 16). She believed that teachers need to “give students credit” (TKII, p. 16) and acknowledge students as knowledgeable individuals with the capability to learn and express their opinions.

Kathy also talked about honouring students’ opinions and suggestions, stating that she believed that new ideas could be generated by accepting students’ input. This was an approach that Kathy mentioned to be similar to her classroom teaching.

Whatever they came up with about these topics, we were like ‘that’s a neat idea! What do you think of this?’ It brings lots of [other] topics [for discussion]. That was how I tried to
do it in the classroom and I thought that was similar to [my experience in] Social Justice Math. (TKII, p. 6)

Accepting students’ responses and allowing the activity to be guided by students’ input was also observed and recorded in the researcher’s field notes. By Week 4, in which the Food Bank Use Increase activity took place, Kathy began facilitating the SJM activities by referring less to the lesson plan. She allowed students’ input about factors that contributed to the increase in food bank use to guide the discussion during that activity.

In future practice, Kathy claimed that she would allow students to create “their own tasks” (TKII, p. 8) and “their own set of activities that relates to some issue that they are interested in” (TKII, p. 8). Kathy stated that she would give opportunities and options for students to relate mathematics to their own interests. Moreover, she would allow students to guide the lesson or activity. For example, she stated, “I wouldn’t just stick to it (the lesson). If the students said something, I wouldn’t say we’re going to talk about that tomorrow. I would try to go with it and . . . I would like the students to lead my teaching” (TKII, p. 6). She felt that this notion was something unique in the SJM experience. “It is where your (students’) discussion is going to take us” (TKII, p. 13).

**Kathy’s ideas for mathematical applications.** Ideas in this section came from observations and the interview with Kathy about her ideas when designing activities in the SJM experience and ideas of activities that will be created in her future mathematics teaching.

**Mathematics content in Kathy’s ideas for applications.** Kathy gave examples of the types of investigation that she would use to engage her students in future practice. She would give opportunities to students to calculate averages in contexts such as gas expenses of their vehicle over a month and the cost of owning a cell phone over a certain number of years. Kathy
expressed budgeting as another important skill that she would like to include in her teaching through budgeting activities involving post-secondary tuition and making purchases at the grocery store. For example, she said, “Going to the grocery store and you have 50 dollars and you need to create a few different meals or something” could be a possible activity. Teaching them about creating healthy meals” (TKII, p. 4). Related to her idea of healthy eating, she also intended to include numerical calculations involved in “calculating their total calorie intake” to “create a meal” (TKII, p. 4) and calculating percentages in “having students understand nutrition labels” (TKII, p. 4), food portions, and food servings. Relating to her prior experience, she also discussed calculating percentages in the Grade 11 mortgages topic and spoke about relating to students by creating a project on this subject matter.

In designing the Haiti SJM activity with the other preservice teacher participants, Kathy proposed that one lesson be about using extrapolation of the line of best fit to predict future data. From this activity, she wished to get students thinking about whether extrapolation will always predict data realistically because this activity involved the life expectancy of the Haitian population (TKFN9, p. 3). Using graphing as a source of activity topics, she would relate to graphing tuition over time, obesity rates over age, or obesity rates at different cities (TKII, p. 3). She also suggested giving opportunities for students to find statistics that they would be interested in for activities related to data management topics.

Overall, the mathematics content that Kathy had created and claimed that she would create in the future consisted of calculating averages, data management, graphing and modelling, extrapolating graphs, monetary and budgeting, numerical calculations, and percentages.

**Contexts in Kathy’s ideas for applications.** Updated available data such as recent census of the local city was one of the sources Kathy reported that she would use to determine her future
mathematics activities. Data from available media sources that could engage students such as “neat videos” was another. Current issues and immediate concerns in students’ lives such as students’ “cell phone bills” (TKII, p. 3), “how much physical activities they are getting” (TKII, p. 3), “creating healthy meals” (TKII, p. 4), and “the sexuality unit” (TKII, p. 4) were also areas to which Kathy felt that she could connect mathematics. She also hoped to use mathematics for the purposes of “long term” (TKII, p. 4) impact on students. For example, she would explore “employment issues” (TKII, p. 3), how students “strategically spend their money” (TKII, p. 4), and how students “understand nutrition labels” (TKII, p. 4). When explaining the sources she would use, she compared her ideas to her perception of the Ferris wheel application example in learning trigonometric graphs:

They (students) are relating it (mathematics) to the real world by saying you go on the Ferris wheel. But, students aren’t connecting to that. I think real world has to be what is happening in students’ lives today. What’s happening to their lives at home. What’s basically happening right now around them is what they are going to say it is the real world. (TKII, p. 14)

In relation to the Poverty and Healthy Eating SJM activity, Kathy mentioned that she would continue activities that explore healthy eating and healthy life styles because these were her own interests. She stated, “Because I am really interested in health, I would like to include more lessons on that. I know we talked about healthy eating, but maybe physical activity or focusing more on the obesity rate” (TKII, p. 3). Another one of Kathy’s interest was sports, which was also her perception of students’ interests. She expressed that she would centre her activities around students’ interests and provided an example from her teaching experience: “A
lot of students were involved in the basketball team and volleyball team . . . so I thought that was something that a lot of students could relate to” (TKII, p. 2).

**Sandra’s self-reported influences on her experience.** In this section, data related to Sandra’s self-reported influences on her experiences including her beliefs, intentions, barriers, and supports will be described. Sandra was a preservice teacher participant who was enrolled in the third year of her concurrent teacher education program at the time the study was conducted. At that stage of her teacher education program, Sandra had experience in lesson planning, classroom observation, and four weeks of teaching experience in practicum. Her mathematics background included the completion of 4.5 full credit undergraduate mathematics courses.

**Sandra’s beliefs and intentions.** When discussing mathematics applications, it appeared also that Sandra believed that applicability varied by grade and was content-dependent. Because she was studying undergraduate mathematics herself and finding that she will not be “using this higher math [in teaching in the secondary classroom] . . . like differential equations”, she believed that not all mathematics content will be applied to her teaching practice. She stated, “if I teach calculus, [it won’t be] to the level I’m learning it at right now” (TSII, p. 1). Despite not being able to bring her current mathematics learning into future high school classrooms, she expressed that she knew “in other situations in life, [she will] be able to think of things from a different perspective” (TSII, p. 1). Thus, she would convey to students that even “if they are not even going into math [and] it’s just a requirement in high school” (TSII, p. 1), “it develops a certain kind of thinking” (TSII, p. 1). Elaborating on her belief that mathematics develops “a higher level thinking” (TSII, p. 3), she mentioned that, “for example with proofs, if A is true, then B is true. That’s a rule you can use [in] logic and inductive reasoning to make simple connections between situations” (TSII, p. 2). Other examples she gave were that mathematics
allows the “elimination [of] choices that may not necessarily benefit [one’s] outcome” (TSII, p. 2) and the inquiry from understanding graphs and trends. She was under the impression that mathematics “would be useful in different situations and . . . [that] it’s a stepping stone to other math that would be more applicable” (TSII, p. 1). To explain the notion of “stepping stone,” she made an example with the following application:

If they were graphing the acceleration of a car as it starts, knowing what distance it was might not be interest, but knowing how fast the car is going at a certain rate at certain distance would be more interesting because maybe you’d want to know how far you want to be behind a car, so that if they stop immediately, you don’t crash into them. (TSII, p. 1)

Regarding mathematics learning, Sandra believed that it takes “a certain type of individual to understand or not understand math” and that “there’s a genetic basis” to mathematics learning. Sandra regarded students’ negative attitudes towards mathematics as a reflection of lack of understanding. She stated that students “don’t have that desire because they don’t understand it or it doesn’t make sense to them” (TSII, p. 14). She felt that “fun” (TSII, p. 2) activities could “improve learning” (TSII, p. 7) by contributing to “a more positive stigma (attitude) towards math” (TSII, p. 7).

Sandra displayed intentions towards connecting mathematics to students and integrating topics for students’ learning. She believed that the curriculum objective to apply expectations to real life “should be embedded within every single thing [students] need to learn” (TSII, p. 9) and that the material should be “important to them [and] significant to them” (TSII, p. 7).

In her SJM experience, she intended to inspire “critical thinking, and not just one-dimensional thinking”, inspire students to take actions on issues, and raise students’ awareness about “what’s going on around the world” (TSII, p. 2). She wished to “inspire them not [only]
mathematically, but [to] become involved or to educate themselves [and] educate others” (TSII, p. 2).

**Barriers and supports in Sandra’s experiences.** The feeling of curriculum restriction appeared to be one of Sandra’s concerns in her practice. She described that SJM “gave us a freedom” because “we weren’t following Ontario curriculum objectives” (TSII, p. 9). By that she meant all of the specific curriculum expectations that mathematics teachers must address rather than relating to certain objectives in the SJM activities. Sandra also perceived rule-bound concepts as a barrier to create mathematical applications that relate to students. “Most of those (mathematics concepts taught to students) are just, there is a rule, and you (the teacher) need to just teach them (students) how to use the rule, and when to use the rule” (TSII, p. 9).

In addition, Sandra suggested inadequacy in experience and understanding as a barrier. Her lack of exposure to applications as a focus in mathematics learning was found in both her experiences as a learner and a teacher. As a learner, she “put applications last,” “didn’t focus on applications at all,” and “dreaded the application questions” (TSII, p. 9). She also felt that she “couldn’t relate” because applications tended to be “situations that were just so simplified” (TSII, p. 9). She expressed that applications were always encountered “at the end of the unit” in “one or two problems” (TSII, p. 10). As a preservice teacher, Sandra asserted that she has never “developed an exercise in math that is centered around applications” (TSII, p. 10). Being one of the activity designers in SJM, she said she “didn’t even think of using an application as a centre-point of the lessons” (TSII, p. 12). At the same time, Sandra appeared to have insufficient experience in the classroom in general because she only had four weeks of teaching experience in practicum and she mentioned that she didn’t know “if grading them (students) on the ability to do [applications] is the right way to go” (TSII, p. 10).
Because Sandra expressed a positive attitude towards mathematics, she stated that “it (students’ negative attitudes towards mathematics) is hard for [her] to understand” and she felt that she “would have to go into the perspective of the student and . . . ask them why they don’t like it (mathematics) [and] why they don’t see it as applicable” (TSII, p. 7).

In terms of supports, Sandra communicated that the SJM experience “definitely changes my perspective on how to develop lesson plans” (TSII, p. 11) and she “would definitely consider focusing more . . . on real-world application” (TSII, p. 12). She claimed that through discussing the SJM activities with Kathy, the session facilitator, during lesson planning meetings, she felt that “students really like to learn it (mathematics) that way” (TSII, p. 12), referring to the approach of having applications as a basis of activities. This idea supported her in her lesson planning approach that she described as “switch[ing] it up so [she] can cover all . . . ranges [of students] (TSII, p. 12).

**Sandra’s comparison between SJM and other educational experiences.** Sandra compared her role as a teacher, students’ experience, and the goals and intended outcomes between SJM and her teaching experiences as a Concurrent Education student. Sandra’s idea about giving students autonomy in her future teaching practice will also be described.

**Sandra’s role as a teacher.** In terms of a teacher’s basic responsibilities, which include lesson planning and instruction, Sandra compared her classroom and her SJM experiences.

I think math in the classroom is more focused on the algorithms and mechanisms in which you complete the problem. In the Social Justice Math Club, [students] would also learn about aspects of life...Social Justice Math is what led me to think about building the lesson around student experiences. (TSII, p. 8)
By participating in activity designing for SJM, Sandra described her experience by comparing it to the classroom lesson planning approaches she has completed before:

Our [SJM] lessons were basically structured around first finding something that is extremely applicable, and then developing the lesson around that as opposed to . . . going from top to bottom . . . It (classroom lesson plans) is not based on applications. It (classroom lesson plans) is more based on the technical things that I need to cover. (TSII, p. 9)

Sandra clarified that the “technical things” referred to curriculum expectations required by the Ministry of Education. Another comparison she made was that she did not have exemplars or “anything to guide” (T2II, p. 10) her classroom lesson planning other than the “objectives” (TSII, p. 9), resulting in a “here’s the rule, here’s how to use it, practice it” (TSII, p. 10) teaching approach. The following are other comments Sandra made to reinforce her perceived difference in lesson planning:

When you are constructing a lesson, you are just forced to use what [students] have learned last class, so you would have that restriction. It needs to be sequential [and] within curriculum guidelines. There needs to be some rules, I understand that. So, ‘guided’ isn’t necessarily a bad thing. But, it is definitely more ‘on a path’ than creative like the Social Justice Math. (TSII, p. 14)

and

The “focus in our [SJM] lesson plans was to relate and structure them around real life settings; as opposed to when you give them a textbook, the situations seems kind of simple of something they would encounter, but something that’s not really relevant or important” (TSII, p. 2).
Sandra appeared to have appreciated the “collaborative effort of lesson planning” (TSII, p. 9) because “it was great to have all that kind of criticism right on the spot; as opposed to, developing a lesson plan and then reflecting on it later by yourself” (TSII, p. 9). Furthermore, she felt that it was “interesting to see how the lesson plan unfolds with everyone’s input” (TSII, p. 11). She perceived “sharing ideas about lesson plans” (TSII, p. 12) to be a benefit.

Relating to these experiences, Sandra stated that she “should probably change the way [she is] constructing [her] lessons and not just follow the mould placed by others” (TSII, p. 8). In addition, she would plan her future lessons by going “a step further to look up something that is actually happening in the real world and not just arbitrary situations that could happen to anyone” (TSII, p. 13).

* Sandra’s perceived nature of students’ experience. It is necessary to reiterate that Sandra’s role was in designing, not instructing SJM activities. Sandra commented that she perceived SJM students to participate in a more casual and free environment because “they don’t have the pressure of grades attached to their effort” (TSII, p. 2). She felt that students “internalize[d] [their learning] better” (TSII, p. 2) because “they are not being graded, they are just having fun with it” (TSII, p. 2), and that “the math [was] extremely applicable” (TSII, p. 2).

* Sandra’s perceived goals and intended outcomes. “Learning would be the by-product and wanting to learn [mathematics] would be, I felt, what we were trying to achieve” (TSII, p. 14). This quotation demonstrated Sandra’s impression of SJM’s intended outcome for students. In addition, she spoke about “build[ing] that desire to learn math” and “motivate[ing] them to want to learn” through “focusing on the real world applications” in SJM.

* Sandra’s idea of giving students autonomy. Allowing students to guide activities and valuing students’ questions were approaches that Sandra claimed she would employ in her future
practice. Referring to the general social justice topics in the SJM activities, she mentioned that “if they had questions about this, then . . . I can research that and use the answers and make another math lesson out of it” (TSII, p. 5).

**Sandra’s ideas for mathematical applications.** Sandra’s ideas for SJM activities and ideas for activities that will be created in their future mathematics teaching will be described in this section.

**Mathematics content in Sandra’s ideas for applications.** When discussing future activities that she would create, Sandra referred to applications that related to mathematics topics including data management; the relationship of distance, speed, and acceleration; extrapolating, graphing and modelling; monetary calculations; geometry and measurements; and unit conversions. For example, she would design an activity to graph carbon emission levels and to “take areas under graphs . . . [to find] the cumulative volume of emission” (TSII, p. 4). During collaboration with her colleagues in this study, Sandra suggested that students could plot a graph using months as a unit rather than years of schooling so that students would need to convert years to months from the Haiti data they were given. When describing various possible activities, she used language such as “extrapolate the graph” (TSII, p. 4), “being cost-efficient” (TSII, p. 3), “saving money” (TSII, p. 3), “construct paper cubes” (TSII, p. 5), and “convert units” (TSII, p. 4).

**Contexts in Sandra’s ideas for applications.** This participant asserted that she had “a biology background” (TSII, p. 4) and she felt that “mathematical models are very useful for predicting environmental outcomes” (TSII, p. 4). Based on her interest in biology and current issues, she determined that future activities would involve “data that has been collected” (TSII, p. 4) on the following topics: (a) investigating chlorofluorocarbon (CFC) chemicals from spray
cans that are harmful to the ozone layer, (b) graphing carbon emissions over the years, and (c) constructing paper cubes to represent volumes of melted ice from rising water level data. She hoped to design activities with contexts that “are happening currently [and] are affecting people,” which might lead students to be involved in “evaluating those problems, assigning them quantitative values, so that [they] could compare them . . . compare certain issues [to see] which one’s more pressing and which one should [be] tackle[d] first” (TSII, p. 13). Furthermore, Sandra felt that it was important to use “mathematical models to predict how it would be in the future” (TSII, p. 13) to contribute to solving social problems.

**Brian’s self-reported influences on his experience.** In this section, data related to Brian’s self-reported influences on his experience including his beliefs, intentions, barriers, and supports will be described. Brian was considered as a preservice teacher for the purpose of this study because of his enrollment in an undergraduate mathematics education course and that he was an applicant to various Faculties of Education. The undergraduate mathematics education course allowed him to have practicum experience in teaching mathematics to Grade 7 and 8 students. Having completed 8.5 full credits of undergraduate mathematics courses, he wished to pursue his Bachelor of Education degree and become a secondary mathematics and physics teacher.

**Brian’s beliefs and intentions.** When asked to give an idea of a lesson design around a particular mathematics concept, Brian appeared to be under the impression that “it would be hard” to find relevant data for applications at the “high school level” (TBII, p. 3). For example, he mentioned that “an algebra problem [to] solve for [a certain] variable . . . doesn’t really apply to everyday living” unless “you have a career in construction or engineering” (TBII, p. 2). He also thought that “calculus is a tough one” to relate to everyday life applications other than its
use in “engineering, especially . . . for electrodynamics” (TBII, p. 5) because “someone who
goes into plumbing isn’t going to need advanced calculus” (TBII, p. 12). For individuals
considering plumbing as a career, they will need to learn “volumes, lengths, and bending pipes.”
Similarly, for individuals considering a career direction in economics, they will need to know “a
different set of math skills to analyze economic issues [like] supply and demand” (TBII, p. 6).
Thus, it appeared that Brian believed that mathematics applications vary by grade, are content-
dependent, and are career-specific. He also conveyed this notion through the following example:
“learning how to calculate angles and side lengths for just a triangle may not be relevant” unless
the concept was situated in “construction, like build[ing] trusses for houses that uses
trigonometry” (TBII, p. 1). In addition, he believed that teachers need to “cater to groups of
individuals [so that] they could actually use [mathematics] in their lives, rather than just the lives
of mathematician or a math professor” (TBII, p. 6) because to Brian, “a good way of learning” is
to allow students to “us[e] techniques that they would’ve learned at something that they’re
interested in” (TBII, p. 9). However, at the same time, Brian expressed from his experience,
“Grade 7 and 8’s are too young to question whether what they learn is relevant to their lives”
(TBFN, p. 2). He clarified that because younger students “are required to take all the different
subjects, “are still in the very basics” and “still need to focus on techniques and basics” (TBII, p.
12), he did not think that “they are ready to choose what direction of math” (TBII, p. 12) to be
relevant to their lives.

Despite his view of relevance of mathematics being grade and career-dependent, Brian
felt that certain mathematics concepts play the role “as a building block towards a bigger
problem” (TBII, p. 1) because one would “need those methods in larger problems” (TBII, p. 1).
He emphasized the notion that a student would “learn individual steps . . . [but] won’t use that
single step on its own” (TBII, p. 1) because he/she will “use this in larger problems” (TBII, p. 1). Explaining further, he mentioned that “what we learn in a single course doesn’t necessarily apply directly . . . [and] solving that individual problem may not apply outside of that course or outside of the school, but it’s the technique that you learn for future problems” (TBII, p. 2). Thus, he expressed that mathematics “gives you a problem solving background for other problems that you’ll encounter” (TBII, p. 13) and can be used to “justify the decisions we make” (TBII, p. 2). Thus, Brian expressed his belief in “stress[ing] the importance of how you would use it in the future rather than just in the classroom setting” (TBII, p. 5) for his students.

Regarding mathematics as a body of knowledge, Brian felt that mathematics learning will contribute to future applications, if not immediate ones as he stated the following: “you learn the math behind that so maybe one day, you’ll actually work with it or program it” and “it’s the technique that you learn for future problems” (TBII, p. 2). At the same time, Brian suggested that “just about everything you can look at from a math perspective [and that] you can break everything down into numbers and equations” (TBII, p. 5).

Brian believed that when learning mathematics, students would “go deeper” (TBII, p. 9) when learning a topic of interest and being “compelled to learn it” (TBII, p. 5) when relevance of the topic is provided. Furthermore, he believed that students “don’t like math . . . because that’s not their strong point” (TBII, p. 8).

Stemming from these beliefs, Brian expressed intentions to emphasize the use of mathematics beyond the classroom setting in his own teaching. Because he thought that “people strictly think of numbers and letters” as mathematics, he wished to “point out that math is very widely used and it’s a more broad topic” (TBII, p. 5). To fulfill this, Brian claimed that he would
“find areas, general areas, where large groups of students would relate to and then point out the math that actually goes into that” (TBII, p. 6). He supported his statement with this example:

For example, people who go into construction or auto mechanics or trade, [they] use a lot of torque, measurement, and volume. So for them, you could point out [that] you need to know volume formulas and area formulas . . . when you want to build a house, you need to know the square footage and how much wood you’re going to need and dry wall. So that’s all math. (TBII, p. 6)

In addition to his teaching objective mentioned above, Brian also aimed to show trends and relationships through mathematics. During one of the activity planning meetings, Brian suggested to the other preservice teacher participants that they include an activity component for students to compare Haiti’s life expectancy and women’s education data with that of other countries around Haiti. He discussed intentions to encourage students to apply mathematics in situations such as “see[ing] something that they disagree with and apply[ing] from a math standpoint” to solve the issue (TBII, p. 9) and “find[ing] something that [they are] interested in and graph something or analyze it . . . from a math perspective” (TBII, p. 9). To Brian, “teach[ing] to challenge . . . in the direction that the students need” (TBII, p. 13) was also a form of encouragement.

Finally, Brian demonstrated that he would like to allow critical thinking opportunities. This was shown during the Haiti activity planning, in which Brian suggested the extrapolation of the trend line for students to think about whether increasing years of education would always increase life expectancy or whether various other factors could influence life expectancy.

**Barriers and supports in Brian’s experiences.** Brian discussed his concern about limited resources and not having “enough data in the school for [students] to collect” and having to “use
the internet . . . or newspaper” (TBII, p. 14). He spoke about what he perceived would be a challenge when involving students in the process of generating data for the activities, “You can’t really send students away from the school for a long enough period of time to collect [data] . . . unless they did it on their own time” (TBII, p. 14). In addition, Brian conveyed a feeling of curriculum restriction based on his previous experience: “it’s more this is in the curriculum, you need to teach along this, so it was they give you guidelines and you work around it a little bit” (TBII, p. 9).

In regards to his personal understanding, Brian described his lack of understanding of students’ negative attitude towards and negative performance in mathematics “since math was always [his] strong point” (TBII, p. 18). He felt that he “was good at math, so [he] liked it” (TBII, p. 8). This might have stemmed from his demonstration of inadequate experience in practice through the following quotes from his interview: “I don’t remember when they introduce quadratics” (TBII, p. 3), “I haven’t gone to teacher’s college yet, but this was good practice to see is this something I still want to do [and] is this relevant to what I will do” (TBII, p. 16), and “the unique experience [being in this study] would be it was at a higher level . . . [which was] more towards the age group that I would be leaning towards working with” (TBII, p. 9). Furthering the discussion on insufficient understanding, Brian described his previous experience and the way it was “shocking [for him] to see [that] some [Grade 7] students were incredibly basic in that class [and] . . . some students couldn’t get it no matter how hard you explain it to them” (TBII, p. 18). From this previous professional experience, he questioned the following: “what happened with these students in the past that they’re only at this level?” (TBII, p. 18)
In addition to beliefs, intentions, and barriers, another aspect that was associated with the way the preservice teacher experienced SJM was the support Brian gained. He mentioned that one of the supports he received from participating in SJM was gaining “perspective on what issues, what real life issues we have that are important to students and families and cities and [the] global [world]” (TBII, p. 15). From finding “ways to look at [social issues] at a high school level, [such as] what can high school students do with that data to learn from [and] about it” (TBII, p. 15), Brian gained understanding “that even these global issues, we can take it at a local level and look at it from a Grade 9 . . . [or a] Grade 12 perspective” (TBII, p. 16), which he felt was “more attainable for everybody” (TBII, p. 16).

**Brian’s comparison between SJM and other educational experiences.** In this section, Brian’s comparison between his SJM experience and other educational experiences will be described.

**Brian’s role as a teacher.** Speaking about his previous experiences, Brian stated “hands-on stuff” (TBII, p. 10) as one of his approaches. During one of the meetings for activity designs, Brian conversed with the other participants that the application of arm length and height was, in his perspective, a typical application problem. He thought it would be more interesting to have the data generated by students themselves such as getting them to “get up and measure one another” (TBFN, p. 2). When asked about this approach, Brian mentioned that student-generated numbers would allow students to relate themselves to the data. Furthermore, Brian expressed that he would like to provide opportunities for students to “collect appropriate data about an issue on their own” (TBII, p. 15) and “collect [data] from our community” (TBII, p. 14) for activities similar to those in SJM. On top of teaching approaches, Brian said his role in SJM allowed
“good practice to plan an appropriate lesson based on the material that’s already relevant to students”.

**Brian’s perceived nature of applications and students’ experience.** Orientation to community, current issues, global issues, and situations were some of the aspects about SJM applications that Brian perceived.

Something unique was that we actually used a situation . . . that has come up, a problem in the community, or in Haiti . . . and then pull[ed] data out of that. With the other levels that I’ve helped with or taught, it’s more this is in the curriculum, you need to teach along . . . guidelines (TBII, p. 9).

In relation to his teaching experience in an elementary enrichment class, Brian spoke about the opportunity for students to learn from patterns and from predicting patterns. The students from his previous teaching experience “looked at patterns and sequences . . . relate[d] this sequence to this [other] sequence” (TBII, p. 6), looked into “the relationship between that number and that [other] number” (TBII, p. 6), and “used the specific technique . . . and then apply it to another problem” (TBII, p. 6). From learning that, students predicted in the numerical sequences “what’s going to happen next” (TBII, p. 7). Brian found the “same parallel” (TBII, p. 7) between this observation and his perception of students’ experiences in SJM. Brian felt that “the education versus life expectancy in Haiti” (TBII, p. 7) activity involved “here’s what happened in the past, you can see the average age [of life expectancy] increasing as the amount of education increases. So we [asked students] here’s the pattern we have, what’s going to happen in the future” (TBII, p. 7). Brian pointed out that on the contrary, “the classroom that [he] was in, it was more of the isolated scenario where you just say here’s a pattern, we don’t know if this pattern applies to anything but . . . can you tell me something about it” (TBII, p. 7). He felt that SJM revolved
around “an actual situation that we took from the economy for example” (TBII, p. 7), which was different from “a classroom-based problem” (TBII, p. 7).

In addition, Brian was under the impression that the “grocery shopping” (TBII, p. 2) related activity could make an impact on students’ lives by using “math to place a value on it (daily decisions and activities)” (TBII, p. 2) for students to prioritize necessities in their lives. Based on the activities that he was involved in creating, he felt that students in SJM had opportunities to learn how to apply mathematics skills. For example, in a certain “global justice issue . . . [students] can use math techniques to analyze it” (TBII, p. 1). He conveyed that students “don’t learn about a social justice issue and then apply that to math. [They] apply what [they] learn in math to the social justice issues” (TBII, p. 1).

Because students in SJM “had an interest in [social justice issues] beforehand” (TBII, p. 7), “were concerned with . . . and passionate about” (TBII, p. 7) social justice issues, Brian felt that they were learning with a pre-established sense of interest, which was a difference that he perceived when compared to formal classroom learning opportunities.

**Brian’s experience in giving students autonomy.** “I think teachers need to work with the students’ interest” (TBII, p. 19) was one of the examples that indicated Brian’s understanding about giving students autonomy from this experience. Valuing students’ questions was also important to Brian so that he “can associate [his] next lesson based on what they had already asked” (TBII, p. 16). Thus, Brian said that he would allow students to guide activities such as “find[ing] the data within their own region . . . if it was [an] appropriate topic” (TBII, p. 15). By giving students options “to explore” (TBII, p. 10), Brian felt that students would have the opportunity to “pick something that they’re interested in” (TBII, p.11). He gave the example of
providing students with open-ended tasks such as measuring an object with non-standard units and allowing students to find their own object of interest in the school to measure.

**Brian’s ideas for mathematical applications.** In this section, the mathematics content in Brian’s ideas for applications and the contexts of mathematics applications that Brian created will be described.

**Mathematics content in Brian’s ideas for applications.** The mathematics content that Brian used to make connections when taking part in the design of SJM activities included modelling data about Haiti using equations of the line of best fit and extrapolating the line of best fit. When asked about creating similar activities in the future oriented around issues as well, Brian gave an example of prompting students to graph data on the fuel consumption of transport trucks to look into “how, in comparison, can we change [transport trucks] into a hybrid or a more fuel efficient vehicle” (TBII, p. 4). Another idea he had was “model[ing] the expenses of an owner, who owns a hybrid vehicle versus a gas vehicle because you can find data on gas prices, gas consumption, versus commute times” (TBII, p. 5).

In addition to modelling data, he spoke about mathematical relations since linear relations and quadratic relations were important components in the Ontario secondary mathematics curriculum. Beyond the parabolic curve of a quadratic relation, he was interested in bringing other curves to his future classroom. For example, the “hanging chain” (TBII, p. 4), which is modelled by the Catenary curve, and the “inverted cycloid” (TBII, p. 4), which is the curve that represents the smooth path when riding a square-wheeled bike.

**Contexts in Brian’s ideas for applications.** For the Haiti activity, Brian contributed to the development of discussion topics for students to think more about developing countries, factors affecting life expectancy, and factors affecting number of years of schooling. For future
activities similar to those in SJM, “data [collected] off of Stats Can” (TBII, p. 3) and information from “volunteer organizations [that are] available to the public” (TBII, p. 15) would be sources Brian would use. In terms of a topic related to SJM, Brian “want[ed] to get more into the hybrid vehicles because global warming seems to be one of the new focuses” (TBII, p. 4). Brian mentioned that “you can easily plan a lesson around . . . the benefits and downfalls of electric vehicles and hybrid vehicles . . . for city drivers” (TBII, p. 4). He indicated that understanding the issue of vehicle emissions could lead to further considerations of “what we can do in the future to encourage the type of vehicle or ownership of that vehicle in the city” (TBII, p. 4).

Another reason for this choice of topic was Brian’s own interest in cars.

Non-SJM-related applications based on Brian’s interest, which also included his fascination with astrophysics, to be included in his future teaching of non-linear relationships are the “Planck Curve” (TBII, p. 3), which was “a function of wavelength” (TBII, p. 3) of a star. Brian also talked about relating applications to students’ interests that he perceived. He spoke about his experience in working with a student who “was a hockey player” (TBII, p. 8) and he would use “hockey stats” (TBII, p. 8) to bring relevant mathematics to this student.

The importance of using contexts that relate to “something that [students] already know” (TBII, p. 10), “something relevant for them” (TBII, p. 6) that they would use in the future, and “the issues faced by students themselves” (TBII, p. 9) was expressed. Brian also talked about making mathematical activities job-specific for students. For example, he mentioned that “for workplace [level mathematics courses of the Ontario mathematics curriculum]⁴, [he] would teach using specific workplace examples or different scenarios in the workplace” (TBII, p. 13).

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⁴ Workplace Preparation courses are Grade 11 and Grade 12 mathematics courses in the Ontario Mathematics Curriculum that enable “students to broaden their understanding of mathematics as it is applied in the workplace and daily life” (Ontario Ministry of Education, 2007).
Summary of Preservice Teachers Participants’ Experiences

Although the preservice teacher participants had different backgrounds, were in various stages of their teacher education, and had their unique roles and experiences in the SJM, Kathy, Sandra, and Brian shared experiences that could be organized into three sections. The sections discussed above included: (a) preservice teachers participants’ self-reported influences on their experiences, (b) their comparison between SJM and other educational experiences, and (c) their ideas for mathematics applications.

Kathy, Sandra, and Brian had different teaching experiences prior to participating in SJM. Because Kathy was the only participant who had completed a teaching practicum, she stated that one of her major supports was the role of her associate teacher, who had encouraged her to try various teaching approaches. All three preservice teachers spoke about limited resources and exposure to integrating mathematics with its real-world applications from their prior experience as a barrier in creating SJM activities. Because of their unique experiences, each of the preservice teachers also held their own beliefs about mathematics and mathematics teaching.

Preservice teacher participants also shared similarities when they compared SJM to other educational experiences. Each of the three preservice teachers compared their role as a teacher between the SJM experience and their teaching experiences. Both Kathy and Sandra spoke about giving autonomy to students as a teaching approach that they became familiar with in the SJM experience and that they would bring to their future teaching experience. Because Kathy also had the experience as a SJM activities facilitator, she described her perceptions about students’ experiences more than Sandra and Brian had communicated.
Kathy, Sandra, and Brian derived their ideas for mathematics applications from topics of their personal interest. Despite this similarity they shared, the mathematics content in Kathy’s and Sandra’s ideas for mathematics applications had a greater resemblance to the mathematics content in the SJM activities. Brian, on the other hand, spoke about relating mathematics content to real-world applications by giving novel examples.

This section described influences on preservice teachers’ experiences, the SJM experiences, and perceptions of Kathy, Sandra, and Brian. The data showed that each of the preservice teachers had unique experiences from their participation. In the next section, experiences of student participants will be described.

**Student Participants**

Experiences of student participants’ will be described under the sections of Students’ SJM Experience, Students’ Expanded Perceptions, and Students’ Comparison between SJM and Other Educational Experiences.

**Students’ SJM experiences.** In this section, I will present the perspectives of the student participants (three Grade 10 and three Grade 12 students), as they described their experiences of being involved in Social Justice Mathematics.

**Students’ perception about mathematics learning.** Students recognized the value of learning mathematics using a curriculum integration model. The following are some comments taken from the Student Questionnaire 2:

- “How by graphing dots of food bank usage, annual income, and other related factors, we can find similarities to link together different ideas, aspects, and statistics from someone’s life”
• “Social Justice Math really helped me understand links between things like income and health and health and eating habits”

• “Social Justice Math helped me understand the disparities in costs of living, like in the first lesson where we learned about the costs of different foods and how they were related to nutrition”

During the focus group, Rachel mentioned that “the math itself . . . you’re relating it to all these different subjects together and how they affect each other” (SRFG, p. 14). Similarly, Isabel stated that SJM “touches on math, it touches on social justice, which is like geography [and] all these, the social science part” (SIFG, p. 14). Finally, Rachel perceived her mathematics learning experience to be “worldly” (SRFG, p. 15) “because . . . it’s not just saying that very urban, well-off kids can relate to math, but that women in Haiti with their limited education can also be relating their lives to math” (SRFG, p. 15).

Carmen stated that SJM “really clarified and solidified what [they] learned” (SCFG, p. 9). Similarly, Rachel felt that SJM “also makes what you’re learning stick more” and that she has “learned more here than [she has] in a couple of her math classes” (SRFG, p. 11). Lena spoke about her mathematics learning experience using the activities that involved First Differences and Second Differences as examples. She said, “Now I realize it’s really easy, but I never really got the differences, the first and second differences” (SLFG, p. 10). Lena added that “it kind of helps to see it” (SLFG, p. 10), referring to the SJM activity that integrated calculating First and Second Differences. In the Student Questionnaire 2, when asked to indicate the mathematical concepts that SJM helped clarify, students responded with “it helped me understand graphing and linear relations further” (SSQ2, p. 3) and “I better understood how to read two line graphs
and how looking at a table of values and graphing the information can help better understand materials or subjects” (SSQ2, p. 3).

In addition to clarification and solidification of mathematics concepts, some students also commented on revisiting and applying basic concepts during the SJM activities. For example, Rachel “completely forgot about scatter plots from Grade 9” and she felt that “all of a sudden, they (scatter plots) are just very important” (SRFG, p. 9). Similarly, Isabel described her experience in revisiting the concept of Differences:

When we did the graph of the years of schooling for women in Haiti versus their life expectancy over time, when we were trying to figure out that regression, I had to think back, what’s a First Difference? Because I guess, I would’ve understood all the concepts at one point being in Grade 12 math doing calc (calculus) right now, but it’s just like how do I apply this? So it definitely helped me understand how to apply all the concepts we learned in Grade 9, Grade 10 math. (SIFG, p. 9)

Rachel stated that SJM “shows you what basics of math are used in everyday life” (SRFG, p. 7). Relating to her Grade 12 mathematics learning experience, she added, “We haven’t really done any derivatives and all of that, but we have [done] graphing and first differences and other concepts that you just think it’s very basic math you learned oh so many years ago” (SRFG, p. 7).

**Students’ perception about the mode of mathematics learning.** Carmen spoke about her experience of collaborative learning in SJM: “Listening to other people’s ideas on what we are looking at in the information really helped me understand what was going on” (SCFG, p. 12). On the notion of “other people’s ideas”, Rachel stated that she “actually got time to reflect and to hear other people’s ideas and not just [her] own train of thought” (SRFG, p. 11). Rachel also
discussed the opportunity to “communicate while doing the math” (SRFG, p. 14) and to “relate to these different people while . . . doing the math” (SRFG, p. 14). Isabel commented about “doing the math and . . . also talking in a team” (SIFG, p. 14) to share ideas. She felt that SJM was “more interactive” (SIFG, p. 14).

Carmen, Isabel, Rachel also appeared to enjoy the visual representation of data. Both Isabel and Rachel stated that they “enjoyed the graphing” (SRFG, p. 6) and “really like[d] the visual part” (SIFG, p. 12). Rachel stated that the reason was that it’s “not just numbers and formulas” (SRFG, p. 6). Isabel explained that she found “that the visual stuff helps” (SIFG, p. 12) in the following way: “If I am graphing something, I can actually find what I’m solving for then I can actually find or see what I am applying and be able to find it just by looking on a graph” (SIFG, p. 12). Carmen expressed that the graphs in the activities “was a really good visual aid and it was a lot better than looking at a list of numbers and not really understanding what [they] saw” (SCFG, p. 3). She added that “visual learners would be able to look at these charts and see exactly what they are supposed to be learning” (SCFG, p. 11).

**Students’ reasons for participation.** The reasons for participation expressed by students included a sense of connection to their community, eagerness to learn, impact on personal life, and interest in mathematics and social issues. Not all students spoke about their reasoning for participating. The following are comments from those who discussed this topic:

- “I feel that I am connected to my community and volunteering is a big thing to me. This is an opportunity to bring math, which I love doing, into real world practices” (SRFG, p. 3).
- “It was important for me to get involved to see what I could learn from this” (SIFG, p. 4).
- “To affect my life and not just how I view the world and other aspects” (SRFG, p. 3)
• “It sounded like a really interesting combination, math and social justice, and [the Social Issues Club], which I love, being mathly, but also [being] involved in [the Social Issues Club]” (SIFG, p. 4).

Students’ perceptions about the use of mathematics. When discussing experiences in understanding the use of mathematics, Tessa mentioned that mathematics can be used to find trends “like the way the graphs go up” (STFG, p. 3). She also commented on using mathematics to determine relationships “because you can see the way that things relate to each other and how they affect [each other]” (STFG, p. 3). On the same topic, Isabel stated that in SJM, “we are using math [so that] you can see, oh hey, the linear relation between this variable and that variable” (SIFG, p. 2). Isabel also expressed that mathematics can be used to analyze real data. For example, “you can find the regression using just different data from the world, as opposed to just numbers that people make up on the spot” (SIFG, p. 2).

Students’ expanded perceptions. Students’ perceptions towards social justice issues and mathematics and students’ self-proclaimed expansion of these perceptions will be described in this section. Students self-described insights are used to compare the understanding that they held prior to and subsequent to their SJM experiences.

Students’ understanding of social issues. Carmen and Rachel expressed an appreciation for the cause and effect of various social issues. Referring to the Food Bank activity, Rachel spoke about understanding that “not just the poverty level” (SRFG, p. 3) is a factor of food bank use, but also “the population, the ages of the people who were relying on” (SRFG, p. 3) the food bank, and “the prices of food and of other variables that are necessary in our lives” (SRFG, p. 3). She claimed that she gained an “understanding of math related situations and also the [idea] that not just one thing will affect the outcome” (SRFG, p. 3). Comparable to Rachel’s perceptions,
Carmen stated the following: “I think now when I look at math questions or I see in the news, I think [about] different cause[s] and effect[s] especially since we have been comparing several things in our SoJo Math sessions” (SCFG, p. 3).

In addition, Carmen believed that SJM provided some “eye-opening” (SCFG, p. 5) experiences when mathematical activities were related to issues “around the world,” “about poor countries” and “things in our community” (SCFG, p. 5). She related this understanding of issues to her personal situation and mentioned, “We always think we have it really lucky here, or we don’t think about all the people who have to use food banks, or who live under the poverty line” (SCFG, p. 5).

Participants also expanded their perceptions in understanding relationships between variables. Isabel explained that “now you can actually see how they are in poverty” and gave examples of her insights in “nutrition versus their income, years of schooling versus their income, or . . . life expectancy” (SIFG, p. 2). Rachel mentioned an understanding of the relationship between food bank access and variables such as “population, the ages of people . . . [and] the prices of food . . . and [other] necessities in our lives” (SRFG, p. 3). Pointing to the graph of life expectancy of people in Haiti versus years of Haitian women’s schooling, Tessa claimed that she “would not have thought about that before” (STFG, p. 4). Similarly, Carmen asserted that she “wouldn’t have thought of different things” and “would’ve never thought of that before SoJo Math” (SCFG, p. 4). She used the example of the Food Bank activity to explain her experience in gaining understanding:

My first thought would have been unemployment, so people who are unemployed [accessing the food bank]. But it was so much more than that. It was the population and the age of the people who were using it was a huge factor. (SCFG, p. 4)
**Students’ prior perceptions of real world mathematics applications.** When asked about their perceptions of real-world mathematics applications prior to participating in SJM, students discussed descriptive statistics, job specific applications, and monetary applications.

“I guess before you would just think statistics. Oh, 70% of people in this country live below the poverty line, but now you can actually see how they are in poverty” (SIFG, p. 2) was one of the comments that demonstrated Isabel’s perception of mathematics applications as descriptive statistics.

Rachel and Isabel spoke about job specific applications such as “building a building, how much of this [material] would you need” (SIFG, p. 1), “economics and stocks” (SIFG, p. 1), and “a fisherman caught two tonnes of fish and the fish was this much, how many fish would he have” (SRFG, p. 1). Students’ open responses in Questionnaire 1, which was administered prior to the first SJM session, also showed career-related application examples:

- “Price of food/fuel commercially as opposed to the price of production”
- “Using math to calculate costs of running a business”
- “Cost of running a small business”
- “The revenue of a company and how to find it”

One of the students gave an example of a direct monetary usage to express her understanding of mathematics application in Question 1: “Bob has two dollars and he loses half of it, how much does he have left” (SSQ1, p. 3). Other examples were related to observations of the real world. Rachel discussed modelling a Ferris wheel’s rotation using trigonometric functions as “just observations” (SRFG, p. 1). Other examples included the “rate of population growth/immigration in different countries of different societies” (SSQ1, p. 3) and “Tim is standing
across from a tree. He is 20 m away from the tree and the angle of elevation from where Tim is, is 38 degrees, what is the height of the tree” (SSQ1, p. 3).

Beyond the examples, students expressed how they felt about mathematics applications prior to joining SJM. Rachel expressed that she was under the impression that there was limited application of mathematics to her world. She said that “although it was in our life, it wouldn’t be useful. It’d be like how a sine curve is a Ferris wheel, but that’s not helping us learn about things in our everyday life that we could use” (SRFG, p. 1). Lena mentioned that “SJM helps more. I can use it in the future, as opposed to just random jobs” (SLFG, p. 1). Carmen “found [that] before SoJo Math, real world math wasn’t really applicable in everyday life. It wasn’t really relatable to issues that we saw in our everyday life. It was a little bit unrealistic” (SCFG, p. 1).

Students’ subsequent perceptions of real world mathematics applications. On Questionnaire 2, a few students gave examples of applications that showed immediate relevance between mathematics and real life:

- “Bobby needs to buy as many eggs ($0.16) as possible with 16$ (sic). How many can he buy?”
- “Calculating the amount of money you would spend on gas for different cars. Good for when buying a new car”

On the other hand, Carmen spoke about using mathematics beyond its immediate usage. She stated that “it gave us more of a perspective on not just using math to calculate things, and it kind of broadened the horizons of how you can use math” (SCFG, p. 4). The monetary examples of applications that students provided on their Questionnaire 2, which was administered during the final week of SJM, appeared to be less superficial and related to the SJM activities:
• “How does the annual income of a family affect overall health and what aspects would be a factor?”
• “Finding the correlation between personal income and education by using real data”
• “Calculating interest on savings and investments”

Isabel conveyed that real world mathematics “is more of a diverse topic that we’ve been learning about” (SIFG, p. 2). Throughout the focus group, students discussed their perceptions of applications in relation to current events that are “happening in the world” (SCFG, p. 4), issues beyond the local world, and inclusion of “different parts of the real world” (SIFG, p. 2). Rachel defined current events as “something [that] we look at every day and [that] we don’t realize” (SRFG, p. 15). Isabel’s definition was “something that goes on in the world whether it’s big world or your world” (SIFG, p. 15). Carmen expressed that she perceived real-world mathematics applications as “issues that we may not be talking about everyday but happen every day” (SCFG, p. 15). At a different point of the focus group, Carmen also mentioned that she currently regarded real world mathematics to be related to issues that are going on in the world that are more than just what we see here in [this local city] or in Canada. It would be like poverty in different parts of the world . . . That would be real world math problems to me now. (SCFG, p. 2)

Isabel asserted that “the whole real world math . . . it’s different parts of the real world, different parts in your life. There’s the world, but then you have to manage yourself. There’s the world that other people deal with and there’s like our community” (SIFG, p. 2)

Students said that real-world mathematics applications allows them to understand “how [variables] affect each other and how they all connect” (SRFG, p. 2). For example, Rachel believed that real-world mathematics involves more than “just one set of statistics that we are
analyzing” (SRFG, p. 2). Other examples found in Questionnaire 2 included: “Finding the correlation between personal income and education by using real data” (SSQ2, p. 3) and “Evaluating the link between population and unemployment rates” (SSQ2, p. 3). One example that a student made about real-world mathematics was “How does the annual income of a family affect the overall health and what aspects would be a factor?” (SSQ2, p. 3) From this example, it appeared that this particular student perceived real-world mathematics to involve determining factors of an issue. Using real-life applications, Rachel believed that if she “understand[s] it (the issue), then [she] can help solve it” (SRFG, p. 15), showing a sense of action-taking from understanding.

**Students’ comparison between SJM and other educational experiences.** In this section, students’ descriptions of their SJM experiences in relation to other mathematics learning experiences will be presented.

**Mathematics applications.** In some of the conversations, Carmen used the word “relatable” (SCFG, p. 1, 2, 6) to describe her experience with the mathematics exercises that were part of SJM. Carmen, Isabel, Lena, and Rachel discussed the notion of applicability to real life in comparison to their classroom mathematics learning. Lena said that she liked SJM “because unlike just normal math that they teach in the classroom, which is just random facts” (SLFG, p. 4), she felt that she “can apply [SJM] to real situations (SLFG, p. 4). When discussing this idea, she asked rhetorically “when will you ever need to find out the angle of a cliff and against like a tree or whatever.” Compared to other subjects, Rachel stated that SJM was “actually very useful as opposed to some of the subjects that don’t have many real life applications” (SRFG, p. 7) and Carmen asserted that “it gave more of an actual real life use . . . and the questions that you see in your math textbook are not great at doing that” (SCFG, p. 9).
Rachel and Carmen also conversed with one another during the focus group as they shared agreement on the topic:

Carmen: I think it’s easier to understand the concepts because [it’s] based on real life. You know this has actually gone onwards. Why would you want to bother calculating some . . .

Rachel: Quadratic functions

Carmen: Exactly.

Subsequent to the discussion between Carmen and Rachel, Isabel spoke about her experience in the Grade 12 Data Management course. She felt that applications such as “heights of students in a fictional school versus their age” and “Johnny grew a bean sprout and here’s how much it grew everyday” in the statistics unit involved “statistics [that] were just so useless” (SIFG, p. 11). Isabel mentioned that Grade 12 Data Management was recommended “if you want to go into the social science[s] or business” (SIFG, p. 11). Thus, she believed there was a need to “replac[e] those numbers with something that actually meant something” and “actually apply the social sciences into that math class” (SIFG, p. 11). In the open-ended responses to Questionnaire 2, students suggested other ways to incorporate mathematics applications into the regular classroom. These ideas included: “spend[ing] a couple of days devoted to the application of that concept in the real world and mak[ing] sure the students understood and could make inferences,” “integrat[ing] [SJM] into a course like Grade 9 math, in finding linear relations in real-life situations,” “analyz[ing] real pieces of data . . . in the stats section of data management,” and “applying the math to real-life problems that might help the student not only understand math concepts better, but also help them use this in the future” (SSQ2, p. 3).
Carmen also believed that SJM gave her the opportunity for meaningful problem solving: “The questions that we do help you understand and apply the knowledge that you have instead of just knowing out of habit, oh this question gives me this much information, I have to do . . . the quadratic formula to continue” (SCFG, p. 9). She further conveyed her perception by explaining her “out of habit” (SCFG, p. 9) problem solving experience in classroom learning:

In the textbook, we go through things in units or chapters . . . out of just knowing what to do . . . you just see the information you have and this is the formula I need to use. You don’t really think about everything that I’ve learned in class this year. (SCFG, p. 9-10)

Furthermore, she was under the impression that “the questions aren’t really realistic in a way that would help us understand” and that they just “present you with numbers and you’re supposed to know what to do” (SCFG, p. 10).

Other differences between SJM and classroom mathematics learning included a sense of inquiry stimulated by SJM as opposed to applications that were “very narrow and . . . not as open to other things” (SCFG, p. 15) in Carmen’s formal mathematics learning experience. In addition, Rachel described the application topics covered in SJM to be “more serious than [they] would actually look at in [their] math class” (SRFG, p. 2).

**Mathematics learning approach.** “I find that in SoJo Math, it’s not about memorizing equations, it’s about putting it into practice . . . it’s about using your logic” (SRFG, p. 9) was a quote taken from Rachel during the focus group. Isabel also discussed experiencing beyond factual learning in SJM through the investigation of concepts. Using the Haiti activity as an example, she articulated that when we were trying to figure out what kind of regression [the life expectancy and women’s education data] followed, we didn’t know whether it was exponential or
quadratic. So usually you’re told this is a quadratic, graph it. But then this time, you’re given the data, figure out whether it is quadratic or not. And then we could figure out the first differences and second differences to see if this is exponential or not. (SIFG, p. 8)

When discussing a sense of understanding, Isabel spoke about the role of applications as contexts. The “number of hampers per number of people at the food bank” (SIFG, p. 7) provided the context for Isabel to “think about what exactly is changing” (SIFG, p. 7) when calculating the rate of change through the “rise over run” formula (SIFG, p. 7). She said, “Memorizing a formula is . . . just punching in numbers and then just getting numbers back out. But this, you’re actually punching in the number of hampers and . . . knowing how many hampers . . . the food bank is needing for that many people” (SIFG, p. 7). Isabel and Rachel both conveyed their preference of understanding over memorization of a “magic formula that will help you find x” (SIFG, p. 8). To Rachel, the magic formula also “doesn’t give you any background on what you’re actually finding out” (SRFG, p. 8). She preferred to learn the proofs of formulas to “understand where the concepts came from” (SRFG, p. 8).

Carmen, Lena, and Tessa appeared to agree with Isabel and Rachel on the idea of learning mathematics through conceptual understanding. Furthermore, Carmen mentioned that the context allowed the experience of “evaluating the information other than just looking at it and then saying I need to put it in this formula,” which “develop[ed] an understanding as [she made] the graph” (SCFG, p. 7). On the other hand, Carmen stated that she usually memorized a formula in a mathematics course “because it’s a lot easier...in a classroom, especially on a test or exam” and “it’s a lot quicker” (SCFG, p. 8).

Another comparison students made between the formal and informal mathematics learning environment was the “links” (SRFG, p. 10) SJM provided between the subject and other
topics. Rachel described classroom learning as “segregation between units . . . [being] in their own separate areas of expertise” (SRFG, p. 10). She believed that in SJM, “you have to bring everything together” and “it’s all finally weaving together instead of just being separate” (SRFG, p. 10). Carmen and Tessa both spoke about the experience of learning concepts separately in a mathematics class and from a mathematics textbook. Lena also added that mathematics units “focus just on the one thing that you’re learning” (SLFG, p. 10) and allow limited opportunities to “bring past units into” (SLFG, p. 10) their learning experiences. Carmen claimed that she felt SJM was “so much better because you can see the differences and you can really use more than one thing that you know. It’s not just one topic that you’ve been studying for a couple of weeks. It’s everything together” (SCFG, p. 10).

Students listed note-taking, working independently, making references to the textbook, and listening to oral explanations of concepts as the primary modes of learning in their classroom. “Limited” was the word that Carmen used to express her opinion of limited learning “by someone just talking at you or someone just writing a note at you” (SCFG, p. 13). She preferred other modes of learning that would “incorporate every learning style” (SCFG, p. 12). Tessa conveyed that “it is really easy to not pay attention” with “just the teacher talking” (STFG, p. 13). She felt that in SJM, “you pay attention because there’s a lot of visual things and it’s easier to get it” (STFG, p. 13). Isabel also expressed a preference for visual representations. She stated, “I find solving formulas and solving equations is always easier if you know what it looks like graphically, as opposed to just blindly doing that math” (SIFG, p. 8). Rachel used the term “individual” (SRFG, p. 13) to describe her perception of the classroom environment. She felt that learning did not take place “as a team in math class” because it’s oriented around “your personal goals” and “how you learn” (SRFG, p. 13). On the other hand, “Social Justice Math [is] not
individual,” “it’s very group-related” (SRFG, p. 13), and “[it] is very much like co-oporation [since] you have to work together in a group and discuss ideas” (SLFG, p. 13). In relation to this idea, Rachel stated that she “enjoyed working with other people” during SJM, which was an opportunity she did not “usually get . . . in a regular math class because it’s so intense on learning and moving on” (SRFG, p. 10). Isabel spoke about her teacher-led mathematics classes and she would like “more interaction between students, as opposed to just student-teacher interactions” (SIFG, p. 11). Feeling that SJM was “interactive” (SCFG, p. 13), Carmen claimed that “if [SJM] was incorporated [into a regular mathematics class], there would be a lot of discussion between students and a lot more sharing of ideas” (SCFG, p. 11). Students found the communication aspect and the learning experience as a whole “engaging” (SIFG, p. 14; SSFG, p. 14) when compared to classroom learning. Furthermore, when asked how students would organize their mathematics lessons if they were given the teacher role, responses included “giving students the chance to learn for themselves” and “giv[ing] students time to attempt problems on their own” (SSQ2, p. 3).

Future learning opportunities suggested. Isabel said that after this experience, she would like to “use math to see how we can solve those problems” (SIFG, p. 5), referring to the issues explored in SJM. She also had a curiosity in the origin of data and a sense of “where’s this data from” (SIFG, p. 5). Similarly, Rachel was interested in “understanding where numbers came from” (SRFG, p. 5) by “not just viewing the statistics, but the people who were involved in the statistics” (SRFG, p. 5). Carmen, on the other hand, spoke more about exploring “numbers in the community and seeing the different effects that are happening in the community because of the different social injustices” (SCFG, p. 5).
Recommendations on future activities included experiences beyond the classroom and experimental activities. For example, Rachel suggested that a “field trip” (SRFG, p. 4) to visit the food bank or the Ministry of Education. She wished to examine “the records and different examples from their findings” (SRFG, p. 4). Isabel added the idea of visiting a “groceries store” (SIFG, p. 5) for the Poverty and Healthy Eating activity. Other students suggested “experiments” (SRFG, p. 4) as a component. For instance, “having a set budget and seeing to keep a balanced lifestyle, how expensive it is” (SRFG, p. 6) and allowing a person with a fixed budget to “buy as much as you could, what you can afford, and then after, looking at the different food groups that you need to have and then calculating what you’re getting less of” (SCFG, p. 6). Through this suggested activity, Carmen wanted to examine the long term effects of “a low budget” (SCFG, p. 6) on the health of an individual.

Other topics that students wished to include in the future included issues that are current and those that are related to them. Rachel brought up “global warming and pollution” (SRFG, p. 5) as a possible topic to investigate and Carmen recommended exploring Ontario’s post-secondary tuition and the “amount of debt that people have” (SCFG, p. 6). Isabel conveyed that she would be interested in “something super unpredictable” such as the “rate of a certain disease, like asthma, versus fuel consumption” because she wished to examine “two completely non-directly related variables...as opposed to something that [they] kind of know about” (SIFG, p. 6).

**Summary of Students’ Experiences.** Although each student expressed individual opinions and perceptions towards the SJM learning opportunity, the data collected from students was presented as a whole to provide a broad sense of their experience. The description of students’ experiences in this learning opportunity was organized by their SJM experience, their expanded perceptions, and their comparisons between the SJM experience and other experiences.
It appears that students valued mathematics learning opportunities using a curriculum integration model and the collaboration opportunities they experienced in SJM. In addition, students described their expanded perceptions towards social justice issues and mathematics applications as they discussed their perceptions prior to participating in SJM activities. Students shared their suggestions for future mathematics learning opportunities.

**Analysis of Data**

In this chapter, I presented data on the preservice teacher participants’ and students’ experiences in participating in SJM. These data will be used to answer the research questions of this study, which were the following:

1. How do preservice teachers and secondary students describe their experiences in connecting (a) mathematics and the real world and (b) SJM and their formal mathematics teaching and learning experiences?

2. What are preservice teachers’ and secondary students’ perceptions of mathematics in response to SJM?

Thus, for the purpose of answering the research questions, emergent themes and patterns from the data discussed in this chapter were organized in the structure presented in Table 3. Findings showed that preservice teacher participants connected mathematics to the real-world during the SJM experience. Subsequent to their participation in SJM, preservice teachers connected mathematics to the real-world in a way that extended beyond the connections made in SJM activities. When examining students’ experiences in connecting mathematics to the real-world, their perceptions of real-world mathematics could be organized into perceptions prior to and subsequent to the SJM experience. The data also showed that students had a deeper understanding of real-world issues through the connection of mathematics to the real world.
In answering the research question about preservice teachers’ and students’ perceptions of mathematics, the data revealed preservice teachers’ beliefs about mathematics and mathematics teaching and students’ perceptions about the use of mathematics and mathematics applications. The data showed that preservice teacher participants described barriers and supports and their goals and intended outcomes when connecting SJM to formal mathematics teaching experiences. Similarly, students described SJM as a support for their classroom mathematics learning. Both groups of participants shared their visions of future mathematics teaching and learning in response to the SJM experience.

Table 3

*Organization of Patterns from the Data to Answer Research Questions*

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<th>Research Questions</th>
<th>Patterns of Findings</th>
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<tr>
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<td>The SJM experience</td>
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<td></td>
<td>Intentions</td>
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<td>Extending beyond SJM</td>
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<td></td>
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<td>1(b) Connecting SJM to Formal Mathematics Teaching or Learning Experiences</td>
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<td>Goals and intended outcomes</td>
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<td>2</td>
<td>Perceptions of Mathematics</td>
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<td></td>
<td>Beliefs about mathematics teaching</td>
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</tbody>
</table>
Comparing the Experiences of Students and Preservice Teacher Participants

Six secondary students and three preservice teachers participated in the SJM activities, which was a novel component to the Social Issues Club and was created for the purpose of this study. Students described their experiences in questionnaires and a focus group. Preservice teachers described their experiences predominately in the individual interviews. Data analysis revealed similarities among the experiences of students and preservice teacher participants (Table 4).

Both groups of participants shared their beliefs and perceptions about the nature of mathematics. In addition, students shared their perceptions about the connection of mathematics to the real world. Specifically, preservice teacher participants also talked about their beliefs about mathematics teaching.

When participants described their SJM experience and connected the SJM experiences to other experiences, one of the major commonalities found was their visions of future mathematics teaching and learning. Students and preservice teacher participants stated ways that they believed could enhance experiences in mathematics teaching and learning. Many of these approaches such as collaboration with peers, integrating mathematics with other topics, and having autonomy in mathematics learning, were characteristics of which they found in SJM.

Students and preservice teacher participants also spoke about supports. Specifically, one of the preservice teachers spoke about experiences that supported her role in the implementation of SJM. Students, however, spoke about the SJM experience as a support for classroom mathematics learning.
## Table 4

### Comparing the Experiences of Students and Preservice Teacher Participants

<table>
<thead>
<tr>
<th>Patterns</th>
<th>Codes</th>
<th>Patterns</th>
<th>Codes</th>
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<tr>
<td><strong>Preservice Teacher Participants</strong></td>
<td><strong>Student Participants</strong></td>
<td><strong>Preservice Teacher Participants</strong></td>
<td><strong>Student Participants</strong></td>
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<td>Reasons for participation</td>
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<td>applications</td>
<td>issues-oriented, Enables deeper understanding of issues, Impact on</td>
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<td></td>
<td>students’ lives</td>
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<tr>
<td>Intentions in SJM</td>
<td>Connect mathematics to students, Inspire critical thinking, Integrate</td>
<td>Prior perceptions about real-world</td>
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<td>topics for learning, Raise students’ awareness, Relate to the use of</td>
<td>mathematics</td>
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<td>Extending beyond SJM</td>
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<td>mathematics learning</td>
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<td>Barriers</td>
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<td></td>
<td>topics, Venturing out, Giving students autonomy</td>
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Summary of the Presentation of Data

In this chapter, data about the experiences of preservice teachers and students in participating in SJM activities was presented. The data was then organized into patterns and themes for the purpose of formulating answers to the research questions of this study. From the data analysis, findings showed that both groups of participants experienced a transformation to the connection of mathematics to the real world. Preservice teachers and students also connected the SJM experience to formal mathematics teaching and learning experiences in a way that they were able to offer their suggestions and visions for future mathematics teaching and learning. Thus, the data revealed similarities in the experiences of both groups of participants. Differences in the beliefs and perceptions about mathematics among participants were also described in this chapter. In the next chapter, the emergent themes and patterns will be discussed in relation to the literature.
CHAPTER 5

DISCUSSION OF DATA

In this chapter, I discuss findings of this study in relation to the extant literature. First, preservice teachers’ experiences will be discussed. Next, I present the experiences of secondary students. I then make connections between the experiences of the two groups of participants, and present the implications of this study for research and practice. The thesis concludes with a reflection about my professional learning and development.

Preservice Teachers

In this section, the discussion of preservice teachers’ experience is structured by the research questions that framed this study:

1. How do preservice teacher participants describe connections among (a) mathematics and the real world and (b) SJM and their formal mathematics teaching and learning experiences?

2. What are preservice teacher participants’ perceptions of mathematics in response to SJM?

Connecting Mathematics to Real-World Experiences

In this section, preservice teachers’ description of their SJM experience is discussed, as well as their suggestions for connecting mathematics to the real world in future practice.

The SJM experience. Preservice teachers described their experiences of connecting mathematics to the real-world by discussing specific attributes of the SJM activities that they designed. For example, both Kathy and Brian spoke of SJM as community-oriented and current issues-oriented: applications that brought a local focus to students’ opportunities to learn. Other SJM characteristics included increased awareness about global events and situations as exemplified by the Haiti activity. At the end of the SJM experience, the main idea in preservice
teachers’ definition of connecting mathematics to the real-world was to use mathematical modelling to quantify current events, evaluate phenomena, and solve problems related to issues of importance to local, provincial, national, or international communities. This definition was similar to the secondary mathematics preservice teachers’ notion of real-life mathematics problems in the study conducted by Wubbels et al. (1997). Such problems were perceived by preservice teacher participants in Wubbels et al.’s (1997) study to be situated in contexts that stimulate the use of mathematics in the classroom. Using mathematics to solve real-world problems was perceived to involve “using mathematical results in the real world or translating the mathematical results back to real-life problems” (Wubbels et al., 1997). This is consistent with my participants’ idea of evaluating real-world problems by quantifying and modelling with mathematics.

Like the secondary mathematics teachers in the study conducted by Bartell (2006), the three preservice teachers in this research reported that it was their intention to encourage students to apply mathematics to issues, challenge students to think more deeply, inspire students to take action on issues, and raise students’ awareness about current issues. Bartell (2006) reported that secondary mathematics teachers expanded their conceptions about teaching mathematics by using a social justice context. Subsequent to the opportunity to collaborate on designing and implementing SJM lessons, Bartell (2006) concluded that teachers showed an understanding about connecting issues to their own lives and teaching. They valued the approach because it had the potential to inspire students to take actions on social justice issues. Because of the limitation of implementing the current study for only eight weeks, it is unclear whether the intentions described by the teachers in my research were held prior to their participation in the case study or were attributable to their involvement in SJM.
Brian reported that he gained new perspectives on issues that are important to students and their families because of the SJM experience. He also said that he developed new insights into the ways through which local and global issues could be made accessible to high school students by using mathematics.

Although similar to Brian’s new perspective, Kathy appeared to speak more deeply about her conception of SJM. Perhaps because Kathy facilitated the SJM activities while the others did not, she demonstrated a deeper appreciation for the personal and educational value of connecting mathematics to the real world. For example, Kathy mentioned that her comprehension about the complex issues associated with increased food bank use increased because of the SJM lessons. Prior to SJM, she stated that she had only a passing acquaintance with the phenomenon based on data reported by the media. This transformation was attributable, she said, to the fact that the mathematics played a role in allowing her to find patterns and compare data, which deepened her understanding of the issue. This finding suggested that Kathy’s unique experience as both a facilitator and a designer of SJM activities might have contributed explicitly to the transformation in her conceptions of mathematics and social justice issues. Similarly, the preservice teachers who participated in an undergraduate mathematics course designed to link mathematics and social issues in Bateiha’s (2010) study, transformed their knowledge and beliefs about social issues. Bateiha (2010) found that the preservice teachers moved from making conclusions about issues based on their opinions and emotions to make meaningful statements about social issues based on mathematically-based data analysis. In this present study, Kathy’s self-reports suggested a marked transformation to her awareness of the instructional power of integrating mathematics and social issues.
The results from this study indicated that the specific experience of connecting mathematics to the real world generated a positive response among the participating preservice teachers. These reactions were similar to those of a group of teachers in Barcelona, Spain, who participated in a professional development session about curriculum integration (Planas & Civil, 2009). In the Spanish study, teachers sought out opportunities to learn more about designing activities related to the real world in spite of the fact that they lacked experience in teaching mathematics through real-life contexts (Planas & Civil, 2009). In this present study, Kathy, Sandra, and Brian responded positively about the opportunity to design activities related to the real world and stated that they would continue to seek ways to integrate mathematics and social issues in their future practice.

**Extending beyond SJM.** At the end of the study, preservice teachers were asked to suggest their own ideas for future SJM lessons. All three participants’ suggested integration topics were directly related to their own interests. Kathy wished to include SJM lessons related to diet and exercise because she was interested in health awareness. With her interest in biology, Sandra wanted to integrate environmental topics into SJM. Similarly, Brian wished to expand the SJM activity on vehicles’ fuel consumption due to his interest in motor vehicles, mentioning that if time permitted, he would have incorporated data on hybrid vehicles to deepen that particular lesson.

Another commonality among the three preservice teachers was the use of perceived students’ interests as contexts to connect mathematics to the real world (Gainsburg, 2008; Wager, 2012). Both Kathy and Brian spoke mainly of sports as contexts when discussing ways to make relevant connections between mathematics and the real world for students. For example, Kathy was interested in the trajectory of a basketball as a context to teach quadratic relations.
Previous studies have suggested that such contexts are considered to be “pseudo realistic” (Falkenberg & Noyes, 2010, p. 954) and tend not to connect “mathematical ideas to genuine everyday experiences or scientific and social issues” (Falkenberg & Noyes, 2010, p. 954); nonetheless, teachers commonly use such contexts since they believe that the approach will interest students (Gainsburg, 2008; Wager, 2012).

When asked to provide further details about future real-world mathematics lesson ideas beyond the content, concepts, and contexts they had used in this study, Kathy, Sandra, and Brian had difficulty articulating meaningful mathematics activities that they would embed in the contexts they had chosen. Being interested in health awareness as a topic, Kathy suggested that she would use nutritional labels on products and include the calculation of percentages for content and portions of diet. One of the ideas proposed by Sandra was an activity in which students first would calculate the volume of melted glaciers as a result of climate change, and then construct prisms to represent the volumes. Sandra supported this lesson idea by suggesting that she would also incorporate graphing activities that involved carbon dioxide emissions over time and the reduction of ice volume over time. Similarly, Brian planned for a lesson in which students would plot data on the fuel consumption of transport trucks with the goal of leading students to conclude that trains or hybrid vehicles might be more efficient for transporting cargo than trucks. Other examples that Brian offered were related to his undergraduate mathematics courses. The three preservice teacher participants mainly spoke of graphing data, finding trend lines to model data, and extrapolating to predict data—tasks that featured prominently in the SJM sessions. Apart from these particular mathematics content examples, the preservice teachers in this study also envisioned activities that involved calculating average and percentages, monetary computations, and unit conversions: exercises that focused on skill and procedures,
which Skemp (1976/2006) called instrumental understanding of mathematics. These findings were similar to results obtained by Garii and Rule (2009) who investigated elementary and secondary preservice teachers’ lesson designs that aimed to integrate mathematics and social justice issues. Their participants’ lessons required students to collect and analyze data, and model situations by using their own data and analysis to examine issues such as oppression due to poverty, racial inequalities, disability, and gender. Garii and Rule (2009) found that seven out of 16 lessons designed by secondary preservice teachers involved students in collecting and graphing data obtained from historical record; however, the data did not represent a social justice perspective. Thus, the researchers asserted that these lessons were designed with the purpose to teach graphing rather than to integrate mathematics and social justice issues in a meaningful manner.

In one specific segment of her interview, Kathy talked about the difficulty in connecting trigonometric functions to real life. She stated that she did not like the typical textbook-based problem of modelling the height of a fixed point on a Ferris wheel over time using sinusoidal functions because she perceived a lack of relevance to student’ lives. When asked what she would design to teach trigonometric functions given her experience in SJM, Kathy could not respond with any ideas. After some time, I suggested modelling the motion of blades on a wind turbine to connect trigonometric functions to the real-world. Kathy appeared to show fascination with this idea and mentioned that such a context has the potential to lead into further discussions about environmental sustainability. This conversation with Kathy seems to demonstrate the need of a catalyst for preservice teachers to generate ideas to connect mathematics content to real-world contexts in non-trivial ways.
It appeared that the preservice teacher participants in this current study tended to connect mathematics to the real world either through content applications familiar from the SJM activities or that relied on simple computations. This result could be due to a superficial understanding between classroom mathematics and real-world uses of mathematics (Garii & Okumu, 2008). Despite the intention to integrate mathematics with other topics to bring a connection to the real world, findings from related research suggests that preservice teachers misunderstand the idea of integration (Ziegler & Chapman, 2004). In a similar study that followed secondary mathematics teachers in designing and implementing mathematics lessons that were integrated with social justice issues, Bartell (2006) found that participants viewed connections among mathematics and real-world issues as an “add-on” rather than an enriching context to illuminate and illustrate content in either domain. In the current study, the preservice teacher participants were unable to provide concrete suggestions for ideas to connect mathematics to the real world based beyond the experiences and examples from SJM. Although Kathy, Sandra, and Brian offered interesting plans and expressed enthusiasm for the value of and need for context-based mathematics instruction, as they described the future SJM activities that they would design, their ideas did not reflect meaningful curriculum integration among mathematics content and the real-world. Thus, a gap emerged between their intentions and their planned implementations of connected mathematics in the classroom. Bateiha (2010) and Garii and Rule (2009) suggested this gap could stem from preservice teachers’ inadequate experience with integrating mathematics and social justice issues during their teacher education, a barrier also identified by the preservice teachers in this current study. Other research suggests that preservice teachers can contextualize mathematics in constructing their lessons when they are
given the opportunity to visit workplaces and view the use of mathematics in the real world (Nicol, 2002).

**Summary of connections between mathematics and real-world experiences.** The preservice teachers spoke about their understanding of the connections between mathematics and the real world by describing the mathematics applications featured in SJM. Referencing particular SJM activities as examples, each of the three preservice teacher participants provided a similar definition of real-world mathematics to summarize her understanding based on the SJM experience. Overall, they defined the connection of mathematics to the real-world as evaluating and solving real-world problems by quantifying and modelling events or phenomena with mathematics.

Kathy, Sandra, and Brian stated that their principal rationale for connecting mathematics to real-world experiences was that they believed such an approach would be beneficial to students’ learning. While all three participants reported that they gained new perspectives towards social issues through the SJM experience, it was Kathy’s new appreciation for the potential of curricular connections among mathematics and social issues that appeared to be the richest. Since Kathy spoke deeply about the ways in which the SJM experience contributed to her new conceptions, it seems possible to say that she experienced a transformation to her understanding of curriculum integration because of the SJM experience.

When examining the ideas for continuation and extension suggested by the preservice teacher participants, it was found that their lesson plan suggestions tended to connect mathematical procedures rather than mathematical concepts to real-world contexts. Kathy, Sandra, and Brian made use of their own topics of interest as a source for making future connections. Relating these findings to the literature, these results suggest that preservice
teachers need to be provided with opportunities to strengthen connections among mathematics and the real world for their teaching practice.

Connecting SJM to Formal Mathematics Teaching Experiences

**Barriers.** Common barriers to curriculum integration and the development of context-based mathematics units perceived by the preservice teacher participants in this study were the intended curriculum and inadequate experience in practice. The sense of being confined by curricular demands was expressed both in response to the design of SJM activities and when discussing future implementations of SJM activities in regular classrooms. The challenge in needing to meet curricular demands was similar to several constraints reported by Gutstein (2011) when he examined secondary students’ experiences in using mathematics as a tool to investigate social injustices. As the practitioner-researcher who taught the social justice mathematics lessons, Gutstein (2011) found that his challenges included finding the balance between teaching mathematics content and social justice issues; developing the curriculum that integrates the two topics; teaching mathematics through the curriculum integration; and, co-creating, with students, the learning environment for the integration of mathematics and social issues.

As a student, Sandra had only experienced mathematics applications as an “extra” component added onto typical instruction of rule-bound concepts. Similarly, Kathy and Brian had no introduction to concrete examples or resources for the integration of mathematics with other subjects prior to participating in SJM. In a study conducted by Gainsburg (2008) to examine the ways in which secondary mathematics teachers understand and put into practice real-world mathematics applications, the researcher concluded that a lack of resources, training, and ideas were barriers for secondary mathematics teachers to create meaningful real-world
applications. Kathy mentioned that she had never seen the connection of mathematics to social justice issues in her B.Ed. mathematics curriculum course. Sandra noted explicit examples of curriculum integration topics are not included in the Ontario mathematics curriculum documents even though these policy reference materials advocate strongly for the importance of connecting mathematics to the real world. The absence of explicit examples within the official curriculum posed a barrier to Sandra when she was considering implementing activities similar to those in SJM in her future practice.

An unanticipated barrier identified by Sandra and Brian was the widespread negative attitude towards mathematics held by students. They were not expecting to encounter this student reaction during their practice teaching placements because as students themselves, they had always enjoyed learning mathematics and performed well in the subject. Because of their positive experiences as mathematics learners, they found it challenging to grasp students’ negative dispositions towards mathematics learning. Other barriers identified by Kathy and Brian included time constraints for designing SJM activities, the need to become re-familiarized with specific mathematics content and the feeling of conflict between traditional practice and exploration of novel approaches.

Kathy, Sandra, and Brian stated that inadequate background and expertise were challenges that impeded their efforts to integrate mathematics and social justice issues, especially limited exposure to examples and resources. This finding is similar to one noted by Robbins, Francis, and Elliott (2003) in their research to examine elementary and secondary preservice teachers’ attitudes toward education for global citizenship: preservice teachers lacked confidence or expertise to link mathematics and social justice issues despite recognizing the importance of undertaking such curriculum development. In a study conducted by Gonzalez (2008) to explore
ways to prepare secondary mathematics teachers to teach mathematics for social justice, it was found that teachers needed professional development learning opportunities in areas such as facilitating classroom discussions about social issues and developing SJM lessons with relevance to students’ experiences.

**Supports.** Kathy was the only participant who identified supports for her practice in curriculum integration. As mentioned previously, this might be due to her unique role as a facilitator in addition to designing activities in this study. Kathy stated that one significant support for her efforts in SJM was the students’ positive reactions to the learning activities. Positive student behaviours such as acknowledging other factors when examining issues, arriving at their own conclusions, and applying mathematics skills were identified supports for Kathy’s SJM experience.

Kathy was completing field placements as a student-teacher during the time of this study. She spoke about the positive, influential role of her associate teacher (AT) as a support for her in gaining new skills. For example, Kathy and her AT became learning partners when an interactive whiteboard was introduced to their classroom. Similar to her SJM experience, she felt that her associate teacher encouraged her to try various novel teaching approaches. Thus, she mentioned that she would make an effort to implement SJM in her future practice despite the challenges she was foreseeing.

**Visions of mathematics teaching and learning.** Kathy, Sandra, and Brian each discussed the importance of giving students autonomy at various levels. For example, all three mentioned that they would allow students to guide activities in the classroom by valuing students’ input, addressing students’ concerns and answering students’ questions. Kathy stated that from the SJM activities she led, she gained a new perspective: teachers need to recognize
students as knowledgeable individuals who are capable of learning and expressing their ideas. For example, by Week 4, data from observations indicated that Kathy adhered loosely to the lesson plan of the Food Bank Use activity and facilitated discussions based on students’ responses about the factors that contribute to food bank use increase. Because she felt that she learned how to orchestrate such scenarios from the SJM student participants, Kathy stated that she would encourage students to drive the learning process in her future practice.

The second common vision that the preservice teachers in this study had for future classroom practice was collaboration. Kathy, Sandra, and Brian reported that designing SJM activities collaboratively provided them with opportunities to brainstorm ideas, receive constructive criticism from peers, and share ideas and strategies for lesson planning. This finding was consistent with literature describing two new secondary teachers’ experiences with peer collaboration (Gellert & Gonzalez, 2011). In their study, Gellert and Gonzalez (2011) aimed to gain insights into the ways in which peer collaboration and mentoring influence new teachers’ instructional practice. The participants were mentored by mathematics coaches at their schools; however, because of time constraints and limited opportunities for face-to-face mentorship sessions, the new teachers actively sought collaboration with their colleagues and preferred peer collaboration over mentorship opportunities. Specifically, Gellert and Gonzalez (2011) found that the pair of early-career teachers in their study created their own community by sharing ideas for teaching approaches, sharing resources, clarifying mathematics topics, and developing a common theme in instruction and evaluation. In a similar study, Grade 9 mathematics teachers reported that co-planning lessons reduced workload, increased efficiency, and provided improvement for lessons implementation (Egodawatte, McDougall, & Stoilescu, 2011).
Kathy, Sandra, and Brian appeared to value collaborative practice opportunities during SJM and agreed that sharing ideas for lesson planning would be beneficial to their future practice.

Kathy, Sandra, and Brian predominately spoke about their experience with group lesson planning as eye-opening and good practice for instructional design in the future. Based on these experiences, Kathy and Sandra discussed the importance to continue venturing out and seeking ways to try unconventional approaches in lesson planning and teaching. In addition, these two participants appeared to wish to carry the goal of SJM to their future classrooms. The goal was to not only promote meaningful mathematics learning, but also to stimulate students’ desire to learn mathematics. According to Watanabe and Huntley (1998), this indicated that preservice teachers felt that their role was more than teaching mathematics content, but also teaching students to appreciate the subject.

**Summary of connecting SJM to formal mathematics teaching experiences.** The barriers experienced by preservice teacher participants included the need to meet curricular demands, their inexperience in connecting mathematics to social issues, the lack of resources and examples that model the development and implementation of SJM activities, and their unfamiliarity with allowing mathematics applications to be the focus of classroom instruction. Both Kathy and Sandra attributed these barriers to background such as their own prior experiences as mathematics learners and their classroom teaching practice as preservice teachers. All of these challenges mentioned by the participants were consistent with constraints reported by researchers in similar studies (Gainsburg, 2008; Gutstein, 2011).

Despite facing these barriers, Kathy stated that the SJM student participants’ responses and the associate teacher from her practicum placement were supports for her during the SJM
experience. All three of the preservice teacher participants stated their visions of future mathematics teaching: giving students autonomy in mathematics learning; peer collaboration such as sharing ideas and resources with colleagues; and, seeking novel teaching approaches to stimulate mathematics learning and students’ desire to learn mathematics.

**Perceptions of Mathematics**

In this section, preservice teacher participants’ beliefs about mathematics and their beliefs about mathematics teaching will be presented.

**Beliefs about mathematics.** Although the preservice teachers in this study were not asked explicit questions about their beliefs about the nature of mathematics and its teaching, their beliefs about both were communicated through their responses to open-ended questions during interviews. Kathy, Brian, and Sandra shared the common belief that applicability of mathematics varies by grade and content. For example, all of them agreed that they could more easily find applications for content in Grade 9 and 10 than in Grade 11 and 12, and that some mathematical concepts more readily lend themselves to application. For example, the Ontario Grade 11 Functions course, was interpreted as being entirely theoretical with the exception of the unit on financial mathematics, which includes topics such as calculating interest and mortgages. Another example of a theoretical topic identified by the participants in this study was that of trigonometric identities. Kathy, Sandra, and Brian were unable to find any practical context that could be applied to this concept.

Brian felt that algebra is not necessarily applicable to real life unless it was placed in a job-related context, and suggested that a plumber would need to know and apply skills from geometry rather than advanced calculus. According to Brian, calculus would be more applicable to those in engineering or electrodynamics. This indicated Brian’s belief that application of
mathematics skills tends to be career-specific, which aligns with the beliefs of preservice secondary mathematics teachers in the study conducted by Cooney, Shealy, and Arvold (1998).

Brian held contradictory beliefs about the nature of mathematics. He described himself as a practical person who enjoyed learning mathematics for its immediate applications. To Brian, mathematics is useful because knowledge of the domain could contribute to future applications, if not immediate ones. According to Brian, learning mathematics is valuable because it develops a thinking process that allows the justification of decisions. Brian appeared to believe that mathematics was an instrumental body of knowledge with its applicability limited to specific contexts and careers. Ernest (1989) described this conception as an instrumental view of the nature of mathematics—one in which an individual considers the subject matter to be a “useful but unrelated collection of facts, rules, and skills” (p. 21). On the other hand, Brian stated that mathematics is embedded in the world and that a mathematical lens would allow an individual to see mathematics as ubiquitous. Brian’s statement of this view implied that he held a Platonist view of mathematics, believing that mathematics is an objective and static body of knowledge to be discovered through the mathematical lens of an individual (Ernest, 1989).

A belief shared by Brian and Sandra is the “hierarchical structure” (Godel, 1991, p. 239) of the nature of mathematics. Both believed that certain mathematics concepts are “stepping stones” to understanding mathematics in other situations. They felt that mathematics learning must begin with learning basic concepts and procedures, thus, indicating that they believe that the subject can be organized into a hierarchy. On the other hand, Godel (1991) argued that it is “untrue that at any one time mathematics can be described by a single unique hierarchical structure” (p. 242) because the development of mathematical concepts, theories, and knowledge leads to its restructuring.
Because Brian and Sandra reported that they performed well in mathematics and enjoyed learning it, they felt that an individual’s negative attitude towards mathematics must stem from a lack of understanding of the subject. Based on her own high achievement in mathematics, Sandra also held the belief that mathematical ability is innate (Schoenfeld, 1988; Schommer, 1994). She used herself and her father as an example to argue that there is a genetic basis to mathematics ability. According to Schommer’s (1994) discussion about the belief on control of learning, which ranges from believing that the “ability to learn is genetically predetermined” (p. 301) to believing that learning is “acquired through experience” (p. 301), Sandra appeared to be situated at the “genetically predetermined” end of the spectrum. In a study conducted by Schoenfeld (1988) to observe Grade 10 students in order to determine whether instruction contributed to procedural understanding or conceptual understanding of mathematics, the researcher argued that students develop the belief of “innate ability” as a result of their experiences in learning through the mastery of mathematical procedures. Similar to Schommer’s (1994) description, Schoenfeld (1988) explained that students who held this belief tend to accept that “only geniuses are capable of discovering, creating, or really understanding mathematics” (p. 151).

**Beliefs about mathematics teaching.** The preservice teacher participants in this study held a variety of beliefs about their role in mathematics teaching. The three spoke of the need for teachers to make learning opportunities fun, engaging, and interesting. Brian, in particular, believed that the depth of students’ learning is influenced by their level of interest in mathematics. According to Brian, opportunities for students to apply mathematics concepts and skills to their areas of interest would therefore be beneficial to students’ mathematics learning. He also believed that relevance would bring student engagement to the mathematics classroom. Kathy believed that teachers’ enthusiasm for the subject plays a role in student engagement.
Sandra also addressed affective factors in student learning during her interview, stating that it is the teacher’s role to create fun activities because they could not only help students to learn content, but to develop a positive attitude towards mathematics. Kathy also stressed that it is important for teachers to use continuously updated material in order to engage students, and whenever possible to integrate mathematics with other subjects. Thus, she believed that mathematics teachers need to play a role in developing curriculum resources for their teaching. These findings about their belief in the contribution of engaging activities to students’ learning and attitude towards mathematics was found to be consistent with the findings from the study conducted by Cooney et al. (1998). Cooney et al. (1998) examined four secondary preservice teachers’ beliefs about mathematics and its teaching through a survey, classroom observations, interviews, and their written assignments. The researchers found that the participants held a firm belief that it is the teacher’s responsibility to provide rich mathematics learning opportunities for students. Similar to the beliefs about mathematics teaching held by Kathy, Sandra, and Brian, Cooney et al. (1998) also found that the participants in their study believed in using engaging activities to emphasize the importance of the content being taught. In a study similar to Cooney et al. (1998), Chauvot and Turner (1995) also observed that an intermediate/senior mathematics preservice teacher believed that it is the role of a teacher to interest students in mathematics learning.

Beyond these similarities, each of the preservice teachers had unique voices regarding other beliefs they held. Brian felt that students’ ability to identify relevance in their mathematics learning is dependent on age and maturity. By referencing his previous experience working with Grade 7 and 8 students in mathematics classrooms, he explained that because young students tend to be occupied with learning basic mathematics skills and techniques, they are hindered
from identifying their areas of interest in the subject. This notion is aligned with Brian’s belief of hierarchy in mathematics knowledge (Ernest, 1991; Godel, 1991).

As a third-year concurrent education student studying mathematics, Sandra spoke of her undergraduate mathematics learning experiences, acknowledging that not all content knowledge from her university mathematics courses would have application to her teaching practice. She gave the example that the calculus and differential equations, which she named “higher math,” were not a part of the secondary mathematics curriculum. The “curriculum knowledge of mathematics” (Ernest, 1989, p. 17), in Sandra’s opinion, did not include the “higher math” that she was studying. Ernest (1989) classified “pedagogical and curriculum knowledge of mathematics” (p. 17) as categories within the knowledge of mathematics teaching. More recently, Sandra’s point was highlighted by Davis and Simmt (2006) and Simmt (2009). The way a teacher enacts mathematics is different from the use of mathematics in other professions (Davis & Simmt, 2006; Simmt, 2009). Thus, the nature of a mathematics teacher’s knowledge was described using a nested model (Figure 1) known as Mathematics-for-Teaching. Subjective understanding, classroom collectivity, curriculum structures, and mathematical objects respectively are the levels of the nest from inside to outside. Using this model, it can be observed that Sandra’s idea of “higher math” belongs to mathematical objects, which represents “the transformation of an individual’s understanding of a particular piece of mathematics” (Davis & Simmt, 2006, p. 297). This model showed that the understanding of mathematics is not nested within a teacher’s understanding of curriculum structures. This idea supported the findings about Sandra’s belief that not all mathematics content knowledge would necessarily be brought into the classroom.
The uniqueness in the three preservice teacher participants’ dispositions towards mathematics teaching appeared to reflect their own experiences as mathematics learners. This notion was supported by Holm and Kajander (2012) as they asserted that beliefs of preservice elementary teachers tended to stem from previous experiences. Similarly, from the results of Stemhagen’s (2011) study, teaching beliefs were related to backgrounds of the elementary mathematics teacher participants. Beliefs about the philosophy of mathematics, teaching practice, and self-efficacy were found to differ between these two groups: (a) Grade 4 and 5 teachers and (b) Grade 7 and 8 teachers. In particular, participants who had training in mathematics specialization tended to hold non-traditional teaching beliefs and were found to be less oriented around “transmissive teaching practices” (Stemhagen, 2011, p. 9). Consistent with findings from this present study, the results from the study conducted by Stemhagen (2011) suggested that teachers’
mathematics background and experience played a role in their beliefs about mathematics teaching and learning.

**Summary of perceptions about mathematics.** Kathy, Sandra, and Brian shared their beliefs about mathematics and mathematics teaching. The discussion about their beliefs was focused on the applicability of mathematics concepts, which was believed to vary by grade and content. One distinct finding was that Brian held contradictory beliefs about the nature of mathematics. He believed that mathematics is valuable because of its application and the way it can be used. At the same time, he also appreciated mathematics because he believed that it is an objective body of knowledge that is embedded in the world. Brian also shared with Sandra the belief that mathematics concepts are hierarchical.

The data also revealed the identities of the participants as mathematics learners who were successful achievers who enjoyed mathematics learning. Because they self-identified as being successful in and having a positive disposition towards the subject, Brian and Sandra stated that they had difficulty understanding an individual’s lack of achievement or negative attitude towards the subject. Of all three preservice teacher participants, Sandra was the only one who held the belief that mathematics ability has a genetic basis due to her own positive performance in the subject.

The participants held beliefs about mathematics that influenced their perception of their role as a teacher of mathematics. They believed that students’ depth of learning, achievement performance, and attitude were positive reflections of activities that were designed by teachers to be engaging. Each of the three preservice teachers also held their own individual beliefs about mathematics teaching such as Brian’s belief about students’ ability to identify relevance in their mathematics learning being age dependent and Sandra’s belief that not all undergraduate
mathematics content will be informative to her teaching practice. All of these beliefs were found to be linked with participants’ prior educational experiences.

**Summary of Preservice Teachers’ Experiences**

The preservice teachers who participated in this study shared commonalities in the way they connect mathematics to real-world experience, perceive mathematics and mathematics teaching, and integrate SJM to formal mathematics teaching experience. When discussing their perceptions and experience about SJM, all three participants consistently related their description to their prior experiences either as a mathematics learner or in the role of a mathematics teacher. The individual’s unique background, prior experiences, identity, and particular role in SJM, resulted in distinct perceptions and experiences. Despite some mismatch between preservice teachers’ intentions and the way they claim to implement their intentions into practice, transformation was apparent as they reported their change in viewing real-world mathematics and indicated their visions of mathematics teaching and learning. Kathy, who was more involved in this study than Sandra and Brian due to her additional role as a facilitator of the SJM activities, appeared to have the most prominent transformation in understanding social issues and the connection between mathematics to the real-world. Overall, findings about preservice teachers’ experiences, perceptions, and beliefs were consistent with findings reported in similar studies and could be supported by the literature.

**Secondary Students**

The discussion of secondary students’ experiences will be guided by the following: their experiences of (a) connecting mathematics to real-world experiences, (b) the way they perceived mathematics, and (c) connecting SJM to formal mathematics learning experiences.
Connecting Mathematics to Real-World Experiences

From the findings, there appeared to be a transformation to students’ perceptions of the connections among mathematics and the real world. To illustrate the transformation, I will discuss the perceptions that students held prior to and subsequent to their involvement in SJM. In addition to showing an understanding of the way mathematics is embedded in the real world, students also demonstrated a deeper understanding of real-world issues through the SJM activities.

Transformation in perceptions about real-world mathematics. Students shared both their prior and new perceptions of real-world mathematics at the end of the study by providing examples from their mathematics learning experiences. Prior to participating in SJM, the six students in this study asserted that real-world mathematics must have the characteristic of being job-specific. Students claimed that the SJM activities introduced them to many ways in which mathematics connects to the real-world that were not bound by job-relatedness.

Some students (anonymous on questionnaires) reported that in their view, real-world mathematics was restricted to monetary problems and descriptive statistics. One of students (anonymous) also used the word “unrealistic” to describe classroom mathematics. Before participating in SJM, most students held the view that mathematics has limited application to the real world. A specific example provided by one student was the Ferris wheel’s motion modelled by trigonometric curves. Isabelle’s opinion was that classroom mathematics was comprised of contrived observations of real-life situations rather than illuminative examples that highlight the ways in which mathematics could be used by students in their everyday life. Other examples of contrived applications provided by students that illustrated this perception included modelling population growth and determining the height of a tree by using the angle of elevation to the sun.
When probed about their views at the end of the study, students showed that they had expanded their ideas about the ways in which mathematics was connected to the real world. All students defined real-world mathematics as mathematics embedded in the current events effecting their lives, local community, and the world. Students felt that real-world mathematics needed to be “relatable” to them. Although one student (anonymous) mentioned the immediate use of mathematics in simple financial problems, others mentioned more sophisticated monetary problems related to the SJM activities including gas expenses, family income, personal income, and savings and investments. These factors were explored in the activities about the fuel consumption of vehicles, poverty, and food bank use.

All six students spoke of real-world mathematics as being useful beyond immediate problem solving. One general idea stated by students was the utility of mathematics to determine the factors impacting an issue and determine the relationships among variables. Students emphasized the importance of using mathematics to comprehend social justice issues, identifying “gaining understanding” to be a source of empowerment for action-taking on these issues. Students showed a sense of social responsibility, to which mathematics was perceived to add value. These findings were consistent with Gutstein’s (2003, 2006a, 2011) notion of reading and writing the world with mathematics. In the current study, students’ perceptions about real-world mathematics appeared to have transformed through the SJM experience. The students recognized the importance of using mathematics to read and write the world, which meant using mathematics to understand data pertaining to social issues and to strengthen their arguments made in social action work (Gutstein, 2003, 2006a, 2011).

**Understanding real-world issues.** Despite the short duration of this study, results shared similarities with that of Gutstein’s (2003) longitudinal study and with other studies (Diez-
Palomar et al., 2006; Gutstein, 2011; Turner et al., 2009) that examined the integration of mathematics and social justice issues. In the current study, almost all students spoke about an understanding of the relationship among variables: using SJM activities to substantiate their statements, participants spoke about the ways in which they gained understanding about the relationship between nutrition intake and people’s income, income and years of schooling, life expectancy and years of schooling, and population and food bank access. One of the students, Carmen, explained that SJM provided opportunities for her to expand her consideration of factors that never would have been taken into account prior to this experience. Although the study conducted by Gutstein (2011) involved social justice issues that differed from those considered in the SJM activities in this study, he found that secondary students identified relationships among multiple issues and were able to recognize factors that contributed to particular issues. For example, participants in Gutstein’s (2011) study developed an understanding of racism, sexism, and poverty as contributing factors in the high rate of HIV/AIDS among the African American female population. Similarly, and in addition to this finding, two of the secondary students in my study expressed an understanding of cause and effect of social issues such as poverty and the increase use of food banks. They stated that beyond the issues explored in the SJM activities, they now were able to recognize factors that contributed to an issue that was encountered in everyday life.

Only one of the students, Carmen, spoke about understanding real-world issues in relation to herself as a result of the SJM experience. She felt fortunate as she reflected upon her experience in comparison to people who live under the poverty line and need to access resources such as food banks. Perhaps it was students’ privileged position and their upper-middle class community that brought them a deeper appreciation for the understanding of issues such as
poverty and disenfranchisement. In contrast to this finding, researchers who conducted their studies in communities with a high population of marginalized visible minorities found that students related their personal experiences to the SJM activities (Diez-Palomar et al., 2006; Gutstein, 2003, 2011; Turner et al., 2009). For example, in an activity about global wealth inequity, middle school students related to their own financial situations (Gutstein, 2003); whereas, in a home displacement issue activity, secondary students related to the phenomenon occurring in their community (Gutstein, 2011). When exploring issues about immigration and deportation, elementary students drew on their personal immigration experiences, as well as those of their relatives, and other community members (Diez-Palomar et al., 2006; Turner et al., 2009). Despite not being able to relate personally to the issues explored through SJM, one student participant in the current study, Carmen, showed a transformation in her perceptions about social issues because she realized that she was more fortunate than those directly affected by these issues.

My findings show consistency with other research that suggests that teaching mathematics through a social justice lens strengthens students’ connections among mathematics and the outside world. It also contributes to the development of an understanding of the world using mathematics (Gutstein, 2003, 2011). In addition, similar to the student participants in Gutstein’s (2003) study, students in the current study demonstrated an understanding of and appreciation for the role of mathematics in comprehending complex real-world problems.

**Summary of connecting mathematics to real-world experiences.** Findings suggested that student participants experienced a transformation to the ways in which they perceived real-world mathematics. From the initial perception of real-world mathematics as being strictly limited to the use of mathematics in the work force, students appeared to have experienced a
transformation in that after the SJM experience, they described a broader recognition of the ways in which mathematics is embedded in events in their immediate lives, the local community, and globally. Students referenced the mathematical activities from their SJM experience to describe their understanding of real-world mathematics, explaining the ways in which opportunities to learn that connected mathematics to real-world experiences allowed them to determine relationships among variables—valuable for data-based interpretations of social issues.

With the experience of connecting mathematics to the real world in SJM activities, student participants communicated that they gained understanding about the factors that lead to or influence issues, relationship among variables, and cause and effect relationships in issues. Furthermore, one of the students related her personal experience as a privileged and fortunate individual, far-removed from the poverty issues discussed during SJM activities, which led her to a deeper empathetic interpretation of social issues.

**Connecting SJM to Formal Mathematics Learning Experiences**

The following section is organized by students’ expression of SJM as a support for comparing their SJM experience to formal mathematics learning experiences in the classroom. Next, I discuss students’ visions of mathematics learning in a similar extracurricular opportunity and in the mathematics classroom.

**SJM as a support for classroom mathematics learning.** According to most students in the present study, SJM provided an opportunity for clarification and solidification of mathematics concepts. By referring to lessons that focused on determining first and second differences of a set of data, graphing, and interpreting data that could be modelled by particular types of relationships, students reported that the SJM activities facilitated a deeper understanding of mathematical concepts. In particular, two Grade 12 students, Isabelle and Rachel explained
that SJM provided opportunities for them to revisit concepts that were main foci of the Grade 9 and 10 mathematics curricula: modelling data with linear relations, determining the rate of change of a linear relation using the concept of first differences, and representing the rate of change of a linear relation using the concept of a slope.

All of the students were aware of the explicit integration of mathematics concepts with the SJM activities. When discussing this non-traditional approach to curriculum, students often compared SJM lessons to their classroom learning experiences and commented that in their regular classroom, they felt that there was an isolation between mathematics units. They felt that formal mathematics learning experiences lacked explicit links among topics and connections among concepts: perceptions developed because of their personal observations and interpretations of classroom instruction, resources, and evaluation. Students reported that the integration of specific mathematics concepts into the SJM activities, supported their conceptual learning. In addition to the interrelationships explicated among mathematics concepts made possible by SJM, the students also appeared to appreciate the integration of mathematics with other topics, which were mentioned to be a wide range of social issues.

When students compared the mathematics learning approaches experienced during their SJM participation with regular classroom instruction, they expressed a preference for the approaches used in SJM. SJM activities appeared to have provided students with opportunities to move beyond mathematical ideas as facts. The students in the current study appeared to enjoy investigating concepts such as modelling data using various functions and determining the most appropriate function to represent a set of data when they posed questions about the data. Students reported that often in classroom environments they were told, rather than were asked to discover, the specific function to which a set of data adhered. Similarly, opportunities for investigating and
discovering also arose in a study conducted by Turner et al. (2009) during which SJM activities required mathematics concepts beyond the scope of the elementary students. Turner et al. (2009) found that when students participated in activities that allowed them to discover concepts, the activity became a context for deeper concept exploration. This notion of deeper concept exploration (Turner et al., 2009) might have been experienced by the students in the present study because they described the mathematics learning experience in SJM to be different from accepting procedures and applying rules provided to them during regular classroom instruction.

The student participants in this study stated that they preferred conceptual understanding over memorizing rules and procedures. Despite this preference, one student stated that memorization made classroom mathematics learning more convenient. The student communicated that accessing readily remembered formulas, rules, and algorithms was especially efficient for examination situations. This point of view was also found in Schoenfeld’s (1989) study, in which Grade 10 and 12 geometry students emphasized the importance of memorization when required to write mathematical proofs. Perhaps it was the lack of testing in extracurricular mathematics learning opportunities that benefited students in conceptual understanding experiences.

Students identified real-world social justice issues as a context for mathematics learning opportunities that supported their learning. Students described classroom problem solving as being structured around routine procedures that were the focus of instruction, and recognized that the problems that arose during SJM activities were designed to allow exploration of data and evaluation of information. The SJM lessons led students to value both the realistic contexts and the opportunities provided to develop understanding and engage in meaningful problem solving.

Overall, students showed a positive response towards the ways in which SJM supported
their mathematics learning experiences. Students also shared their visions for future learning experiences.

**Visions of mathematics learning.** The students reported that they would like to see more frequent inclusion of visual representations in future mathematics learning experiences. Students felt that the use of visual representations of data in SJM activities contributed to the successful solution of equations and development of mathematical models. Thus, representing data using graphs as a tool to investigate data about social issues was thought to be valuable.

The students who participated in the SJM study spoke positively about opportunities to solve problems in collaborative ways (for example, through discussions with peers and their session facilitator). According to the students, their regular mathematics classroom tended to provide limited opportunities for collaboration. Participants in this study said that they wished to participate in more interactive activities like the SJM activities in the future. Similar to the experiences of the students in this current study, Mueller and Maher (2009) found that by allowing Grade 6 students to collaborate in an informal afterschool mathematics program, students’ ability to justify their solutions using reasoning, and defending and building arguments was improved.

The students who participated in this study also stated that in future mathematics learning experiences, they would like to have more autonomy for their own work. In the anonymous questionnaire, one of the students explicitly stated that if she were the teacher, she would guide students’ learning and provide opportunities for students to solve problems on their own. When asked specifically to think about potential SJM activities for future learning opportunities, either in an extracurricular program or in the classroom, students wanted to continue to be involved in activities with community issues, community events, current issues, and issues related to
students themselves. In the anonymous questionnaire, one of the students suggested that group discussion of an issue should be used to introduce activities and set the stage for mathematics lessons. Particularly, she wished to see activities that integrated mathematics with topics about which they were concerned, such as high tuition costs and environmental sustainability. During the student focus group, the students talked about extensions to some of the SJM activities. For example, students elaborated on the Poverty and Healthy Eating activity and suggested opportunities for experimental activities that would allow learning experiences to take place beyond the classroom. For example, students suggested visiting local grocery store to simulate spending funds using a poverty-line budget and then examine the impact of selected food on health and well-being. In the study conducted by Diez-Palomar et al. (2006), findings showed that mathematics learning in out-of-school experiences allowed students to make use of their knowledge about the community and bring relevance to their learning experience. The idea of Diez-Palomar et al. (2006) about bringing mathematics into lived contexts could develop students’ appreciation for the subject and empower them to use mathematics. Furthermore, students in this current study showed interest in activities that would allow them to be involved in the origin of data, to take action on the social issues, and to explore unpredictable relationships among variables.

**Summary of connecting SJM to formal mathematics learning.** Students regarded SJM as enriching classroom mathematics learning because the content explored in the SJM activities revisited and clarified concepts that they learned from formal instruction. Students supported this claim by articulating specific mathematics concepts that they understood better because of the SJM experience. When comparing their mathematics experiences in SJM to their regular classes, students pointed out that unlike the SJM learning experience, classroom learning tended to be
organized by discrete mathematics units and was limited with respect to the integration of mathematics with other disciplines. In addition, they stated that opportunities for peer collaboration and exploration of mathematics concepts were limited in regular classroom instruction.

Based on these comparisons, student participants identified several strategies to include in their regular classroom mathematics learning experiences: frequent use of visual representations of data to solve problems; more peer collaboration opportunities; and, more autonomy to discover and explore mathematics.

**Perceptions of Mathematics**

All six students spoke about the value of mathematics as applicable to real life and about their perceptions of mathematics by discussing its use and applications. Similar to Gutstein’s (2003) participants, students in this study were under the impression that mathematics is useful for finding trends, finding relationships, and analyzing data. Isabelle, in particular, emphasized that mathematics should be used to analyze real data rather than contrived data, saying that there is little value in artificial exercises such as analyzing data documenting the height of a plant over time. Mathematics was also regarded as useful through its applications, which students felt could lead to future utility and further inquiry.

Although the intent of this study was to teach mathematics through the lens of social justice issues rather than using mathematics to teach about the far-reaching costs of social inequities, student participants appeared to hold the perception that mathematics is a tool to investigate issues and contribute to social change. Similarly, in another study, middle school students appeared to perceive mathematics as a tool for sense-making of real-world phenomena and explaining decisions made in everyday life (Gutstein, 2003). This finding was consistent
with the outcomes of Brelias’ (2009) study because the researcher also found that secondary students recognized mathematics as a tool to examine issues and lead to social action. In Brelias’ (2009) study, secondary students also mentioned that they recognized the limitation of mathematics as a tool because of the complexity of social justice issues. However, this was not found in this study.

**Summary of Students’ Experiences**

Transformation was apparent in students’ experiences of connecting mathematics to the real-world. Students admitted that their voluntary participation was driven by a sense of eagerness to learn and connection to the community; anticipation to experience personal growth through this experience; and, an interest in both mathematics and social justice issues. In addition to reasons for participation, students shared their views about mathematics. Students focused on discussing mathematics as a useful instrument and their new perspectives on connecting mathematics with social justice issues. Secondary students’ beliefs about the nature of mathematics “both enables and constraints their ability to construct conceptual bridges between familiar everyday practices and mathematical concepts taught in school or university” (Presmag, 2003, p. 293). Thus, their perceptions about mathematics and experiences in connecting mathematics and social justice should be further explored.

**Comparing the Experiences between Students and Preservice Teachers**

There were similarities as well as differences observed in the findings of students’ and preservice teachers’ experiences. In this section, I will compare and contrast the two groups of participants with respect to the views and visions of mathematics teaching and learning described, based on SJM experiences.
Similarities

Students and preservice teachers shared commonalities in their visions of mathematics learning including autonomy in mathematics learning, curriculum integration, and peer collaboration. Both groups of participants described the importance of autonomy in mathematics learning. Preservice teachers stated that they intended to give autonomy to students to enhance their learning experiences by valuing their input and allowing their responses to guide the lesson. Students stated that they would like to have more autonomy for their own mathematics activities such as problem solving instead of being provided with mathematics procedures and rules, which they tended to accept as facts.

Findings also showed that students and preservice teachers valued curriculum integration. They described the integration of mathematics and social justice issues to be beneficial to the understanding of both mathematics concepts and social issues. Both groups provided specific examples from the SJM activities that supported their understanding of mathematics, social issues, and the connection of mathematics with the real world.

Students appreciated the collaboration opportunities they were given during the SJM activities. Similarly, preservice teachers appreciated the collaborative effort in activities planning with their peers. All participants stated that collaboration opportunities would be beneficial to future mathematics teaching and learning experiences.

All participants expressed that they enjoyed SJM activities because of a sense of freedom from curriculum expectations. Both students and preservice teachers felt that the formal curriculum tends to compartmentalize mathematics concepts and restrict the integration of multiple concepts and topics during instruction. Although participants did not discuss the way to
overcome this challenge in classroom mathematics learning, they showed a sense of value towards extracurricular experiences that could liberate pedagogy from this barrier.

In addition to these similarities, both groups appeared to have transformed the ways in which they connect mathematics to real-world experiences. Students were able to describe their change in perception towards the connection of mathematics to the real world by discussing their perceptions prior to and following their participation in SJM. Similarly, preservice teachers described a change to perceptions and shared new ideas to connect mathematics to the real world in their teaching.

**Differences**

Both groups spoke of their beliefs about mathematics and mathematics teaching and learning. Despite the belief of needing to differentiate between the interests of students and the teacher, there was a gap between preservice teachers’ understanding of students’ interests and the actual topics of interests of students. Sports was the context that they mainly spoke about when discussing future activities they would create to connect mathematics with the real world for students. On the other hand, students showed an interest in issues relevant to their lives such as tuition increase and environmental issues. It is worth mentioning that the student participants in this study might have stronger interests towards social issues due to their involvement in the Social Issues Club, which could be unlike the interests of typical students.

Another belief that differed between the two groups was their perception of mathematics. Overall, students expressed an instrumental belief about mathematics and showed appreciation for mathematics as a tool. From the SJM experience, students felt that mathematics is applicable to the real-world. In contrast, preservice teachers believed that the applicability of mathematics tended to be dependent on content, grade, and students’ career focus.
Summary

Although there are similarities and differences between students and preservice teachers, one major commonality observed was the transformation in connecting mathematics to the real world. Another similarity was the participants’ vision for future mathematics teaching and learning experiences, which included autonomy in mathematics learning, curriculum integration, and peer collaboration.

In contrast to students’ instrumental view of mathematics, preservice teacher participants did not regard mathematics as a subject that is always applicable. Thus, there was a difference found in the beliefs of students and preservice teachers about mathematics. In addition, findings indicated there was a disconnect between students’ preferred contexts for mathematics learning and students’ preferred contexts as assumed by preservice teacher participants.

Concluding Thoughts

With reference to the definition of transformation detailed in the conceptual framework of this study, I discuss the reorganization of experiences described by the participants. A model generated from the results of this study is used to summarize participants’ experiences and demonstrate the interrelated nature of SJM and other experiences.

Organization of Preservice Teachers’ Experiences

One of the major conclusions of this study is the difficulty participating preservice teachers had in suggesting real-world connections that they would make in their future mathematics teaching. In each case, the suggested real-world mathematics ideas were reflective of their own field of academic specialization, that is, biology, physics, or mathematics. The mathematics content suggested by Kathy and Sandra was adapted from content included in the SJM activities. By suggesting new lessons based upon their studies of mathematics and the other disciplines of interest indicated that the unique learning experiences of mathematics content
knowledge are instrumental in preservice teachers’ attempts to integrate curriculum and make real-world connections. The literature suggests that teachers’ knowledge of mathematics content embodies other areas of knowing including knowledge about the curriculum and classroom structures (Davis & Simmt, 2006). In addition to this idea in the current literature, the results of this study showed that the content knowledge learning experiences of preservice teachers are intertwined with other experiences.

Kathy, Sandra, and Brian identified barriers such as the limited resources, time constraints, and unfamiliarity with curriculum integration as influences that contributed to their inability to make meaningful connections among mathematics and the real world, because curriculum integration was not a focus of their formal teacher education. This study found that preservice teachers viewed their experiences in secondary school/undergraduate mathematics instruction, teacher education, and SJM as valuable components of their professional development as mathematics educators. Kathy attributed her transformation to a more expanded conception of mathematics and social justice issues, as a response to her role as an activity planner and the session facilitator of SJM and the positive feedback she received from the SJM students. She also identified her associate teacher’s mentorship support as a positive factor contributing to this transformation.

From these examples, it is apparent that it is difficult to separate preservice teachers’ SJM experience with other factors such as their mathematics learning experiences as a student and their teacher education experiences when seeking to explain the transformation that participants described. Using Doll’s (1989, 1993) notion of “reorganization of experiences,” Figure 2 shows a model that illustrates the organization of preservice teacher participants’ experiences in a three-way Venn diagram. The Venn diagram is organized into experiences in learning mathematics
content knowledge, experiences in participating in SJM, experiences in teacher education, or the overlap of more than one of these experiences. The coloured area indicates that experiences in the suggested category were described by the preservice teacher participants. The unshaded area shows that none of the described experiences belonged in that category of the Venn diagram. For example, preservice teachers’ mathematics background can be categorized into experiences in learning mathematics content knowledge. Beliefs about mathematics and mathematics teaching, was placed in the overlap of experiences in learning mathematics content knowledge and experiences in teacher education because preservice teachers described their beliefs using these two experiences.

Figure 2 indicates that most of the preservice teachers’ described experiences tend to belong to the intersection of more than one of these experiences. This result suggests that the nature of preservice teachers’ experiences is highly interrelated. The outcomes of this study suggest that for preservice teachers to transform their understanding of curriculum integration, the integration of mathematics and social justice issues, or connecting mathematics to the real world, it would be necessary to consider all their experiences. Allowing preservice teachers to integrate multiple experiences would allow the reconstruction and reorganization of experiences, which is an essential for the transformation process in a learning experience (Doll, 1989, 1993).
Figure 2. Organization of Preservice Teacher Participants’ Experiences
Organizations of Students’ Experiences

Similar to the organization of preservice teacher participants’ experiences, student participants’ experiences can also be categorized using a three-way Venn diagram. The coloured area indicates that experiences in the suggested category were described by the student participants. The unshaded area shows that none of the described experiences belonged in that category of the Venn diagram. Students also described their SJM experience in relation to other experiences, which included their experiences in learning mathematics content knowledge and their experiences in the Social Issues Club. Thus, using a three-way diagram, a model was created to organize students’ experiences (see Figure 3). This model suggested that students’ experiences tended to be integrated. From the findings, students appeared to have transformed their perceptions about real-world mathematics. This transformation could be associated with the rich integration of students’ experiences in mathematics learning and experiences by participating in SJM. Similar to the conclusion made for preservice teachers, using this model to organize students’ experiences brings insights into the need to integrate students’ multiple experiences to allow for the reconstruction and reorganization of experiences, which is necessary for the transformation process (Doll, 1989, 1993).
Figure 3. Organization of Student Participants’ Experiences
Implications for Research

Examining the participants’ beliefs about mathematics and mathematics teaching and learning was not an explicit goal of this study; nonetheless, this topic surfaced during both preservice teachers’ interviews and the students’ focus group. For example, preservice teachers spoke about their beliefs about applicability of mathematics, the hierarchy of mathematics concepts, mathematics ability, and engagement and attitude towards mathematics learning. Similarly, students talked about their views about mathematics as an instrumental body of knowledge and the applicability of the subject. The expression of beliefs about mathematics suggested that beliefs and experience might be inseparable (Holm & Kajander, 2012). While one informs the other (Holm & Kajander, 2012), further research is necessary to delve into this interaction to support mathematics teaching and learning experiences. According to Stemhagen (2011), it is necessary to consider teachers’ beliefs about the nature of mathematics and mathematics teaching and learning for a change to occur in practice. This gap needs to be addressed through both research and teacher education, in which preservice teachers could be provided with support to develop an understanding of “mathematics as a human endeavour” (Falkenberg & Noyes, 2010, p. 955).

Currently, there is limited research on how best to bring the integration of mathematics and social justice issues into teacher education (Turner et al., 2009). In this study, the “Shared” curriculum integration model developed by Fogarty and Stoehr (2008) was used; however, little is known about integrating mathematics and other disciplines through other curriculum integration models. Linking mathematics with other subjects in the practice of teaching would benefit from further research that examines this integration through other models.
Because this study was conducted with all female secondary student participants, with three in Grade 10 and three in Grade 12, research that further examines this topic and involves a more diverse sample that better represents the general population might allow deeper understanding about participants’ experiences in SJM.

**Implications for Practice**

In this study, a gap was found between students’ interest in mathematics learning and preservice teachers’ understanding of students’ interest. This finding indicated that there is a need for teachers to avoid assumptions about their students’ interest and to communicate with their students to understand their interests. Teachers could also involve students in topic selection. Integrating mathematics with other disciplines in the classroom could benefit from using contexts of students’ interest for mathematics teaching and learning. In addition, it was suggested by Nicol (2002) that in order to expand preservice teachers’ understanding about connecting mathematics and the real world, opportunities for them to experience mathematics in the real-world context could be necessary. In a study conducted by Nicol (2002), preservice teachers were found to be able to contextualize mathematics in their lesson design when given the opportunity to visit the workplace and understand the way mathematics is used in real life. This opportunity could be a beneficial component to be added to mathematics curriculum courses in teacher education programs.

A primary challenge that all preservice teachers in this present study identified was the limited models of integrating mathematics and other disciplines that they have been exposed to during their teacher education program. Concrete examples could be the missing bridges between the preservice teachers’ intention to link mathematics concepts with other topics in their teaching and enacting this kind of curriculum integration. Findings from this study and the study
conducted by Turner et al. (2009) each suggested that supports for preservice teachers to learn to integrate mathematics and students’ knowledge about their local community is required. Particularly in terms of the integration of mathematics and social justice issues, Gonzalez (2008) also recommended that classrooms need to be environments that facilitate the exploration of social issues using mathematics and that teachers need to be provided with support to implement such practice. Modelling lesson planning, activities designing, and implementation of SJM lessons and activities should be next steps in both curriculum courses and preservice teachers’ classroom placements (Garii & Okumu, 2009).

Findings about the visions that students and preservice teachers stated for future mathematics teaching and learning indicated implications for practice such as including visual models for solving real world problems, allowing peer collaboration during mathematics activities, and providing students with next steps in taking social action upon conclusions made from mathematical analyzes. Activities such as writing letters to local politicians using data discovered in lessons could both give meaning to the use of mathematics and empower students to take action by using data to inform their endeavours to advance social responsibility.

Reflection

I began this journey as a newly certified secondary mathematics teacher who had limited formal classroom teaching experience. After 18 months of planning and conducting this study and completing this thesis, my role transitioned from researcher to classroom teacher when I had the opportunity to teach a summer session Grade 11 mathematics course. In this section of my thesis, I will reflect on the way my role and learning experience as a researcher and as a classroom teacher became intertwined.
In the role of a researcher, I related to the participating preservice teachers of this study because I was a recent B.Ed. graduate at the time when I started the Masters of Education program. I related to the challenges Brian, Kathy and Sandra communicated such as time constraints and limited resources in designing lessons that integrate mathematics with other disciplines: catalysts for my passion to conduct this study. Overall, I have gained insights into the way students and preservice teachers connected mathematics to their real life experiences and the visions they had for mathematics teaching and learning in regular classrooms. The beliefs about mathematics that the participants shared also allowed me to understand the inseparable nature of beliefs, experience, and practice. The implications for further research and the implications for practice from this study had an impact on my understanding on bridging the gap between research and practice. This study has resulted in my professional growth by contributing to my knowledge as a secondary mathematics teacher and my appreciation for the value of focusing on students’ interests and curriculum integration.

As I was completing my thesis, I had the opportunity to have my very first classroom as a summer session Grade 11 mathematics teacher. Because another teacher was also teaching Grade 11 mathematics, we collaborated by sharing materials and discussing our own lesson plans. In addition, I gained support from this teacher when new issues and challenges regularly arose in the classroom. Similar to the preservice teacher participants in my study, I experienced the benefits of collaboration in planning lessons and sharing ideas. I found this experience to be invaluable, especially because I am an early-career teacher.

I learned from the student participants in this study the importance of connecting mathematics to their real-world experiences. Thus, I decided to use real-world contexts in my mathematics teaching despite the need to rush through curriculum expectations due to the time
constraints in a one-month summer session program. On the second day of my teaching, I decided to integrate the teaching of independent variables, dependent variables, and linear relations using the context of the monthly expense of using a cell phone. Students identified that the number of minutes used per month, the amount of mobile data used per month, and the type of plan were variables that affect the monthly cell phone expense. I then provided students with the cost of mobile data in dollars per gigabyte used based on information obtained from a real mobile network corporation. During this activity, students became less responsive and to prompt them, I asked them to start by calculating the amount of mobile data they use. The class was silent until one student said, “We don’t have data plans.” At that moment, I realized that I had assumed that the context I had chosen was going to relate to students’ everyday life. This reminded me of one of the major findings from this study: the disconnect found between teachers’ assumption of students’ topics of interest and the actual topics about which students were interested. Learning from both the research findings and the anecdotal experience, I understand more deeply the need to communicate with students about their topics of interest in order to provide meaningful contexts for mathematics learning.

From this study, I also learned from the participants the importance to give students the autonomy to explore and investigate mathematics in their learning opportunities. In several occasions during my teaching, I caught myself wanting to interrupt and correct or provide hints to students when they were discussing among themselves their approach to solving a problem. In these moments, I was able to stop myself from interfering and simply become the spectator as they interacted. I felt that these were crucial learning moments for me as a teacher because not only had I recognized the importance of giving students the autonomy for their learning, I
realized that I had brought research into practice. The findings of this study contributed to my professional growth as a mathematics teacher.

I believe that these were unique experiences that I might not have encountered through other learning opportunities such as professional development activities or professional conferences. In conclusion, I take with me the importance of life-long learning as a mathematics educator because this experience had shown me the value of connecting research and practice.
REFERENCES


APPENDIX A: SECONDARY SCHOOL RECRUITMENT SCRIPT

Dear Principal,

My name is Mandy Lam and I am a Masters student at the Faculty of Education at Queen’s University. I will be conducting an eight-week study beginning October 2011, for my Master’s Thesis under the supervision of Dr. Lynda Colgan. My study, which is entitled, A Case Study of Social Justice Mathematics: The Experiences of Secondary Students and Preservice Teachers in Mathematics Teaching and Learning, will involve the implementation of a Social Issues Club, in which students will be taught mathematics by a pair of preservice teachers in the context of social issues. This study has been granted clearance according to the recommended principles of Canadian ethics guidelines and Queen’s policies. This study has also been cleared by the Limestone District School Board.

I would like to invite you to participate in this study by allowing the implementation of a Social Justice Mathematics Club in this school during after school hours for eight weeks beginning October, 2011. Each weekly club meeting will consist of a 90-minute lesson designed and taught by a pair of preservice teachers from the Faculty of Education, Queen’s University. Students at this school will be invited to join as club members and attendance is voluntary. Participating students will have the opportunity to learn mathematics through the context of social issues. If you would like to participate in this study, recruitment of students will begin at your earliest convenience.

The purpose of this study is to understand the transformation of preservice teachers and secondary students in terms of their perceptions towards mathematics and their experience in mathematics teaching and learning. The findings from this study will be published as a Masters Thesis and may be presented in education research conferences. Please be assured that confidentiality will be protected to the greatest extent possible.

If you would like your school to participate in this study, please contact me at mandy.s.lam@queensu.ca at your earliest convenience.

Sincerely,

Mandy Lam

M.Ed. Candidate
APPENDIX B: STUDENT PARTICIPANT RECRUITMENT SCRIPT

The Social Issues Club is formed for my Master’s Thesis Research. The purpose of the study is to understand the experience in mathematics teaching and learning in the Social Issues Club. The findings from this study will be published as a Masters Thesis and may be presented in education research conferences. More information about the study is given to you in the Letter of Information. If you would like to join and participate in this study, please attend the first Social Issues Club meeting with your Consent Form signed. Your Consent Form will be collected in the first session.
APPENDIX C: LETTER OF INFORMATION TO STUDENTS

A Case Study of Social Justice Mathematics: The Experiences of Secondary Students and Preservice Teachers in Mathematics Teaching and Learning

Dear Student and Parents/Guardian,

You are invited to participate in a research study conducted as a Masters Thesis by Mandy Lam at the Faculty of Education, Queen’s University. As a M.Ed. student, my study is conducted under the supervision of Dr. Lynda Colgan. This study has been granted clearance according to the recommended principles of Canadian ethics guidelines and Queen’s policies. This study has also been cleared by the Limestone District School Board and by the principal of your school.

For the purpose of this study, mathematics-based social issues lessons will be implemented in your school’s extracurricular club, the Interact Club that you are participating in. Club members will learn mathematics by exploring important social issues that this club focuses on. These topics may include poverty, food security, environmental sustainability, health concerns, and diminishing global resources. With the implementation of these lessons, club members will engage in activities that might include investigating relevant data, group discussions, problem solving and social action. The club will be led by a teacher candidate who is studying at the Faculty of Education at Queen’s University. The goal of this study is to examine ways in which the mathematics-based social issues lessons make a difference in the way you experience mathematics learning. This research will help future development of extracurricular activities and events that strengthen mathematics learning.

As a member of the Interact Club, you are invited to participate in this study beginning November, 2011, for 8 weeks. Your club sessions will remain in the same schedule. Your regular activities in the club meetings will remain the same in addition to the mathematics-based social issues lessons that partially take up your club meetings. By participating in this study, you will be asked to complete a paper questionnaire during the first and the eighth week of the study. The questionnaire will take approximately 15 minutes to complete. At the end of the study, you will also be asked to participate in a one-hour group discussion with other student club members. This group discussion will allow me to understand your experience in participating in this study. The group discussion will be held in a seminar room located in the library of your school. You are requested not to discuss the content of the group discussion outside of the group. Your work relating to the mathematics-based social issues lessons during the weekly club meetings will be collected at the end of each session. Shortly after the completion of the study, you will also be contacted to review the researcher’s notes to ensure accuracy of the data collected. In total, you will be expected to commit to approximately 1.5 hours during the 8-week period in addition to your regular attendance and participation in the Interact Club. Full attendance of all 8 sessions will not be mandatory.

During each club session, hand-written notes will be taken by the researcher to record observations. Responses to questionnaires will remain anonymous. The group discussion will be audio-
taped and recorded in written notes by the researcher. All your work completed during the club sessions will be collected anonymously. Raw data such as audio-recordings, hand-written notes, and work completed during the session will be stored in a locked location. All data in electronic form will be stored in a password-protected computer. Any data that contains your identity will be changed to a pseudonym to replace your name. All data will only be accessible by me as the researcher, my supervisor, and my committee member.

There are no known risks resulting from participation in this study. However, the mathematics-based social issues lessons that partially take up your club meetings might cause inconvenience by interfering with your regular club activities. Participation is voluntary and you will be free to withdraw or request to have your data removed at any point of the study without any consequences. If you would like to attend club sessions but not participate in the study, then all observations and conversations pertaining to you during club sessions will not be recorded. If you began participating and would like to remove yourself from the study but still remain in the Interact Club, then all observations and conversations pertaining to you during club sessions will not be recorded. In both of these cases, you also will not be asked to fill in any questionnaires or to participate in any group discussion outside of the club.

You may choose not to respond to any questions in the questionnaires or group discussions if they cause any discomfort. Your decision on participation will not impact your grades. Your participation will not be disclosed to your regular teachers. You will not receive any compensation by participating in this study.

The findings of this study will be published as a Masters Thesis and may be presented in education research conferences. Pseudonyms will be used to replace your name when discussing findings. In accordance with Queen’s University’s policy, data will be kept for a minimum of five years, after which data will either be destroyed or will be kept indefinitely. If data is used for further analysis by other researchers, it will contain no identifying information of any of the participants. Please be assured that confidentiality will be protected at the furthest extent possible.

Any questions about study participation may be directed to Mandy Lam at mandy.s.lam@queensu.ca or my thesis supervisor, Dr. Lynda Colgan, at 613-533-6000 ext 77675 or lynda.colgan@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at 613-533-6081 or chair.GREB@queensu.ca.

Please indicate your decision to participate in the study by signing one copy of the Consent Form and return it to the teacher candidate. Please retain the second copy for your records.

Sincerely,

Mandy Lam

Master of Education Candidate
APPENDIX D: CONSENT FORM TO STUDENTS

- I agree to participate in the study, A Case Study of Social Justice Mathematics: The Experiences of Secondary Students and Preservice Teachers in Mathematics Teaching and Learning, conducted by Mandy Lam through the Faculty of Education at Queen’s University.

- I have read and retained a copy of the Letter of Information and Consent Form, and I have had any questions answered to my satisfaction.

- I understand that the purpose of the study is to understand my experiences and perceptions in the informal, extracurricular learning environment, in which the mathematics in the context of social issues will be implemented.

- I understand that my participation in the study involves eight weekly participations at the Interact Club. During that period, I will be asked to participate in the completion of questionnaires, and a one-hour focus group discussion, which will take place in a seminar room at the library of my high school.

- I understand that the total time commitment in participating will be approximately 1.5 hours during the eight-week period in addition to my regular attendance and participation at the Interact Club.

- I understand that the club sessions will be observed by the researcher and hand-written notes will be made to record observations.

- I understand that the focus group discussion will be recorded using audio-recording devices and hand-written notes made by the researcher.

- I understand that my work related to the mathematics-based social issues lessons will be collected as data.

- I understand that the researcher will protect my confidentiality to the furthest extent possible.

- I understand that my participation is voluntary. I understand that I am free to withdraw and request the removal of all or part of my data at any time during the study without any consequences to my grades at school.

- I understand that if I withdraw from this study any time during the eight-week period but would like to remain in the Interact Club, then all observations and conversations pertaining to you during club sessions will not be recorded.
• I understand that, upon request, I may obtain a full description of the results of the study after its completion.

• I understand that there are no known risks or discomforts associated with participation in the research study. However, I do understand that the time commitment during after school hours may pose as an inconvenience.

Any questions about study participation may be directed to Mandy Lam, at mandy.s.lam@queensu.ca, or my supervisor, Dr. Lynda Colgan, at 613-533-6000 or lynda.colgan@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at 613-533-6081 or chair.GREB@queensu.ca

Please sign one copy of this Consent Form and return to the researcher, Mandy Lam. Retain the second copy for your records.

I have read and understood this consent form and I agree to participate in this study.

I have read and understood this consent form and I agree to allow my son/daughter to participate in the study.

Student’s name (Please print)                     Parent/Guardian’s name (Please print)

Student’s signature:                             Parent/Guardian’s signature:

Date:                                            Date:

I would like to request a copy of the results of the study.

Email:                                             Postal Address:

__________________________________________     _________________________________________
APPENDIX E: PRESERVICE TEACHER RECRUITMENT SCRIPT

My name is Mandy Lam and I am a Masters student at the Faculty of Education at Queen’s University. I will be conducting an eight-week study beginning October 2011, for my Masters Thesis under the supervision of Dr. Lynda Colgan. My study, which is entitled, A Case Study of Social Justice Mathematics: The Experiences of Secondary Students and Preservice Teachers in Mathematics Teaching and Learning, will involve the implementation of a Social Issues Club, in which students will be taught mathematics by preservice teacher(s) in the context of social issues.

I would like to invite you to participate in this study. As participants of this research, you will be assigned to work with another secondary mathematics teacher candidate. As a pair, you will design lesson plans, teach these lessons in the club, and reflect upon them in a journal using jot notes. These developed lessons will be collected and the lessons taught during the club sessions will be observed by the researcher. In addition, you will be asked to be involved in a 40-minute interview individually at the end of the study, which will be audio-recorded.

The club will run weekly beginning November, 2011 for eight weeks. Each club meeting will be approximately 90 minutes during after school hours. Topics of social issues that will connect to mathematics in this club will include but will not be limited to poverty issues, environmental sustainability, health concerns, and depleting global resources. To allow you to further understand the Social Issues Club in this study, I will provide you with some sample lesson plans.

The purpose of this study is to understand the perceptions of preservice teachers and secondary students towards mathematics and their experience in mathematics teaching and learning. The findings from this study will be published as a Graduate Thesis and may be disclosed in education research conferences. Please be assured that confidentiality will be protected to the greatest extent possible.
APPENDIX F: LETTER OF INFORMATION TO PRESERVICE TEACHERS

Dear Preservice Teacher,

I am writing to invite you to participate in this study, which is conducted as a Masters Thesis by Mandy Lam at the Faculty of Education, Queen’s University. As a masters student, my study is conducted under the supervision of Dr. Lynda Colgan. This study has been granted clearance according to the recommended principles of Canadian ethics guidelines and Queen’s policies.

In this study, mathematics-based social issues lessons will be implemented in an extracurricular club, known as the Interact Club, of the local high school, Frontenac Secondary School. The purpose is to understanding the experiences of students and preservice teachers towards mathematics teaching and learning. The club was selected based on its orientation to social justice issues. Preservice teachers will lead these lessons in weekly 25-minute club meetings, from 11:30 am to 11:55 am, over a period of eight weeks. These lessons will engage students in investigating and discussing mathematics in the context of social issues. Topics of social issues will depend on the focus of the club, which may include issues of poverty, food security, environmental sustainability, health concerns, and depleting global resources. This research will provide an important extracurricular opportunity for students and may support achievement in numeracy.

Participating preservice teachers will be expected to commit to eight weeks of weekly club meetings beginning Wednesday, November 9th, 2011. Tasks will include: a) designing lesson in collaboration with the researcher and other preservice teachers, b) implementing the lessons in the participating club, and c) recording your teaching experiences using jot notes in a reflection journal. In addition, you will be requested to participate individually in a 40-minute interview at the end of the study. Interviews will take place in a seminar room at the Faculty of Education of Queen’s University. Shortly after the interview, you will also be contacted to review the researcher’s recordings to help ensure accuracy of the findings. In total, you may be expected to commit to approximately 13 hours during the eight-week period. Transportation to the school location will be provided by the researcher upon request.

Teaching activities in the participating club will be observed by me as the researcher and observations will be recorded in the form of hand-written notes. Interviews will be audio-recorded using audio-recording devices, which will be stored in a locked location to ensure the confidentiality of raw data to the furthest extent possible. For data analysis, interviews will be transcribed verbatim with the use of pseudonyms to replace names of all participants. Transcribed data will be stored in a password-protected computer. Products including lesson plans, materials, and resources developed by you and other preservice teachers will also be used as a form of data collection. These products will be converted to electronic form and will be analyzed as visual data, which will be stored in a password-protected computer as well. All data can only be accessed by me as the researcher, my supervisor, and my committee member.

There are no known risks resulting from participation in this study. Participation in this study will not entail any expectation that you will compromise attendance at your own scheduled classes or any
practicum you will be in. Please be assured that your decision on participation is voluntary and you will be free to withdraw or request to have your data removed at any point of the study without any consequences. There is also no obligation to respond to any questions in interviews if they cause any discomfort. Your decision on participation will not influence your academic standing in this education program.

The findings of this study will be published as a Masters Thesis and may be presented in education research conferences. Pseudonyms will be used to replace your names in discussion of findings. Raw data pertaining to participants will be disposed of to maintain confidentiality. In accordance with Queen’s University’s policy, data will be retained for a minimum of five years, after which data will either be destroyed or retained indefinitely. If data is used for secondary analysis, it will contain no identifying information pertaining to any of the participants. Please be assured that confidentiality will be protected at the furthest extent possible.

Participating preservice teachers will receive a book titled Maththatmatters: a teacher resource linking math and social justice by David Stocker as compensation for committing in this study.

Any questions about study participation may be directed to Mandy Lam at mandy.s.lam@queensu.ca or my thesis supervisor, Dr. Lynda Colgan, at 613-533-6000 ext 77675 or lynda.colgan@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at 613-533-6081 or chair.GREB@queensu.ca.

Please indicate your decision to participate in the study by signing one copy of the Consent Form and return it to me. Please retain the second copy for your records.

Sincerely,

Mandy Lam
Master of Education Candidate
APPENDIX G: CONSENT FORM TO PRESERVICE TEACHERS

- I agree to participate in the study, Social Justice Mathematics – A Case Study of Social Justice Mathematics: The Experiences of Secondary Students and Preservice Teachers in Mathematics Teaching and Learning, conducted by Mandy Lam through the Faculty of Education at Queen’s University.

- I have read and retained a copy of the Letter of Information and Consent Form, and I have had any questions answered to my satisfaction.

- I understand that the purpose of the study is to understand my experiences and perceptions in the informal, extracurricular learning environment, in which lessons of mathematics in the context of social issues will be implemented.

- I understand that my participation in the study involves eight consecutive weekly commitments which involves the following: (a) preparing lesson plans and resources along with another preservice teacher and the researcher, (b) implementing 25-minute lessons in the participating Interact club of Frontenac Secondary School, (c) completing of reflection journals in the form of jot notes, and (d) participating individually in a 40-minute interview, which will take place in a seminar room at the Faculty of Education of Queen’s University.

- I understand that the total time commitment in participating will be approximately 13 hours during the eight-week period.

- I understand that the club sessions will be observed by the researcher and hand-written notes will be made to record observations.

- I understand that interviews will be recorded using audio-recording devices and hand-written notes made by the researcher.

- I understand that lesson plans, resources, and materials developed and used in the participating club will be collected and analyzed as visual data.

- I understand that the researcher will protect my confidentiality to the furthest extent possible.

- I understand that my participation is voluntary; and that I am free to withdraw and request the removal of all or part of my data at any time during the study without any consequences my academic standing in school.

- I understand that, upon request, I may obtain a full description of the results of the study after its completion.
I understand that there are no known risks or discomforts associated with participation in the research study. However, I do understand that time commitment may pose as an inconvenience.

I understand that this study does not entail any expectation that I will compromise my attendance at my own scheduled classes or practicum.

Any questions about study participation may be directed to Mandy Lam, at mandy.s.lam@queensu.ca, or my supervisor, Dr. Lynda Colgan, at 613-533-6000 or lynda.colgan@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at 613-533-6081 or chair.GREB@queensu.ca

Please sign one copy of this Consent Form and return to Mandy Lam. Retain the second copy for your records.

I HAVE READ AND UNDERSTOOD THIS CONSENT FORM AND I AGREE TO PARTICIPATE IN THIS STUDY

Preservice Teacher’s name (Please print):

________________________________________________________________________

Preservice Teacher’s signature: Date:

________________________________________________________________________  ______________________________________________________________________

I would like to request a copy of the results of the study.

Email: Postal Address:

________________________________________________________________________  ______________________________________________________________________
APPENDIX H: STUDENT QUESTIONNAIRE 1

Section 1: Please fill in your response

1. I am in Grade
   - [ ] 9
   - [ ] 10
   - [ ] 11
   - [ ] 12

2. I am a
   - [ ] Male
   - [ ] Female

3. I am taking math this semester.
   - [ ] Yes
   - [ ] No

4. I have taken the following math courses up to present (Check all that applies).

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Course Type</th>
<th>Course Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 9 Principles of Mathematics</td>
<td>Academic</td>
<td>MPM1D</td>
</tr>
<tr>
<td>Grade 9 Foundations of Mathematics</td>
<td>Applied</td>
<td>MFM1P</td>
</tr>
<tr>
<td>Grade 9 Mathematics Transfer</td>
<td>Applied to Academic</td>
<td>MPM1H</td>
</tr>
<tr>
<td>Grade 10 Principles of Mathematics</td>
<td>Academic</td>
<td>MPM2D</td>
</tr>
<tr>
<td>Grade 10 Foundations of Mathematics</td>
<td>Applied</td>
<td>MFM2P</td>
</tr>
<tr>
<td>Grade 11 Functions</td>
<td>University</td>
<td>MCR3U</td>
</tr>
<tr>
<td>Grade 11 Functions and Applications</td>
<td>University/College</td>
<td>MCF3M</td>
</tr>
<tr>
<td>Grade 11 Foundations for College</td>
<td>College</td>
<td>MBF3C</td>
</tr>
<tr>
<td>Grade 11 Mathematics for Work and Everyday Life</td>
<td>Workplace</td>
<td>MEL3E</td>
</tr>
<tr>
<td>Grade 12 Advanced Functions</td>
<td>University</td>
<td>MHF4U</td>
</tr>
<tr>
<td>Grade 12 Calculus and Vectors</td>
<td>University</td>
<td>MCV4U</td>
</tr>
<tr>
<td>Grade 12 Mathematics of Data Management</td>
<td>University</td>
<td>MDM4U</td>
</tr>
<tr>
<td>Other:</td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>
Section 2: Please fill in your response

1. I enjoy learning math.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

2. I believe that math is used in everyday life, in many ways, by many people.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

3. I see a connection between math and my life.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

4. I believe that it is useful for me to learn math.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree
5. I believe that math is valuable
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

6. I enjoy using math in the real-world
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

7. Most of the math problems I have done are related to real-life in the following way.
   (Check all that applies)
   - Analogy to a Real-Life Situation
   - Analysis of Real Data
   - “Hands-on” Representations of Math Concepts
   - Modeling Real Phenomena
   - Discussions of Math in Society
   - Other:
     ______________________________________________________

8. I would like to do math problems that are related to real-life in the following way.
   (Check all that applies)
   - Analogy to a Real-Life Situation
   - Analysis of Real Data
   - “Hands-on” Representations of Math Concepts
   - Modeling Real Phenomena
   - Discussions of Math in Society
   - Other:
     ______________________________________________________
9. Overall, I enjoy learning math in the classroom.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

10. I would like to learn math as an extracurricular activity.
    - Strongly Agree
    - Somewhat Agree
    - Neither Agree nor Disagree
    - Somewhat Disagree
    - Strongly Disagree

Section 3: Please answer the following open-ended questions

1. Give an example of a real-life math problem.

2. If I observed your math class for a day, describe the following:
   a) What I would see you doing
   b) What I would see your teacher doing
   c) What I would see your classmates doing

3. If you were the teacher, how would you organize your math lessons?
APPENDIX I: STUDENT QUESTIONNAIRE 2

Section 1: Please fill in your response

1. I am in Grade
   - 9
   - 10
   - 11
   - 12

2. I am a
   - Male
   - Female

3. I am taking math this semester.
   - Yes
   - No

4. I have taken the following math courses up to present (Check all that applies).

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<td>Grade 9 Mathematics Transfer</td>
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<td>MPM1H</td>
</tr>
<tr>
<td>Grade 10 Principles of Mathematics</td>
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<td>MPM2D</td>
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<tr>
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</tr>
<tr>
<td>Grade 11 Functions</td>
<td>University</td>
<td>MCR3U</td>
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<tr>
<td>Grade 11 Functions and Applications</td>
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</tr>
<tr>
<td>Grade 11 Foundations for College Mathematics</td>
<td>College</td>
<td>MBF3C</td>
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<td>Grade 11 Mathematics for Work and Everyday Life</td>
<td>Workplace</td>
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<tr>
<td>Grade 12 Advanced Functions</td>
<td>University</td>
<td>MHF4U</td>
</tr>
<tr>
<td>Grade 12 Calculus and Vectors</td>
<td>University</td>
<td>MCV4U</td>
</tr>
<tr>
<td>Grade 12 Mathematics of Data Management</td>
<td>University</td>
<td>MDM4U</td>
</tr>
</tbody>
</table>

Other: ________________________________________________
Section 2: Please fill in your response

1. I enjoy learning math.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

2. I believe that math is used in everyday life, in many ways, by many people.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

3. I see a connection between math and my life.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

4. I believe that it is useful for me to learn math.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree
5. I believe that math is valuable
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

6. I enjoy using math in the real-world
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

7. Most of the math problems I have done are related to real-life in the following way.
   (Check all that applies)
   - Analogy to a Real-Life Situation
   - Analysis of Real Data
   - “Hands-on” Representations of Math Concepts
   - Modeling Real Phenomena
   - Discussions of Math in Society
   - Other:
     ____________________________________

8. I would like to do math problems that are related to real-life in the following way.
   (Check all that applies)
   - Analogy to a Real-Life Situation
   - Analysis of Real Data
   - “Hands-on” Representations of Math Concepts
   - Modeling Real Phenomena
   - Discussions of Math in Society
   - Other:
     ____________________________________
9. Overall, I enjoy learning math in the classroom.
   - Strongly Agree
   - Somewhat Agree
   - Neither Agree nor Disagree
   - Somewhat Disagree
   - Strongly Disagree

10. I would like to learn math as an extracurricular activity.
    - Strongly Agree
    - Somewhat Agree
    - Neither Agree nor Disagree
    - Somewhat Disagree
    - Strongly Disagree

Section 3: Please answer the following open-ended questions

1. Give an example of a real-life math problem.

2. Give a detailed example of a math concept that the Social Justice Math sessions helped you understand further.

3. If you were the teacher, how would you bring Social Justice Math into the regular math classroom?
APPENDIX J: STUDENT FOCUS GROUP QUESTIONS

1. Think back to a time before our SoJo Math sessions, what did the phrase “real-world math” mean to you?

2. I would like you to think about the activities that we have done in our SoJo Math sessions. When you hear the term “real-world math”, what do you think about?

3. From the experiences in the SoJo Math session, how have you learned to understand the world using math?

4. Why was it important for you to be involved in SoJo Math?

5. If this club was running beyond these 8 weeks, what other math-related activities would you like to do and participate in?

6. Remember in the lesson that we looked at Food Bank Use vs. Population of Kingston, you guys told me that you prefer to remember rate of change as \( \frac{\text{rise}}{\text{run}} \) rather than \( \frac{y_2-y_1}{x_2-x_1} \) or \( \frac{f(b)-f(a)}{b-a} \) because “letters are just letters”. How have SoJo Math helped you with understanding concepts the way you prefer over memorizing formulas?

7. Looking back at our sessions, we have done scatter plots to see if there is a relationship between prices of food and their healthy ratings, linear relationships in car’s fuel consumption, rate of change in Kingston’s food bank use, and calculated monthly expenses for people in poverty and receiving welfare. What have you learned in the SoJo Math sessions that helped you understand a math concept that you didn’t know before?

8. If you could transfer the things you enjoyed in SoJo Math to your regular math class, what would this new regular math class be like?

9. To close this focus group, I want you to think about your experiences in (a) the regular classroom and (b) the Social Justice Math sessions. Give me one word for each setting that describes your experience and why you chose that word.
APPENDIX K: PRESERVICE TEACHERS INTERVIEW QUESTIONS

1. In one of our meetings, we talked about the issue of students finding math they learn in the classroom being irrelevant to their lives. If you encounter a student in your class who said: “how are we going to use this in real-life?”, how would you respond?

2. How do you think Social Justice Math could help students see math in everyday life?

3. How do you think mathematics helps us understand the world around us?

4. You have helped in designing lessons that involved graphing, interpreting graphs, linear relationships. If you are asked to create a math lesson on non-linear relationships such as quadratic relationships, how would you design your lesson?

5. If the Social Justice Math sessions in this club was running beyond these 8 weeks, what other lesson or activities would you design?

6. As a teacher, how would you convey the value of learning math to your students?

7. Tell me an experience in lesson planning/teaching that is the same between Social Justice Math lessons and regular classroom lessons.

8. Tell me an experience in lesson planning/teaching that is different between Social Justice Math lessons and regular classroom lessons.

9. What was something unique about this experience that you didn’t get from your (Kathy) B.Ed./ (Sandra) Con-Ed/ (Brian) Math-010?

10. How would use this in your future practice?

11. Kathy: In one of our meetings, you told us that you have suggested using our poverty and healthy foods example to another teacher candidate and that TC was reluctant because his/her associate teacher would feel that it “strays away too much from what they are suppose to teach”. So, to you, how do you find the balance of using real-life examples and not straying too far from the curriculum?
**Brian (1):** In one of our meetings, you expressed your belief that in general, Grade 7/8’s are too young to question whether what they learn is relevant to their lives. So, how does this belief influence how you teach mathematics?

**Brian (2):** You have said that it is typical to see the arms length and height example when teaching scatter plots and that it would be more interesting to have the data generated by students (getting students to get up and measure the arms length and height of one another). Why do you think it is more interesting to include such activity into your math classroom?

12. To close this interview, I want you to think about your experience either designing lessons for, observing, or teaching in (a) the formal classroom and (b) the Social Justice Math sessions. Give me one word for each setting that describes your experience.
APPENDIX L: FOOD BANK USE FROM THE 2010 DEPRIVATION INDEX REPORT

The Partners in Mission Food Bank has distributed food hampers in Kingston since 1986. Their busiest year of all time was 1994 (10,572 hampers). The second-place year was 2009, with 10,247 hampers. The year-on-year increase for 2009 was the biggest single year increase since the food bank’s first year.

Food bank usage is largely about paying rent, which is a non-negotiable cost each month. In Kingston, very high rental costs and low vacancy rates cause greater food insecurity, because renters are unable to find relief by moving. As the recent Where’s Home report states, “There are no charities that will pay the rent, but there are food banks.” For low-income people, their only budget mobility is in their food expenditures.

According to an Ontario Association of Food Banks report, almost all of those who use food banks live in rental housing, with 65% in market rental housing and 34% in assisted housing. A third of those who use the food banks are new Canadians and over half have a post-secondary degree.

The Sick and Tired report suggests that social assistance recipients have a household food insecurity rate 15 times higher than the non-poor do. According to our Public Health Unit, in Kingston 11.4% of residents have experienced or worried about food insecurity in the past 12 months.
## APPENDIX M: LESSON PLAN FOR ACTIVITY 1 (POVERTY AND HEALTHY EATING)

**Topic: Lesson 1 - Poverty and Healthy Eating**

### Expectations
- Scatter plots
- Interpreting trends using mathematical understanding (positive, negative, strong, weak)
- Relationship between poverty and health

### Materials
- Worksheet with food pictures for healthiness rating
- Food labels
- Worksheet with food and prices on it
- Chart paper
- Markers
- Health by Income Bar Graph (2010 Deprivation Index, page 8)

### Minds-on

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Time</th>
</tr>
</thead>
</table>
| Students rate healthiness of foods | 1) Students are divided into groups of 3  
2) Students are given worksheets with food pictures.  
3) Students are asked to rate from 1 to 10 (10 being the healthiest) based on their knowledge and their interpretation of food labels | 5 min |

### Action

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Time</th>
</tr>
</thead>
</table>
| Students are calculating the price per serving of various foods | 1) Remaining in groups of 3, students are given worksheets with food and prices  
2) Students calculate the price per serving of the food items on the worksheet  
3) Students will plot their points on a scatter plot with axes Cost per Serving and Student-rated Health Index of the food. Each group will plot on the same set of axes on the chart paper. Each group will be given a different colour of marker to do so. | 15 min |

### Consolidation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Time</th>
</tr>
</thead>
</table>
| Students will explore the trend of the graph and discussion relevant data from Kingston reports. | 1) Students will discuss the trend of the scatter plot and interpret its meaning  
2) Students will be presented with data: Health by Income from the 2010 Deprivation Index (page 8) | 5 min |
APPENDIX N: 2011 A LIVING WAGE FOR KINGSTON

A Living Wage for Kingston

The Kingston Community Roundtable on Poverty Reduction, Living Wage Working Group
APPENDIX O: LESSON PLAN FOR ACTIVITY 2 (DIFFERENT SOURCES OF INCOME AND AFFORDABLE HOUSING)

<table>
<thead>
<tr>
<th>Topic: Lesson 2 – Affordable Housing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expectations</strong></td>
</tr>
<tr>
<td>- Addition, subtraction, positive/negative integers</td>
</tr>
<tr>
<td>- Affordable housing</td>
</tr>
<tr>
<td>- Ontario works, ODB, Minimum wage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minds-on</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be assigned a source of income:</td>
<td>- Worksheet with chart</td>
</tr>
<tr>
<td>1) Students will be assigned into 3 groups</td>
<td>- Kingston Living Wage Report 2011</td>
</tr>
<tr>
<td>2) Each group will be assigned an income source (Ontario Works, Ontario Disability Benefits, and Minimum Wage)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will estimate the monthly cost of expenses such as rent, food, transport, etc on the worksheet they are given</td>
<td>15 min</td>
</tr>
<tr>
<td>In the same groups, student will be given the Kingston Living Wage 2011 Report to look up actual expenses and fill in their chart</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consolidation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher will prompt the following ideas for discussion</td>
<td>9 min</td>
</tr>
<tr>
<td>1) What is the difference between their estimated cost and the actual figures found in the report? (Are their estimations way off?)</td>
<td></td>
</tr>
<tr>
<td>- Introducing the definition of affordable housing: “housing that is within 30% of the income of an individual”, what do students think about the accuracy of this definition?</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX P: LESSON PLAN FOR ACTIVITY 3 (FOOD BANK USE INCREASE)

<table>
<thead>
<tr>
<th>Expectations</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Bar graphs, line graphs</td>
<td>- Page 5 of the 2010 Deprivation Index</td>
</tr>
<tr>
<td>- Use of Food Bank</td>
<td>- Chart paper</td>
</tr>
<tr>
<td>- Data interpretation</td>
<td>- Markers</td>
</tr>
<tr>
<td>- Identifying factors of a social problem</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minds-on</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation of Bar Graph</td>
<td></td>
</tr>
<tr>
<td>3) Teacher will prompt discussion of the following:</td>
<td></td>
</tr>
<tr>
<td>- Do students notice any trends in the use of food bank over the years?</td>
<td></td>
</tr>
<tr>
<td>- Is there a better visual representation of this data?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line graphs:</td>
<td></td>
</tr>
<tr>
<td>3) Students will be randomly assigned into small groups</td>
<td></td>
</tr>
<tr>
<td>4) Each group will be given chart paper and students will graph the data from the bar graph into a line graph</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consolidation</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion:</td>
<td></td>
</tr>
<tr>
<td>1) Teacher will prompt discussion of the following:</td>
<td></td>
</tr>
<tr>
<td>- What other factors have we not taken into account in the interpretation of this data?</td>
<td></td>
</tr>
<tr>
<td>- Brainstorm factors such as the following:</td>
<td></td>
</tr>
<tr>
<td>- Population of Kingston</td>
<td></td>
</tr>
<tr>
<td>- Economic recession</td>
<td></td>
</tr>
<tr>
<td>- Population of immigrants</td>
<td></td>
</tr>
<tr>
<td>- Industrial development</td>
<td></td>
</tr>
<tr>
<td>2) Teacher will let students know that they will be looking into these factors the in the following lesson</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Next Lesson</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Consolidation might be carried into the next lesson due to time constraints</td>
<td></td>
</tr>
<tr>
<td>- For next lesson, students will be given other data on other factors that could have contributed to changes in the use of food bank. Students will graph them on the same set of axes in parallel with the food bank use line</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX Q: LESSON PLAN FOR ACTIVITY 4 (CORRELATING FOOD BANK USE AND POPULATION GROWTH)

<table>
<thead>
<tr>
<th>Topic: Lesson 4 – Food Bank Use vs. Population in Kingston</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expectations</strong></td>
</tr>
<tr>
<td>- Line graph</td>
</tr>
<tr>
<td>- Slopes and rate of change</td>
</tr>
<tr>
<td>- Factors affecting food bank use</td>
</tr>
<tr>
<td>- Slopes worksheet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minds-on</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recap</td>
<td>2 min</td>
</tr>
<tr>
<td>1) Teacher will ask students to recap last lesson</td>
<td></td>
</tr>
<tr>
<td>2) Students will return to the small groups they were working in before</td>
<td></td>
</tr>
<tr>
<td>3) Students will have their chart paper graph returned to their group</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphing population of Kingston</td>
<td>20 min</td>
</tr>
<tr>
<td>1) Students will be given the data on the population of Kingston</td>
<td></td>
</tr>
<tr>
<td>2) Students will graph a line graph in parallel with the line of Food</td>
<td></td>
</tr>
<tr>
<td>Bank Use Increase on the same set of axes</td>
<td></td>
</tr>
<tr>
<td>3) Because the population data is obtained from census that is conducted every 5 years, students will calculate slopes to determine the rate of change of population in each 5 year intervals</td>
<td></td>
</tr>
<tr>
<td>4) Students will then calculate the slopes of the equivalent 5 year intervals to determine the rate of change of use of food bank over the years</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consolidation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion – Is population a factor?</td>
<td>3 min</td>
</tr>
<tr>
<td>1) Are the line graphs changing at a similar rate with one another?</td>
<td></td>
</tr>
<tr>
<td>2) Are the slopes of each 5 year interval similar between food bank use and population?</td>
<td></td>
</tr>
<tr>
<td>3) What other data would you gather to explore other factors that influence the use of food bank?</td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX R: LESSON PLAN FOR ACTIVITY 5 (FUEL CONSUMPTION OF VEHICLES)

<table>
<thead>
<tr>
<th>Topic: Lesson 5 – Fuel Consumption of Vehicles</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expectations</strong></td>
<td>- Lesson 5 resource: fuel consumption of vehicle worksheet</td>
</tr>
<tr>
<td><strong>Minds-on</strong></td>
<td>Stimulate conversation about fuel consumption of vehicles</td>
</tr>
<tr>
<td>e.g.</td>
<td>Why do we need to know about fuel consumption of vehicles?</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>5 min</td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td>Distribute worksheet on Fuel Consumption</td>
</tr>
<tr>
<td>Teacher and students will work collectively in answering the questions on the worksheet</td>
<td><strong>Time</strong></td>
</tr>
<tr>
<td><strong>Consolidation</strong></td>
<td>15 min</td>
</tr>
<tr>
<td>Notice the worksheet contains all hypothetical scenarios.</td>
<td></td>
</tr>
<tr>
<td>Ask students to do the following for homework:</td>
<td></td>
</tr>
<tr>
<td>- Determine their family’s car fuel consumption for both city driving and highway driving</td>
<td></td>
</tr>
<tr>
<td>- The amount of city driving in a year</td>
<td></td>
</tr>
<tr>
<td>- The amount of highway driving in a year</td>
<td></td>
</tr>
<tr>
<td>For Week 8 (January 25), students will bring these results and estimate the amounts of money they can save using the data presented today.</td>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX S: LESSON PLAN FOR ACTIVITY 6 (HAITI - WOMEN'S EDUCATION AND LIFE EXPECTANCY)

**Topic:** Lesson 6 – Haiti - Women’s Education vs Life Expectancy

<table>
<thead>
<tr>
<th>Expectations</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brainstorming (before giving data)</td>
<td></td>
</tr>
<tr>
<td>- Ask students to think about factors that affect life expectancy</td>
<td></td>
</tr>
<tr>
<td>- If students are thinking about this in the Canadian context, prompt students to think about factors that affect life expectancy for people in developing countries</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minds-on</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presenting students with data</td>
<td></td>
</tr>
<tr>
<td>- Ask students to interpret the data</td>
<td></td>
</tr>
<tr>
<td>- Leave it open-ended to see what students come up with</td>
<td></td>
</tr>
<tr>
<td>- Type of graph</td>
<td></td>
</tr>
<tr>
<td>- Choosing appropriate number for interval to graph (every 5 years/10 years etc)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask students to model the data using a function</td>
<td></td>
</tr>
<tr>
<td>- Students will most likely find a linear equation of the line of best fit ((y = mx + b))</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consolidation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>- Is there a limit to life expectancy?</td>
<td></td>
</tr>
<tr>
<td>- Will life expectancy continue to increase linearly with the increase of education opportunities?</td>
<td></td>
</tr>
<tr>
<td>- What would the data look like for Canada? Ontario? Kingston?</td>
<td></td>
</tr>
</tbody>
</table>

Relating to project
- On top of sewing pillowcase dresses for Haiti, what other initiatives can you be involved in?

**Time**
- Minds-on: 2 min
- Action: 13 min
- Consolidation: 10 min
APPENDIX T: HARDCOPY OF MAP DIAGRAM FOR DATA ANALYSIS
APPENDIX U: ACTIVITY 1 – STUDENT HANDOUT

Product Chart

Is Unhealthy Eating Related to Poverty?

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost (price per unit)</th>
<th>Student-rated Health Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraft Dinner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homemade pasta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canned Vegetable Soup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwavable Dinners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken Dinner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ham Sandwich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instant noodles</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td>Egg noodles</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td>Canned fruits</td>
<td></td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>Fresh fruits</td>
<td></td>
</tr>
<tr>
<td><img src="image4.png" alt="Image" /></td>
<td>Juice Cocktail (from concentrate)</td>
<td></td>
</tr>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td>Juice (not from concentrate)</td>
<td></td>
</tr>
<tr>
<td><img src="image6.png" alt="Image" /></td>
<td>Express Rice</td>
<td></td>
</tr>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td>Rice with Tomatoes</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Price</td>
<td>Quantity</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>Kraft Dinner</td>
<td>$0.89/ 200g</td>
<td>2 servings</td>
</tr>
<tr>
<td>Pasta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken breasts</td>
<td>$13.21/kg</td>
<td></td>
</tr>
<tr>
<td>tomatoes</td>
<td>$2.18/kg</td>
<td></td>
</tr>
<tr>
<td>Asparagus</td>
<td>$6.59/kg</td>
<td></td>
</tr>
<tr>
<td>Pasta</td>
<td>$1.99/900g</td>
<td></td>
</tr>
<tr>
<td>Sweet yellow peppers</td>
<td>$2.99/454g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 servings</td>
</tr>
<tr>
<td>Canned Vegetable Soup</td>
<td>$0.59/ 284 mL</td>
<td>2 servings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$3.99/455g</td>
<td>1 serving</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken thighs</td>
<td>$15.19/kg</td>
<td></td>
</tr>
<tr>
<td>Celery</td>
<td>$1.99/lb</td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>$2.99/lb</td>
<td></td>
</tr>
<tr>
<td>Beans</td>
<td>$2.99/lb</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 servings</td>
</tr>
<tr>
<td>Bread</td>
<td>$2.99/loaf</td>
<td></td>
</tr>
<tr>
<td>Ham</td>
<td>$4.99/125g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 servings</td>
</tr>
<tr>
<td></td>
<td>$1.19/120g</td>
<td>1 serving</td>
</tr>
<tr>
<td>Egg noodles</td>
<td>$3.99/500g</td>
<td></td>
</tr>
<tr>
<td>Ground beef</td>
<td>$6.59/kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 servings</td>
</tr>
<tr>
<td>Item</td>
<td>Unit Price</td>
<td>Servings</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Dole Pineapple</td>
<td>$2.99/170g</td>
<td>5</td>
</tr>
<tr>
<td>Raspberries</td>
<td>$2.99/170g</td>
<td>5</td>
</tr>
<tr>
<td>Apples</td>
<td>$3.49/41lb</td>
<td>15</td>
</tr>
<tr>
<td>Grapes</td>
<td>$2.99/454g</td>
<td>15</td>
</tr>
<tr>
<td>Strawberries</td>
<td>$2.99/lb</td>
<td>15</td>
</tr>
<tr>
<td>Bananas</td>
<td>$1.74/kg</td>
<td>15</td>
</tr>
<tr>
<td>Juice from concentrate</td>
<td>$1.49/2L</td>
<td>8</td>
</tr>
<tr>
<td>Juice not from concentrate</td>
<td>$3.49/1.75L</td>
<td>7</td>
</tr>
<tr>
<td>Express Rice</td>
<td>$2.79/250g</td>
<td>2</td>
</tr>
<tr>
<td>Rice with tomatoes</td>
<td>Rice: $6.48/2kg</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Tomatoes: $3.73/kg</td>
<td>5</td>
</tr>
</tbody>
</table>
## APPENDIX V: ARTIFACTS FROM SJM ACTIVITIES

Figure V1

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost (price per unit)</th>
<th>Student-rated Health Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraft Dinner</td>
<td>0.445</td>
<td>3/10</td>
</tr>
<tr>
<td>Homemade pasta</td>
<td>2.25</td>
<td>9/10</td>
</tr>
<tr>
<td>Canned Vegetable Soup</td>
<td>0.295</td>
<td>5/10</td>
</tr>
<tr>
<td>Microwave Dinners</td>
<td>3.49</td>
<td>2/10</td>
</tr>
<tr>
<td>Chicken Dinner</td>
<td>5.25</td>
<td>8/10</td>
</tr>
<tr>
<td>Ham Sandwich</td>
<td>1.33</td>
<td>6/10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>Health Index</th>
<th>Cost (price per unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg noodles</td>
<td>1.32</td>
<td>10</td>
</tr>
<tr>
<td>Canned fruits</td>
<td>0.46</td>
<td>7</td>
</tr>
<tr>
<td>Fresh fruits</td>
<td>1.15</td>
<td>10</td>
</tr>
<tr>
<td>Juice Cocktail (from concentrate)</td>
<td>0.18</td>
<td>3</td>
</tr>
<tr>
<td>Juice (from concentrate)</td>
<td>0.49</td>
<td>8</td>
</tr>
<tr>
<td>Express Rice</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Rice with Tomatoes</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>
Figure V2
Figure V4

Table: How Lower Fuel Consumption Translates into Savings

<table>
<thead>
<tr>
<th>4 L/100km</th>
<th>6 L/100km</th>
<th>8 L/100km</th>
<th>10 L/100km</th>
<th>14 L/100km</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000</td>
<td>$1,200</td>
<td>$1,300</td>
<td>$1,400</td>
<td>$1,500</td>
</tr>
</tbody>
</table>

1) Is fuel consumption and savings in a linear relation?

2) Predict the savings per year if you drive a vehicle with the following Fuel Consumption Label.

3) Calculate fuel consumption and savings in a linear relation.

4) Annual fuel costs on some typical vehicles based on 16,000 km per year at $1.20/litre.

5) Cost estimate for different fuel consumption rates.

6) Savings and fuel consumption for different vehicles at varying distances.
Figure V6

```
X^2
X | Y
---|---
1 | 1
2 | 4
3 | 9
4 | 16
5 | 25
```

This was when I asked the students what the differences would look like in a quadratic function.
The table below shows the data on the mean years in school for women in Haiti and the average life expectancy of the general population in Haiti.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean years in school for women at age 15-44</th>
<th>Life expectancy (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>0.9</td>
<td>47.203</td>
</tr>
<tr>
<td>1971</td>
<td>1</td>
<td>47.963</td>
</tr>
<tr>
<td>1972</td>
<td>1</td>
<td>48.923</td>
</tr>
<tr>
<td>1973</td>
<td>1.1</td>
<td>49.281</td>
</tr>
<tr>
<td>1974</td>
<td>1.2</td>
<td>49.665</td>
</tr>
<tr>
<td>1975</td>
<td>1.3</td>
<td>50.020</td>
</tr>
<tr>
<td>1976</td>
<td>1.4</td>
<td>50.339</td>
</tr>
<tr>
<td>1977</td>
<td>1.5</td>
<td>50.507</td>
</tr>
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<td>1978</td>
<td>1.6</td>
<td>50.606</td>
</tr>
<tr>
<td>1979</td>
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<td>50.909</td>
</tr>
<tr>
<td>1980</td>
<td>1.8</td>
<td>51.254</td>
</tr>
<tr>
<td>1981</td>
<td>1.9</td>
<td>51.614</td>
</tr>
<tr>
<td>1982</td>
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<td>52.813</td>
</tr>
<tr>
<td>1983</td>
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<td>54.445</td>
</tr>
<tr>
<td>1984</td>
<td>2.2</td>
<td>54.994</td>
</tr>
<tr>
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<td>56.626</td>
</tr>
<tr>
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<td>2.4</td>
<td>53.42</td>
</tr>
<tr>
<td>1987</td>
<td>2.5</td>
<td>53.928</td>
</tr>
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<td>54.502</td>
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</tr>
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<td>56.506</td>
</tr>
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<td>57.599</td>
</tr>
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<td>3.5</td>
<td>58.834</td>
</tr>
<tr>
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<td>3.6</td>
<td>59.312</td>
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</tr>
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<td>59.912</td>
</tr>
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<td>60.414</td>
</tr>
<tr>
<td>2006</td>
<td>5.2</td>
<td>60.721</td>
</tr>
<tr>
<td>2007</td>
<td>5.3</td>
<td>61.009</td>
</tr>
<tr>
<td>2008</td>
<td>5.5</td>
<td>61.202</td>
</tr>
<tr>
<td>2009</td>
<td>5.7</td>
<td>61.483</td>
</tr>
</tbody>
</table>

Source: Gap Minder (www.gapminder.org/data)
APPENDIX W: ACTIVITY 2 – STUDENT HANDOUT

According to Do the Math Kingston (Source: dothemathkingston.com), the following is information on monthly income of an individual:

<table>
<thead>
<tr>
<th>Monthly Income</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly income for a single person on Ontario Works</td>
<td>$585</td>
</tr>
<tr>
<td>Monthly income for a single person on Ontario Disability Benefits</td>
<td>$1,042</td>
</tr>
<tr>
<td>Monthly before-tax income for a person earning minimum wage (35 hrs/week)</td>
<td>$1,555</td>
</tr>
</tbody>
</table>


Complete the chart below:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car Payment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto Insurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas for car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toiletries and Supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entertainment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Expense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount Remaining at the end of the month</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table adapted from Bateiha (2010)
APPENDIX X: ACTIVITY 4 – STUDENT HANDOUT


<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>122 350</td>
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<tr>
<td>1991</td>
<td>136 401</td>
</tr>
<tr>
<td>1996</td>
<td>143 416</td>
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<tr>
<td>2001</td>
<td>146 838</td>
</tr>
<tr>
<td>2006</td>
<td>152 358</td>
</tr>
</tbody>
</table>
APPENDIX Y: ACTIVITY 5 – STUDENT HANDOUT

1) Is fuel consumption and savings in a linear relation?

2) Predict the savings per year if you drive a vehicle with the following Fuel Consumption Label.

The table provided below shows the data on the mean years in school for women in Haiti and the average life expectancy of the general population in Haiti.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean years in school for women at age 15-44</th>
<th>Life expectancy (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>0.9</td>
<td>47.203</td>
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<tr>
<td>1971</td>
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<td>47.563</td>
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<td>1972</td>
<td>1</td>
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<td>50.929</td>
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<tr>
<td>2007</td>
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<td>61.009</td>
</tr>
<tr>
<td>2008</td>
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<td>61.262</td>
</tr>
<tr>
<td>2009</td>
<td>5.7</td>
<td>61.483</td>
</tr>
</tbody>
</table>

Source: Gap Minder (www.gapminder.org/data)