

How and Why Teachers use Real World Connections in the Secondary Mathematics Classroom

by

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Abstract

Real world connections are considered to be an important aspect of a mathematics classroom. There is an abundance of literature that expresses how beneficial real world connections are for students. However, there is little literature that looks at a teacher's point of view: what is a real world connection and how are teachers using these in their secondary mathematics classrooms? This study focuses on the teacher perspective of real world connections by surveying and subsequently interviewing participants within one school district. It can be concluded that there is still no global definition for real world connection, but there are trends that show teachers make connections in order to motivate students, increase their interest, and build skills that can be transferred into the real world, such as collaboration, independence, and communication.

Keywords: real world connection; curriculum; motivation for real world connections; context; teacher perception of real world connections

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List of Acronyms

AP	Advanced Placement
NCTM	National Council of Teachers of Mathematics
SFU	Simon Fraser University

Chapter 1. Introduction

So often, it is stressed how important connecting mathematics to the real world is. There is an abundance of research as to how these connections affect students, and how students perceive these connections. Students who experience meaningful real world connections are better able to apply their mathematics knowledge and skills, and can adapt to new situations (Boaler, 1998). Additionally, the British Columbia Ministry of Education documents state that real world connections are necessary in order to build numeracy in our students (2008).

While going through my teacher education, and as a student teacher, I was shocked at how much emphasis was placed in the textbooks and Ministry of Education documents on the importance of real world connections. When observing other teachers' practices and trying to investigate what a real world connection was, there did not seem to be a common interpretation. Every teacher seemed to have a different teaching practice and a unique way of bringing the curriculum to life in their classes. Every teacher also had their own interpretation of how to bring real world connections into their classes. Some teachers were trying to incorporate projects to give the topic at hand more of a real world feel, while others seemed content on using word problems to make connections to the real world. Now, with my own classes to mould, I am challenged as to how to incorporate these connections into my classroom. I find myself trying to give examples as to where a mathematical skill or topic would come up in a student's life, or trying to find a meaningful project for students to work on that would show them how the mathematics they are learning is applicable.

As a newer (first five years) teacher, I am interested in how other teachers approach real world connections. In particular, I am interested in exploring if current secondary mathematics teachers are making these real world connections. Are teachers making an effort to include connections in their courses, how are they making

these connections, and why do they choose to make the connections they do? Teachers have their own perspectives influenced by a variety of factors, such as the student population they are working with, their own experience as students, as well as their experience as a teacher, among others. I would like to uncover these perspectives.

This research project focuses on teacher interpretations and perceptions of real world connections. In Chapter 2, I review literature that discusses existing definitions of real world connection, why we need to be making real world connections, and what makes real world connections beneficial for students. I also consider what previous studies show as the reasons for how and why teachers use real world connections. In Chapter 3, I explain the methodology I used to address the research; this includes a description of the interview participants, data collection, and analysis. Throughout Chapters 4 and 5 I present and analyse the results of my research, including interview cases as well as a cross-case analysis. These chapters first describe each interview, and then offer similarities and differences across the teacher perspectives. Finally, in Chapter 6 I address the research question, conclusions, and future considerations.

Chapter 2. Related Literature

In this chapter, I begin with exploring what current literature suggests as being a real world connection. I then review recent literature on why teachers should make real world connections and how students benefit when this is done. Finally, I review literature concerning teachers and real world connections, including how teachers are making real world connections, a discussion around teachers' concerns with word problems, what they are doing to make real world connections, and why they make real world connections.

2.1. What is a Real World Connection?

2.1.1. Definition of Real World Connection

There is no formal or professionally established definition among secondary mathematics teachers of what a “real world connection” is. Mathematics education literature characterizes many things as being a real world connection. Simple analogies, analysis of real data, discussion of mathematics in society, hands-on representation of mathematics concepts, mathematical modeling of real phenomena, and even the classic word problem can be considered to be real world connections (Gainsburg, 2008). For some teachers, connections in general refer to a real world connection (Businskas, 2008). These are something students encounter outside of the classroom that they can relate to, such as relating combinatorics to the lottery. These real world contexts are often starting points to develop abstract thinking (Povey, 2013). For example, by providing a concrete geometrical example, such as the net of a box and then the actual box, this helps students visualize various sizes and examples of three-dimensional shapes (Povey, 2013). Povey (2013) further suggests this can be a jumping off point to investigating possible questions, such as: what kind of chocolates would fit in this box? What shape are they? Size? How many? We can see there are many interpretations

that describe real world connections as a connection outside of the classroom through various media.

Alternatively to seeing a real world connection as being a link to real life or the outside world, some see a real world connection as a way of learning or a way of doing math. Realistic Mathematics Education in the Netherlands has placed an emphasis on offering students situations that they can imagine and make real in their mind (van den Heuvel-Panhuizen, 2000). This may not be a direct application to the real world, but rather a puzzle, story, or fictitious situation that the students can imagine are real (Dickenson & Hough, 2012). Boaler (1993) extends this idea and suggests that it is not the problem to which the mathematics is applied, but rather the environment in which it takes place, which “determines the selection of mathematical procedures” (p. 12). Another argument is that we are teaching students skills they can apply to their real life through teaching them mathematical topics (Businskas, 2008). As shown briefly, the interpretations of what is a “real world connection” are various and numerous. There are many interpretations of real world connections, varying as greatly as using ‘real world connection’ as a verb or as a noun: a connection being something we do versus a connection being something we have. As Gainsburg (2008) points out, this lack of a recognized definition of what constitutes a “real world connection” makes investigating and researching how these connections are brought into mathematics classroom complicated.

2.1.2. Real World Skills

From the literature, there are two broad types of skills within real world connections that I can see emerging. I have synthesized the above range of real world connection definitions to provide descriptions of these two types of skills. The first of these skills is mathematical in nature. Gainsburg’s (2008) listed a variety of methods of making real world connections. Teachers expected students to be able to analyze real data, model real world phenomena, and use a variety of methods to represent mathematics concepts. Some teachers also expected students to be able to discuss mathematics in society (Gainsburg, 2008). Povey (2013) suggested that students be able to carry out measurements, such as in a surface area problem. In addition, the

British Columbia Ministry of Education includes measurement, estimation, and reasoning within their learning outcomes for secondary mathematics courses (British Columbia Ministry of Education, 2008). For the purposes of analyzing the cases, I consider these “mathematics-based connections” or “mathematics-based skills”. These are skills that require students to use specifically mathematical knowledge, such as measurement, estimation, or a calculation.

The second broad type of skills emerging out of the literature concerns more generic skills. Boaler (1993) suggested that the environment can help students determine their mathematical procedures, which might include students working in groups, collaborating with one another, and building their communication skills. Businskas (2008) suggests that we are teaching students skills that they can apply to real life through teaching them mathematics, such as independence or self-awareness. These skills may include communication, group work, or independence. To further enforce the importance of building these skills in students, The British Columbia Ministry of Education includes communication, problem solving, making connections, and reasoning within their processes that they believe are part of developing a well-rounded student (British Columbia Ministry of Education, 2008). These skills can be called “process-based skills” or “soft skills”. For the purpose of consistency, I refer to these as “process-based skills” for the remainder of this thesis.

2.2. The Reason for Connections

Connections between mathematics and the real world are important for student learning of mathematics. In British Columbia, it is required that students complete mathematics courses up to and including grade 11. Given that not all students go to post-secondary, this must mean that there is an expectation that taking mathematics up to grade 11 will, in some way, contribute to their life. The British Columbia school system values mathematics in preparing students for life after graduation, and part of this preparation includes students making connections to the world around them. The curriculum documents also state that Number Sense is the most important foundation of numeracy, and that “number sense develops when students connect numbers to real-life experiences” (British Columbia Ministry of Education, 2007, p 13). Goals of the

curriculum include using mathematics to better understand the world around us and make connections between mathematics and its applications (British Columbia Ministry of Education, 2007). Teachers are instructed in the higher grades (10-12) to use, wherever possible, meaningful contexts for examples, problems, and projects (British Columbia Ministry of Education, 2008). Connections in mathematics to the real world are clearly important in our British Columbia curriculum. The British Columbia Association of Mathematics Teachers (1998) are quoted in the curriculum documents that “Numeracy can be defined as the combination of mathematical knowledge, problem solving, and communication skills required by all persons to function successfully within our technological world. Numeracy is more than knowing about numbers and number operations” (as cited in British Columbia Ministry of Education, 2008). Although the importance is stressed in the Ministry documents, teachers may not be placing sufficient importance on making these real world connections in their classrooms.

The British Columbia Ministry of Education is not the only source saying that real world connections are beneficial for student learning. The National Council of Teachers of Mathematics (NCTM) has stated in their standards that students should be able to confidently use their mathematics skills to explain applications in the outside world and to analyze situations that arise in the real world (National Council of Teachers of Mathematics, 2014). In Businskas’ (2008) study, teachers found real world connections to be identifiable as being important amongst the other types of connections teachers make. Teachers found that real world connections give students motivation and a sense of purpose.

2.3. How Students Benefit

Students benefit from being exposed to real world connections in different ways. Through the Realistic Mathematics Education movement in the Netherlands, students are employing strategies that are making sense to them, rather than simply manipulating numbers (Dickenson & Hough, 2012). As students progress through school, they find that “math and real math become disconnected and mathematics is no longer a tool” (Martin, 2007, p. 30). The likelihood of students being able to transfer their mathematics skills outside the classroom is increased if school mathematics is learned in real life

contexts and “the connections between mathematics in school and real life are made explicit” (Boaler, 1993, p. 12). By working with real world problems, we can necessitate certain skills, notation, or learning, rather than hypothesizing that someone else might need to know it later on (Stocker, 2005). Boaler (1998) found that students in a project-based learning environment were able to transfer their mathematics skills to new situations. These students were able to see mathematics as flexible and were able to adapt and change to new environments. Conversely, students from a school with traditional learning environment, with rote learning and teacher-centered classrooms, felt they were unable to translate their mathematics skills into real life situations (Boaler, 1998). Students’ views of mathematics can be improved and affected by the real world connections that they learn with, and the environments they learn in.

Connections in themselves are not enough to be beneficial for students, but rather that these connections must be made effectively. For example, social issues that are relevant to all students, or will be someday, are one way to find problems that are real world for our students (Stocker, 2005). Karakoc and Alacaci (2015) found that when real world connections are made, students have an increased motivation and interest in mathematics, as well as increased attitudes towards mathematics. In addition, students’ conceptual learning, ability to generalize, and their mathematics skills such as reasoning or problem solving improved (Karakoc & Alacaci, 2015). However, students often find that connecting mathematics with real-life is done poorly, and they simply end up crunching the numbers (Baki et al, 2009). Students need teachers to be effective at making real world connections in order to benefit.

The question becomes, how can we make these connections in a meaningful way for students? In order for real world mathematics to be effective, it must carry meaning for the learner (Povey, 2013). What are teachers doing to accomplish this? For example, teachers can have students use dynamic software, where they can see what is happening, in order to better understand a mathematical concept. An object following a parabolic arch in a textbook would be static and not have much meaning to students. However, if they can see the object moving and can therefore better visualize the result, this may have more meaning to them and thus create a connection to their world (Drier, Dawson, & Garofalo, 1999). Students being able to plan, hypothesize, and make their

own decisions through investigation will positively affect their enjoyment and understanding of mathematics (Boaler, 1998). For students, context is also extremely important, and students benefit when they make connections between mathematics and real life, professional life, and beyond (Baki et al, 2009). Students can understand their world by using mathematics. Doing so encourages them to think (Stocker, 2005). We should not be choosing situations in the real world for the sole reason of being able to say we made a real world connection, or that we made the mathematics more interesting. Rather, we should be looking to the real world connections to understand the world around us through mathematics.

The good intentions of teachers to make connections to the real world do not always result in benefiting students. For example, this attempt we make to strive to have textbook questions be more motivating and interesting by relating them to students' lives ignores the complexities of student backgrounds and the degree of their experiences, as well as underestimating the importance of the relationship between a student's previous experience, their mathematical goals, and their beliefs (Boaler, 1993). Lubienski (2000) found that students who come from higher socio-economic backgrounds were better able to benefit from real world connections, as they were able to generalize and relate to the problems, while students from lower socio-economic backgrounds "focused on real world constraints" (p. 476) and had trouble focusing on the mathematics. Students may have weak mathematical backgrounds that are not accounted for in these problems, or insufficient understanding of the mathematics the question is addressing (Businkas, 2008). As we can see, despite teachers' good intentions of incorporating real world connections into their classrooms, doing so can bring up further issues for teachers.

2.4. Teachers using Real World Connections

2.4.1. Are Teachers Making Connections?

Even given the requirement by curriculum documents to make real world connections, and the vast amount of research showing students benefit when this is done well, many teachers do not make these connections. In a study in the United States, most teachers made no attempt to connect content to students' lives (Gainsburg, 2008). In Karakoc and

Alacaci's study (2015), teachers thought that real world connections may not be suitable for all mathematics courses or topics, and that these connections could actually hinder students' understanding of abstract topics. Moreover, Ellis (2001) found that students forgot how to use reasoning and prior knowledge as a problem solving method after taking an algebra course (as cited in Martin, 2007). Without any real world connections being made in this course, these students saw that the only way to solve a problem was to set up equations and use variables.

The curriculum teachers are given to work with can also be a hindrance to a teacher's ability to make real world connections. Based on Gainsburg's (2008) research, it is possible that teachers are viewing their job to be simply teaching the content, and that real world connections simply enhance understanding or motivation. Some teachers find that real world connections can be too time consuming and hinder their ability to cover the curriculum (Karakoc & Alacaci, 2015). Teachers may find they have no time to make connections, and find that teaching real world connections does not lend itself to high-stakes testing (Bryan, 2005). Simply teaching to this high-stakes testing by reverting to traditional methods is tempting, but often students who are at risk will remain at risk in this environment, rather than being engaged in meaningful mathematics (Martin, 2007). However, there may be other reasons for teachers' lack of real world connections. Teachers may not understand how to best accomplish real world connections.

Teachers may be avoiding real world connections due to a lack of training and resources. During Gainsburg's (2008) study, she had an overwhelming percentage of teachers citing that in order to make more real world connections; they "would need more resources, ideas, or training about what connections to make or how to make them" (Gainsburg, 2008, p. 209). Some teachers have the idea that they do not have the flexibility to stray from the curriculum, as doing explorations would take too much time and research to find how to make these connections (Bryan, 2005). The Realistic Mathematics Education group in the Netherlands found that changing perceptions of teachers was imperative before being able to provide them with the necessary training to change their teaching approach for the Realistic Mathematics Education movement (Karakoc & Alacaci, 2015). It is unclear whether teachers' lack of

knowledge/training/resources is the biggest reason for their brief encounters with real world connections, or if it is their belief that these connections are of little interest to students (Gainsburg, 2008). Regardless, teachers need training in the area of real world connections, and prospective teachers should be given this opportunity before entering the workforce (Karakoc & Alacaci, 2015). Teachers seem to avoid making real world connections, whether due to lack of training or otherwise.

2.4.2. The Issue with Word Problems

In a study by Gainsburg (2008), many teachers responded that word problems were an acceptable form of making a real world connection. In fact, some responded that this was their only method of making real world connections. These can be called 'pizza party' problems, which are often contrived, and there are other real world connections that could be more worthwhile doing (Stocker, 2005). In fact, it has been argued that focusing on textbook questions develops procedural knowledge and cannot be transferred outside of the classroom (Boaler, 1998). However, Gerofsky (2010) says that "mathematical word problems are the only way available to establish mathematical generality" (p. 62) and that teachers will tend to use numerous examples in story form. She says there is a problem with the word problems that are provided to teachers, and that they need to be re-designed to introduce ambiguity and to lend more truth to the 'real-life situations' they mimic (Gerofsky, 2010). Gerofsky (2006) argues that the references we make in word problems are constructed realities, that only seem to refer back to other word problems, and that these word problems cannot be considered to be transparent simulations of real world situations.

Word problems are often found in mathematics textbooks, which are sometimes the only resources provided to teachers. The textbooks that are provided to British Columbia public schools are written for the provincial curriculum. These textbooks typically contain an attempt to make a general connection between mathematics and the real world at the beginning of each chapter (McAskill, Watt, Balzarini, Johnson, Kennedy, Melnyk, & Zarski, 2012). Following this introduction, the chapter is broken down into sections which each contain worked out examples. At the end of each section are 3 types of practice problems: rote calculation questions of the same type as the

examples given, called 'practice'; 'apply' questions which are typically word problems; and 'extend' questions, which typically attempt to have students think past what has just been explicitly taught and require students to apply knowledge outside of the current section's topic (McAskill et al., 2012). The real world connections found in these textbooks are the general connections at the beginning of each chapter and, as Gainsburg (2008) suggested, the word problems that fall within the 'apply' portion of the practice problems provided.

Many other researchers have also found issues with word problems. Greer (1997) claims that word problems have the potential of being a useful connection to the real world, but to provide connections between the real world and mathematics, they are often unrealistic and always solvable problems (as cited in Gainsburg, 2008). Because we are pretending these things are realistic when they are not, it can create confusion for students (Povey, 2013). Students are often asked to engage in 'real tasks' yet are asked to ignore factors that would be present if the task was being used in 'real life' (Boaler, 1993). These word problems are an attempt at being real world connections, but many argue that they are a stretch at best.

In her research, Gainsburg (2008) concluded that teachers found their textbooks and curricula were insufficient in providing real world connections for students, as these often only contained word problems as an option for real world connections. Students may have difficulty interpreting the textbook word problems or deciphering what it is the textbook is asking for (Businskas, 2008). Teachers are lacking training in this area, which can affect their preparation and comfort level with making connections, and which students can sense (Karakoc & Alacaci, 2015). The question becomes: where do teachers go to get these resources and the necessary training? Gainsburg (2008) found this to be an issue for teachers, with them citing a lack of available resources and training.

2.4.3. What Else are Teachers Doing?

How are teachers making real world connections, if not via a word problem? What is it that they are doing? In her study, Gainsburg (2008) found that although teachers

responded in favour of word problems, they also had other ways of exposing students to real world connections. Teachers may refer to a real life situation or use during an example, have students generate real data, or show students real artefacts or information using the topic of interest (Gainsburg, 2008). However, these do not seem to be in depth connections. Technology is one avenue teachers use to make real world connections. Technology allows teachers to more easily relate mathematics to the real world, as they can include 'messy' data, and not always be using the artificial, 'nice' numbers provided in a textbook word problem (Drier, Sawson, & Garofalo, 1999). One example is to use video analysis to predict trajectories with quadratics, rather than doing a word problem from the textbook (Bryan, 2005). Video analysis programs are inexpensive, interactive, and remove the barriers that teachers often encounter when trying to include real world problems into their mathematics classrooms.

2.4.4. Teachers' Motivation for Connections

Why do teachers make real world connections? Most teachers in a study by Gainsburg (2008) cited the purpose for making connections to be to motivate students, to grab their interest, or to make a mathematics concept easier for students to understand. Participants in Karakoc and Alacaci's study (2015) echoed this opinion, stating that they not only thought real world connections could increase motivation, but could also build their problem solving abilities and conceptual understanding. The idea is that by relating mathematics to students' lives, you can curb the question of "When are we going to need to know this?" (Martin, 2007). However, often the tasks presented to students may be real world connections, but they are a lot more real life to the teachers than to the students. For example, asking students to balance a budget. This task is a process that takes place in the real world, but to a student, this is something they do not consider relevant to their own life (Boaler, 1993). However, many teachers said that when they do connect to the real world, it is often done to teach procedures (Gainsburg, 2008). Boaler (1993) emphasises that in order to make the mathematics relevant, if that is our goal, we need to be making connections to students' lives, to something students perceive they will use outside of our classrooms.

2.5. Research Questions

While we have ample data that suggest students benefit from real world connections, it seems often these connections are more real for the teachers than the students. Although teachers are aware of these benefits, simply put, they need better resources, time, and training to make more connections (Gainsburg, 2008). Most teachers in Gainsburg's (2008) study cited that they do not have enough resources or training on how to better use real world connections in their courses, and that they don't have enough time to be able to incorporate real world connections into their teaching, that it takes more time than they feel they have. There is a need for professional development to train teachers how to use real world connections in order to build mastery of a topic, and it is rarely included in teacher training/education (Gainsburg, 2008). These conclusions are based on limited studies as to how teachers interpret real world connections, and more research is needed. As such, my research questions are:

1. *What do teachers view as being a real world connection?*
2. *How and why do teachers make use of real world connections in secondary mathematics classrooms?*

Chapter 3. Methodology

In order to explore teachers' use and views of real world connections, the research questions are pursued through case studies, where teachers draw attention to how they interpret and execute real world connections. In this section, the setting, survey, interviews, participants, data collection, and analysis are detailed. Following the review of relevant literature, for the purposes of this study, real world connection means connecting to something students will, or could, encounter outside of their current mathematics classroom. This may not necessarily be a mathematical encounter, but rather anything that students could experience or make use of.

3.1. Setting

The research setting was the Lakeview¹ School District, in South Western British Columbia. The data were collected in the spring of 2015, towards the end of the 2014-2015 school year. The School Board and Director of Instruction gave approval to conduct the survey and interviews, conditional upon the approval of the SFU Office of Research Ethics. The SFU Office of Research Ethics gave approval to conduct the research as reported here.

3.2. Participants

The participants of this project were selected using convenience sampling. Participants invited to participate in the survey portion of the research were current secondary mathematics teachers with contracts within the Lakeview School District. Names of teachers and their email addresses were obtained from school Department Heads or

¹ Pseudonym

Administrators. Emails were sent out inviting each teacher to participate, with a link to the survey and an attachment of the consent form and ethics information. Teachers had four to six weeks to respond to the survey. Within the survey, teachers had an opportunity to provide their name if they wished to be considered for an interview.

After sending out surveys to 60 secondary mathematics teachers working at a secondary school in the Lakeview School District, I received 19 responses. Respondents could choose to identify the school at which they teach, and provide contact information if they were willing to be contacted for an interview. Eighteen of the 19 surveys indicated their school, and seven provided contact information for the interview. Of the 19 participants for the survey, teachers were currently teaching a variety of courses from Mathematics 8² up to Pre-Calculus 12³, and some reported teaching AP Calculus⁴ and AP Statistics⁵. Ten of the survey participants chose to remain anonymous, so the ratio of male to female respondents is not being reported.

3.3. The Survey

The survey was administered online using SFU's online survey instruments. The survey was designed so as to find interview participants that had varying teaching experiences and varying views on real world connections. Participants of the survey were given the opportunity to state whether they would be willing to participate in a subsequent interview or not. Resultant survey questions appear below and in Appendix B in the format received by the participants:

School: _____

Best way to contact you (optional): _____

² Mathematics 8 is a required academic class by students. There is one mathematics class that all grade 8 students take.

³ Pre-Calculus 12 is one of three possible mathematics 12 courses students may choose to take. It is preparing students for university Calculus and is rigorous in nature.

⁴ AP Calculus is an optional Advanced Placement course. Students learn university Calculus and may write an exam at the end of the course, which may result in university credit for Calculus.

⁵ AP Statistics is an optional Advanced Placement course. Students learn university Statistics and may write an exam at the end of the course, which may result in university credit for Statistics.

Should you be selected for an interview, would you be willing to participate? (Please clearly write YES or NO): _____

What grades/courses do you currently teach?

What other grades/courses (if any) have you taught in the past 3 years?

1. For each statement below, please select one of the following answers: Strongly Agree, Agree, Disagree, Strongly Disagree, N/A
 - a. Connecting math to the real world is extremely important in Math 8.
 - b. Connecting math to the real world is extremely important in Math 9.
 - c. Connecting math to the real world is extremely important in Apprenticeship & Workplace 10.
 - d. Connecting math to the real world is extremely important in Foundations and Pre-Calculus 10.
 - e. Connecting math to the real world is extremely important in Apprenticeship & Workplace 11.
 - f. Connecting math to the real world is extremely important in Foundations 11.
 - g. Connecting math to the real world is extremely important in Pre-Calculus 11.
 - h. Connecting math to the real world is extremely important in Foundations 12.
 - i. Connecting math to the real world is extremely important in Pre-Calculus 12.
2. Please check each method you use to connect math to the real world:
 - Telling stories
 - Assigning tasks to be completed outside of the classroom (for example, at home)
 - Relating math to careers or jobs
 - Assigning real world problems
 - Relating math to student interests or lives
 - Assigning students hands-on activities or projects that replicate a real scenarios (for example, design and build a cereal box with certain Surface Area or Volume)
 - Bringing artefacts into the classroom (for example physical products or real data)
 - Relating math to a historical event, person, or discovery
3. Please select the 3 methods you use most often to connect math to the real world. Number them 1-3, 1 being the most often.
 - Telling stories
 - Assigning tasks to be completed outside of the classroom (for example, at home)
 - Relating math to careers or jobs
 - Assigning real world problems
 - Relating math to student interests or lives
 - Assigning students hands-on activities or projects that replicate a real scenarios (for example, design and build a cereal box with certain Surface Area or Volume)
 - Bringing artefacts into the classroom (for example physical products or real data)
 - Relating math to a historical event, person, or discovery

4. Do you assign tasks to your students where the *process* is a connection to the real world? For example, you may ask students to collaborate with one another, which is something they will inevitably be asked to do outside of a school setting, in the real world. Can you think of other tasks where the *process* is the connection to the real world?

Seventeen of the 19 respondents answered the open-ended survey question, describing tasks where students made non-mathematical connections to the real world. At the conclusion of the survey, there was an opportunity for teachers to include anything they feel I may have missed with the questions, or any comments they wished to add. Six of the 19 respondents chose to leave additional comments.

3.4. Interviews

From the 19 participants who responded to the survey, seven consented to be interviewed. As this was a small sample of teachers willing to participate, I decided to interview all of them. There were three male and four female teachers who were interviewed. All are currently practicing secondary mathematics teachers within the Lakeview School District, with a range of three to 25 years of experience. Teachers were contacted individually to set up an interview. Interviews took place in person over a four-week period, beginning two weeks after the surveys had concluded. Each interview took between 20 and 60 minutes, and was audio-recorded.

Profiles of each interview participant are given in the table below. All names are pseudonyms to maintain teacher anonymity.

Table 1. Participant Profiles

Participant	Years teaching	Current courses taught	Recent courses taught	School environment
Chad, male	7	Mathematics 8, Mathematics 9, Apprenticeship & Workplace 10, Apprenticeship & Workplace 11, Science 9	Foundations & Pre-Calculus 10, Foundations 11, Foundations 12	Smaller school with many refugees, English Language Learners, and single parent families. Many students not motivated to perform in academic subjects.

Participant	Years teaching	Current courses taught	Recent courses taught	School environment
Duncan, male	15	Mathematics 9, Apprenticeship & Workplace 11, Pre-Calculus 12	Mathematics 8, Foundations & Pre-Calculus 10, Apprenticeship & Workplace 10, AP Statistics	Smaller school with many refugees, English Language Learners, and single parent families. Many students not motivated to perform in academic subjects.
Elizabeth, female	3	Mathematics 8, Mathematics 8 Honours	Mathematics 9, Pre-Calculus 11, Pre-Calculus 12	Mid-size school with many sports academies. A wide range of socioeconomic backgrounds. Varying degrees of academic motivation.
Jessica, female	12	Mathematics 8 Honours, Pre-Calculus 12	Foundations & Pre-Calculus 10, Foundations 12	Large school with many international students, and many English Language Learners. High degree of motivation for academics, with high academic achievement school-wide.
Kyle, male	18	Mathematics 9, Pre-Calculus 12	Mathematics 8, Mathematics 9 Honours, Foundations & Pre-Calculus 10,	Mid-size school with many sports academies. A wide range of socioeconomic backgrounds. Varying degrees of academic motivation.
Kristen, female	25	Mathematics 8, Mathematics 9	Apprenticeship & Workplace 10, Pre-Calculus 11, Foundations 12	Mid-size school with many sports academies. A wide range of socioeconomic backgrounds. Varying degrees of academic motivation.
Samantha, female	8	Foundations & Pre-Calculus 10, Pre-Calculus 11, tutoring	Tutoring all grades	Large school with many international students, and many English Language Learners. High degree of motivation for academics, with high academic achievement school-wide.

Participants were interviewed using open-ended questions, with room for the interviewer (myself) to ask additional or clarifying questions when necessary. The results of my survey suggested that teachers found real world connections more

important in the lower grades and levels of mathematics, and less important in the higher, more abstract mathematics courses offered. Because of this, I chose to ask participants again about their views of making real world connections in various grade levels and courses, and the importance they placed on connections in these. Participants used the terms 'higher grades', 'abstract courses', 'higher level' grades or courses, and 'advanced' courses to discuss courses such as Pre-Calculus 11 and 12, and sometimes even Foundations and Pre-Calculus 10. For consistency, I will refer to these as 'advanced courses' for the remainder of this thesis. As the curriculum in British Columbia is being redesigned for secondary mathematics courses, I also asked some of the participants if they believe that the new curriculum will have any effect on their ability to make real world connections. Many participants' answers to the questions below led me to ask them about what they viewed as being a real world connection, since this was not explained to or defined for them in any way during the survey or interview.

Having said that, the following list of questions guided me in leading the interview:

1. What is your motivation for connecting mathematics to the real world?
2. What would help you make more connections to the real world in your classroom?
3. What is the most common reason you decide to make a real world connection?
4. Where do you find resources to support making connections?
5. Are there skills you see yourself trying to develop in students specifically for the purpose of serving them in real life?
6. Are there skills you just happen to develop in the teaching of mathematics that you think will also serve them in real life?

Based on participants' previous answers, not all questions were asked to all participants. Participants who answered a question before they were asked were not asked again.

3.5. Data

The interviews that were carried out resulted in a wide range of viewpoints and opinions from participants. Participants were able to articulate their thoughts well, and no

interviews were omitted from analysis. The survey results were inconsistent with the results of the interviews. For example, surveys showed that teachers believed that making real world connections was more important in younger and lower level grades compared to more advanced courses. However, interviewees expressed that they disagreed with this statement and one even reported: “I don’t actually remember what I answered in the survey” (Duncan). There was an ample amount of data produced from the interviews that I did not feel it was necessary to include the survey results as well, in addition to the previously mentioned inconsistencies. Having said that, the survey was instrumental in helping me to formulate the interview questions and to recruit and identify interview participants.

As mentioned, the interviews were audio recorded. Initially, I tried listening to the recordings and transcribing by stopping and starting the audio file as I typed. However, this was a tedious process. Following the initial transcription, I transcribed the interviews using the VLC Media Player and the dictation feature on Microsoft Word. The dictation feature did not work by simply playing the digital audio file into the microphone on my computer. However, the dictation feature did work well for live sound, so I was able to use the dictation feature if I read out the interviews aloud while listening to them through headphones. I had the audio files playing on one computer through VLC, slowed down to 65% of the true speed. On a second computer, I enabled the dictation feature of Microsoft Word and, while listening to the interview through headphones, spoke the interviews into a microphone connected to the computer running Microsoft Word, which did the typing for me. In addition, I found it helpful to keep one hand on the pause button of the VLC computer to be able to pause the audio at any moment if my dictation got behind or there were errors. Once transcriptions of all interviews were complete, they were imported into NVivo⁶, and coding of the transcriptions was done using NVivo software.

⁶ NVivo is “software that supports qualitative” research by helping to “organize, analyze, and find insights in unstructured, or qualitative data” (NVivo, 2016).

3.6. Analysis

The data mentioned above were coded using a process of analytic induction (Patton, 2002). Similar to grounded theory (Charmaz, 2006), this process relies on the use of a constant comparative method. Unlike grounded theory, analytic induction starts with a set of *a priori* codes from the literature. In the case of these data, specific codes that emerged from the literature were:

- Advanced Mathematics/Courses (Karakoc & Alacaci, 2015)
- Authenticity (Gerofsky, 2010)
- Collaboration (Boaler, 1993)
- Communication (British Columbia Ministry of Education, 2008; & Boaler, 1993)
- Curriculum (Karakoc & Alacaci, 2015; Gainsburg, 2008; & Martin, 2007)
- Estimation (British Columbia Ministry of Education, 2008)
- Group work (Boaler, 1993)
- Hands-on (Gainsburg, 2008)
- Independence (student independence) (Businkas, 2008)
- Measurement (Povey, 2013; & British Columbia Ministry of Education, 2008)
- Motivate students (Karakoc & Alacaci, 2015; & Gainsburg, 2008)
- Need more resources (Gainsburg, 2008)
- Need more time (Karakoc & Alacaci, 2015; Gainsburg, 2008; Martin, 2007; & Bryan, 2005)
- Problem Solving (British Columbia Ministry of Education, 2008)
- Reasoning/Logic (British Columbia Ministry of Education, 2008)
- Self-awareness (Businkas, 2008)
- Transferrable Skills (Boaler, 1998)
- Understanding (Boaler, 1993)
- Word problems (Povey, 2013; Businkas, 2008; Gainsburg, 2008; Stocker, 2005; & Boaler, 1998)

Some of the above mentioned codes fit into the previously mentioned categories of process-based skills or mathematics-based skills, discussed at the end of section 2.1. However, not all codes fit into one of these two categories, as they are not all skill-

related. Aside from drawing codes from the literature, analytic induction also allows for the emergence of new codes. In order to determine emergent codes from the interviews, I considered topics that were either mentioned by multiple participants or topics that a single participant discussed at length. In this regard, the codes that emerged through this analysis are:

- Art/Beauty of mathematics
- Careers
- Community
- Explicit with students (in order to convey the importance of the connection being made)
- Goal setting
- History (meaning mathematics in history)
- Interest or enjoyment
- Make mathematics realistic or relevant
- Online as a resource
- Planning connections
- Prerequisite mathematics skills
- Presentation (neatness and the ability to present work professionally)
- Provide context
- Reading/literacy
- Relationships
- Research skills
- Staff as resource
- Stories
- Talking or discussions
- Technology
- Textbook

As with the *a priori* codes, some of the above mentioned emergent codes fit into the previously mentioned categories of process-based skills or mathematics-based skills, discussed at the end of section 2.1. However, not all codes fit into one of these two categories, as they are not all skill-related.

The majority of the codes used were emergent. However, some of these codes were in the back of my mind as I began coding, remembering them vividly from a specific interview, not yet sure if they were “worth” coding. It was not until I began coding the set of interviews that I noticed them to be present in other transcriptions as well. Sometimes, the emergent codes were present in only one source, albeit passionately and strongly present. Often, however, they were themes in multiple interviews.

Chapter 4. Analysis of Cases

What follows is a description of each teacher's views on real world connections, skills they view as important to build for the purpose of real world, and their opinions on how real world connections are affected by our curriculum. Teachers also comment on if they feel they make enough real world connections and what they feel they need in order to make more.

The results will first be presented in the form of cases. This will include a description of the participant, and the interview that took place. In Chapter 5, I will look at themes that emerged across these cases.

Although the description of these cases is full of seemingly colloquial terminology, the use of the aforementioned codes from the literature is deliberate. To communicate this clearly, I will represent these in italics so as to show which terms are codes and which are not.

4.1. Jessica

As mentioned in the Methodology chapter, Jessica is a female mathematics teacher with 12 years of teaching experience. At the time of the interview, she was teaching Mathematics 8 Honours and Pre-Calculus 12. In recent years, she has also taught Foundations and Pre-Calculus 10, as well as Foundations 12. Her school is one of the largest public schools in the province, with many international students in attendance. As such, there are many English Language Learners. Jessica's school is highly academic, and students in the school have a high degree of motivation to succeed in academics and extra curricular activities.

When asked about her motivation for making real world connections, Jessica found that by linking something to students' real lives they become more *interested* in mathematics. She finds that making these real world connections increases student *understanding* of the topic at hand. In Jessica's words: "If they're just learning it for the sake of math, it is just math, then they're not going to remember it". Jessica's main driving force when utilizing real world connections in the classroom is to enhance student *understanding*.

Given her answers, what does Jessica consider to be a real world connection? To Jessica, a real world connection is:

Teaching them whatever concept you're trying to teach them, but have it connected to: how can I use this at home? Or, how could I use it elsewhere?

This is telling in Jessica's perception of what is a real world connection, in that it is more of a real world context than a real world connection. When asked for examples, Jessica found that geometry, and more specifically surface area, was the easiest topic to make connections in, because she could connect it to things students might do at home. This speaks to a personal connection, as Jessica is trying to relate the mathematics to something the student might actually encounter, rather than some other potentially irrelevant real world situation. Jessica also mentioned that connections are sometimes made in her classroom when students prompt a *discussion* of how a topic is related to their lives, allowing her again to make a personal connection that is also real world.

Jessica found that a real world connection was something students could use outside of her classroom, at home, or elsewhere; she wants to *make mathematics relevant*. These could be mathematics or process-based skills. One of the interview questions asked was whether teachers find themselves developing skills in their students because they think these skills will be useful in real life. Jessica was able to quickly identify which skills she values: *community*, *relationships*, *communication*, and *group work*. Jessica uses vertical spaces in her classroom for group work. Vertical spaces have students working on questions collaboratively on vertical whiteboards (Liljedahl, in press). Students are in random groupings, and work together to solve

problems. Because of the culture Jessica has created in her classroom through these vertical spaces, she finds that students develop a good sense of *community* and good *relationships* with one another. Students are helping each other rather than relying on the teacher for support. This culture is a purposeful decision Jessica has made in her classroom, as she thinks these skills are necessary to be successful. Rather than being knowledge that students have obtained through real world connections, these are process-based skills that students are acquiring.

When asked if there were skills students were developing that were not her initial intention, Jessica really had to slow down to think about her teaching practice. Jessica found there were other skills that her classroom environment naturally fostered. During vertical spaces, students learn *problem solving* skills, as the teacher is not standing there telling them how to solve questions step-by-step, which also results in students learning *self-awareness* and *independence*. Jessica also fosters *self-awareness* by using self-assessment at the beginning of every class, hoping students will take this information as useful to determine where their strengths and weaknesses are. These are *transferrable skills* that Jessica is not intending to develop, but come out because of her intentional classroom environment and the process-based skills she is intentionally building in her students.

Jessica, like many of the other participants, felt that she is not able to make as many real world connections as she would like to. She feels like she *needs more time* to be able to think about the connections she could be making, and that she *needs resources* to allow her to make connections and give her ideas. Since Jessica had identified resources as a barrier to making increased connections, I asked her where does she get her ideas now? Jessica's main resources were *textbooks* or *other teachers*. Jessica's reference to the textbook, as indicated in the literature in Chapter 2, likely means she is using word problems from the textbook. As the cases continue to be presented, if the textbook is mentioned as a resource, word problems are likely inherently being used from these textbooks.

Jessica emphasized that she does not think it is less important to make connections in the higher, more *advanced courses*, but that it is harder to do. When asked about this, Jessica said:

I think it's always important to make connections. I feel like, though, once you're getting in to Pre-Calculus 11 and 12, then there are less connections to make.

Jessica tries to make connections in courses such as Pre-Calculus 12, because she feels it still helps students understand the subject. However, she often finds she is limited to *word problems*. She finds that when students in Pre-Calculus courses ask for a personal connection, such as "when are we using this in real life?", her response is that they won't, but rather they are being prepared for Calculus. Alternatively, if a student asks such a question in the *younger grades*, or a less advanced course, she is able to help them with those connections to help create *understanding*. The *curriculum* variance in these higher grades, such as between Foundations 12 versus Pre-Calculus 12, seems to greatly affect whether or not connections can be willingly and easily made.

Jessica had suggested that she gets stuck with *word problems* when trying to make real world connections in more *advanced mathematics courses*. When asked to explain further about *word problems* being real world connections, Jessica clarified that in order for her to consider these as being valid real world connections, a conversation must be included:

I think it is a real-world connection, but I wouldn't say, "Here's a word problem, do it". I wouldn't just hand them or just give them a problem and tell them to do it. I think talking about it we would have a conversation about it and how it is connected and how it makes sense...giving the word problem is not making the connection.

Talking about the context, the situation, or what the connection is and how the problem is a real world connection is what makes it so. *Word problems* are the main vehicle in which *textbooks* try to make real world connections. For Jessica, *textbooks* were one of the main resources for finding connections, and *textbooks* are the main resource given to teachers to deliver our curriculum. This speaks to a deficiency in our *curriculum*

addressing real world connections, as in Jessica’s words, “giving the word problem is not making the connection”.

4.2. Elizabeth

Elizabeth is a newer teacher, with just over three years of experience. Within that time, Elizabeth has taught a variety of courses, including Mathematics 8, Mathematics 9, Pre-Calculus 11, and Pre-Calculus 12. Elizabeth has been fortunate to be at the same school for the duration of her teaching career so far. Her school is mid-sized with a range of socio-economic backgrounds and varying degrees of academic motivation.

Elizabeth was able to identify one obvious motivation for making real world connections in her classroom. Similar to Jessica, Elizabeth wants her students to be *interested* in the topic. Elizabeth adds that she wants them “to see that there is use of this math and their learning” and that mathematics can be *realistic*. When asked what would help her use these connections more to build *interest* in her students, Elizabeth’s main complaint was a *lack of time*. She is motivated to use projects to help her with creating *interest* through connections; however, she finds that the set *curriculum* hinders her ability to do so. She finds that it is “hard to make that extension on the topics that we teach.” Contrary to Jessica, Elizabeth finds there is no shortage of resources; “you simply have to seek them out, and take the time to find them”. Elizabeth finds her resources *online*, particularly on Twitter, and through blogs. Her favourite resources are Dan Meyer⁷ and Fawn Nguyen’s⁸ blogs.

Elizabeth sees these real world connections as “something that they will actually use after they get out of our classes.” Elizabeth added pointedly that she does not see *word problems* as a real world connection:

⁷ Dan Meyer is a prominent mathematics teacher from California, United States, who shares resources for other teachers to access on his blog, <http://blog.mrmeyer.com/>

⁸ Fawn Nguyen is a prominent mathematics teacher from California, United States, who shares resources for other teachers to access on her blog, <http://fawnnguyen.com/>

The word problems we have in the textbook are more like a story that is trying to assess certain skills. There's no natural real world connection to it.

Similarly to other participants in the study, Elizabeth views real world connections as something students can use elsewhere, and that these connections are not necessarily connected directly to the *curriculum*. Some examples given of what Elizabeth views as being a real world connection are: surface area and volume, percent, loans, interest rates, and survey projects for a Mathematics 9 probability and data unit. This led to Elizabeth discussing her views on making connections in various grades and course levels.

Elizabeth notes that topics such as surface area and volume, car loans in Foundations 12, discussing interest rates, and percent in Mathematics 8, are easy to make connections. Some of these topics she noted as being intuitive for students. Elizabeth finds that sometimes they are not as necessary with students taking *advanced courses*:

Students that tend to take Pre-Calculus are more likely to appreciate the abstract and the beauty of math, and sometimes the beauty of math is not the real world application.

Like Jessica, Elizabeth notes that when you get to *algebraic topics*, such as trigonometry or function transformations, the connections are harder to make. Elizabeth finds that in subjects such as Pre-Calculus 12, it is often hard to find somewhere to make a meaningful connection, and instead, you are stuck with the typical "Ferris wheel for trigonometry" type question. She does try to make connections in these *higher grades*, when possible, giving the example of using the Angry Bird game (see Figure 1), which can be played on a smart phone or tablet, to show Pre-Calculus 11 students how to model a projectile with a quadratic equation.

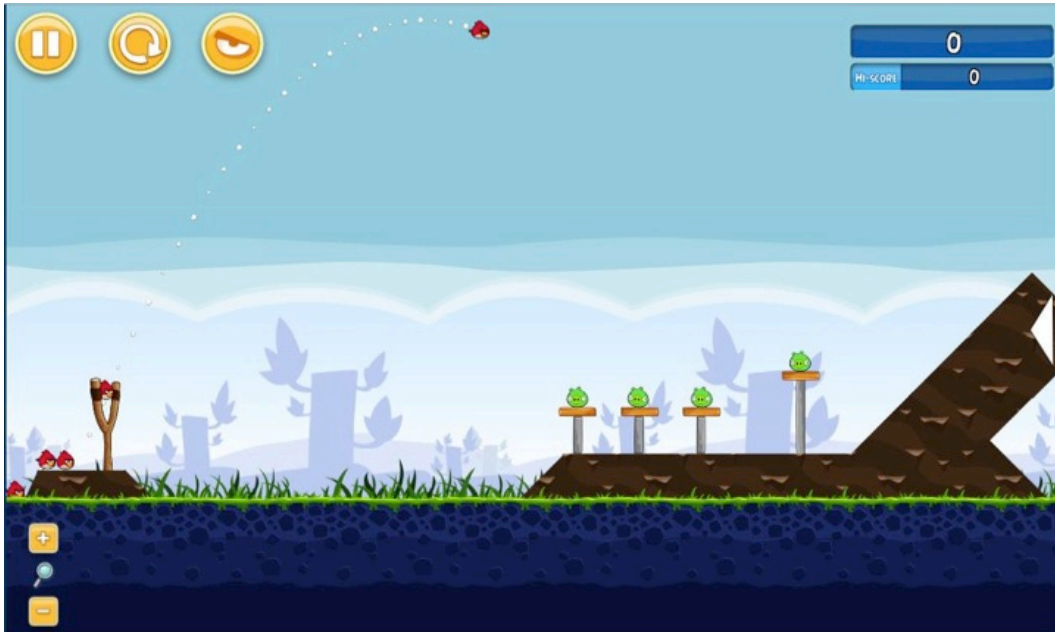


Figure 1 Angry Bird game

Figure 1 shows what the Angry Bird game looks like from Elizabeth's PowerPoint she uses. Her caption for this image is, "will the bird hit the third pig from the left?". The Angry Bird game has you launch a cartoon bird across the screen, as a projectile, to try to knock cartoon pigs off of their respective platforms. You have three birds to use, and if you knock over all the pigs, you win the game. Because the birds travel in a parabolic motion, they can help students visualize and understand the shape of a parabola and how to predict where a projectile would land using a quadratic equation.

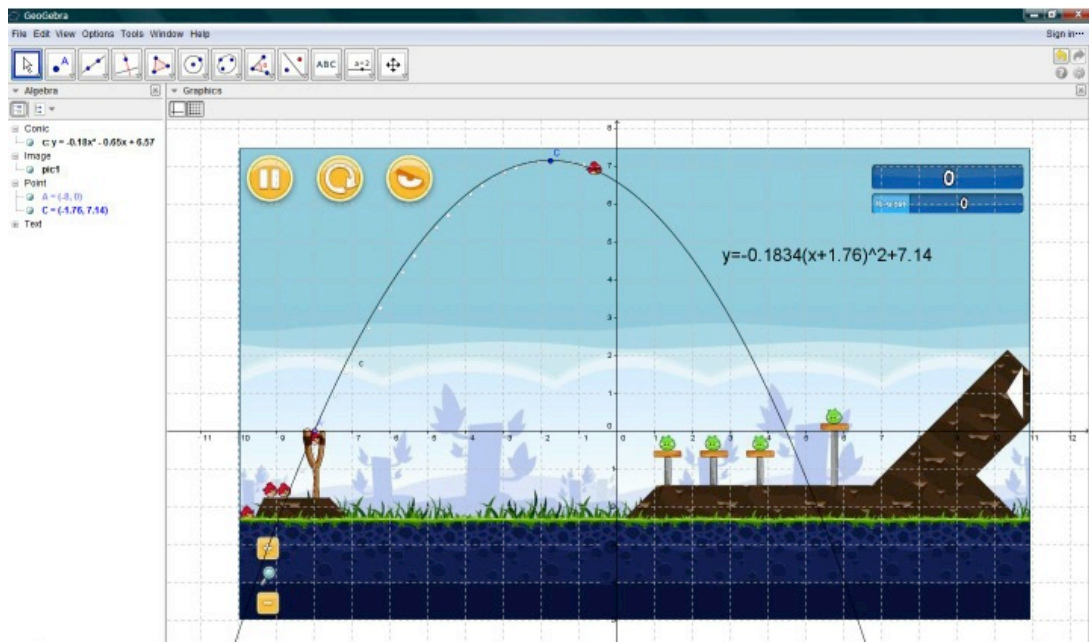


Figure 2 Angry Bird game with parabola overlay

You can see how Elizabeth does this in Figure 2, which is another image from her PowerPoint she uses where she overlays a parabola with one of the birds being launched in the game. Finally, Elizabeth will then test the prediction with the students in the actual game by launching the bird and seeing if it hits one of the pigs or not.

In Elizabeth's classroom, there are many process-based skills that she tries to build with her students to enhance their learning. She finds that these are real world skills, which will fulfill her definition of real world connection, and serve students outside her classroom. Students are often unable to explain their learning, so Elizabeth works on *communication*, *logical thinking* and how to properly and *neatly organize* their thoughts. *Technology* is also used often in Elizabeth's classes. Occasionally, she has students do *research* projects instead of tests. Elizabeth also uses GeoGebra⁹ and

⁹ GeoGebra is "dynamic mathematics software for all levels of education that brings together geometry, algebra, spreadsheets, graphing, statistics and calculus (Geogebra, 2015).

Desmos¹⁰ with students for graphing. In addition, students engage in *presentations* and peer teaching.

Elizabeth occasionally uses vertical spaces, as described in Jessica's classroom, which works on *collaboration* and *communication*. In addition, this helps students with their *problem solving*, which as Elizabeth says, is "what math is about". Building on the problem solving aspect, she finds that if she takes away the information from a word problem, she can have students pose their own problems. These types of activities she draws from Dan Meyer's blog mentioned earlier. While she finds many benefits to vertical spaces, she does find students need to be able to "solve problems on their own and not always rely on others". Elizabeth values the ability of students to work *independently*.

4.3. Samantha

Unlike the other participants in the study, most of Samantha's teaching experience is outside of the public school system. Samantha has years of experience with private tutoring, spanning all grades and levels of mathematics, with eight years in the school system. Recently, she has re-entered public teaching, with a Mathematics 10 Foundations and Pre-Calculus class, as well as Pre-Calculus 11. At the time of the interview, Samantha was at a large school with many international students and English Language Learners. There is a high level of academic motivation and achievement, and students take pride in their extra-curricular activities.

Samantha is similar to Elizabeth and Jessica when looking at her views on what constitutes a real world connection. Samantha feels that these connections are things that people do with mathematics outside of school or the field of mathematics. She feels that students need to be exposed to the idea that mathematics is useful and *relevant*. Mathematics is not confined to the classroom:

¹⁰ Desmos is an online graphing calculator or application that can be downloaded to mobile devices. The website also provides educational activities to be done using the graphing calculator (Desmos, 2015).

You do not just come and do math here. It extends outside of the classroom. It is part of life.

Samantha finds that due to a *lack of resources* at her school, she must search externally to find resources to plan her real world connections. She also finds that students seek these connections to their personal lives. Students mention a potential connection, or ask a question, and it becomes a teachable moment. Samantha, like Jessica, can then extend the real world connection into something personal and have a *discussion* around the connection.

As mentioned, Samantha finds how she makes her connections has a direct correlation to her school's resources. The *textbook* is currently her only resource provided by the school. She finds this text segregated. If the book were more cohesive, Samantha would be much happier to use it, but she finds it is split up in too many ways and does not convey any big ideas. In addition, the *word problems* often seem made up, even if it may actually depict a real place or give true facts. Samantha is trying to use the textbook in a different way, where students use it as a learning tool rather than guiding her teaching. In addition to using the *textbook*, Samantha finds resources on her own by looking up articles she has heard about. She imagines teachers could also use Google or the Internet, like Elizabeth does. Samantha has a wish list of resources to help her with making more real world connections, which include a unit outline with connection ideas and guest speakers. Samantha would like to include *research* projects in her courses, but is prevented from doing so due to her school's insufficient *technology* resources. In addition to extra resources, Samantha finds that she *needs more time* to make real world connections.

Real world skills that Samantha focuses on are process-based, and not necessarily connected to the mathematics *curriculum*. Although not often seen as important, Samantha finds that student *literacy* is extremely important in her mathematics classroom. This is a new thought amongst participants that she is the only one to mention. Samantha has noticed that students are lacking *literacy* skills, which then affect their *problem solving* abilities.

Literacy is sorely lacking. And reading is just this really small piece of the puzzle that goes together with what you are looking at with the problem solving, which you can't do without the reading.

She likes to bring in stories, or "challenging materials" that are not "just solving a math problem". She tries to give students reading strategies, and "walk students through literature" that mathematicians have written, or mathematics history. By using these approaches, Samantha is hoping to help students' ability to properly utilize their *textbooks*, since that is her main resource for making real world connections.

In addition to building student *literacy*, Samantha spends lots of time reinforcing social behaviours in her students. She works on *group work*, *communication*, and writing. Samantha finds that often students are unable to ask each other for help or problem solve on their own, and instead, follow her around the classroom, so she is trying to have students not rely on her as much and instead be self-reliant and *independent*. Students are encouraged to be members of a *community* and contribute by communicating, taking turns, and socializing with one another.

I'll have one group that will say that we've got the guy who doesn't speak English! And I'll be like, yeah, but he's part of this class. So there's membership, socialization, taking turns.

Students are given abstract problems that require them to think outside the box, which Samantha hopes will build their persistence and determination to not give up on a problem just because it is challenging. In addition, students are taught about fairness. Samantha also appreciates the ability to laugh and have fun in her mathematics classroom.

Because much of Samantha's experience is outside of a classroom, she did not have many comments about the importance of real world connections across the grade levels. Samantha feels that students in *advanced courses* do need "rigor and fluency". However, her views aligned with Jessica and Elizabeth's views that some real world connections are still necessary in the Pre-Calculus courses:

I would love to take a grade 11 or 12 Pre-Calculus class and just do the first quarter where we are doing this project and then let's pull the math into it.

Samantha finds it difficult to place importance on certain skills or topics in courses such as Foundations and Pre-Calculus 10, because not all students will follow the same course path. For example, she says that some students may not plan on going into Calculus, so if you are trying to justify a curriculum outcome based on that, some students may not see the point. Samantha's main concern when trying to make connections in *higher grades* is that it would take time to plan that teachers do not have, and students may not understand the significance of the connection you are trying to make or the topic you are trying to teach.

4.4. Kyle

Kyle has been teaching for 18 years. He currently teaches Mathematics 9 and Pre-Calculus 12 at a mid-sized school with a wide range of socio-economic backgrounds. Students show varying degrees of academic motivation and extra-curricular commitment. Kyle has previously taught Mathematics 8 and Foundations and Pre-Calculus 10.

Dissimilar to the previous cases we have seen, Kyle's motivation for real world connections is not to create interest in students. Rather, Kyle finds that students need to see some kind of necessity for what they are learning. He finds that because mathematics is so abstract, he needs to give students *context* and find "something they can connect to". Kyle sees real world connections as how mathematics is used to do something bigger, like engineering, for example. One of Kyle's other motivators is a student asking "what is that used for?" or "what am I learning this for?". Kyle finds an important connection here is being able to relate this to something in the real world, like a specific *job or career*. Similar to Jessica and Samantha, Kyle likes to create personal real world connections with his students. He brings in videos or examples that relate to his students based on personal relationships he has formed with them. Another example Kyle gives is having students come up with the question from a scenario or

video, which brings in their prior knowledge and lets them create a question for something they find interesting and want to know more about.

Kyle finds that a real world connection often means connecting mathematics to the bigger picture, especially *jobs or careers*. However, this also results in where he experiences barriers in making connections. Kyle finds he often cannot make the connections he wants to, because he has limited experience with other careers or jobs as a high school mathematics teacher. In Kyle's words:

I'm not some kind of Renaissance man that knows all jobs of all people. I don't know that. I know my job, and it would be handy if I could connect that to other people and other jobs, but I just can't. I don't have the resources or the knowledge for that.

He finds that while he can make surface level connections, he has difficulty in making connections effectively. Kyle sees his job as a "toolbox filler", where students gain tools to be able to use for something down the road. Kyle's main roadblock here is that he does not know where each student will end up when they leave his classroom, and so he finds it difficult to tell students what specific task they will need a certain tool for.

Kyle mainly uses the *textbook* as a resource, as that is the resource he is given. The textbooks that are provided to British Columbia public schools are written for the provincial curriculum. Kyle *needs additional resources* that can make meaningful links between curricular topics and careers or jobs that go past the introduction pages of textbook chapters. As previously mentioned, Kyle has limited experience with other careers, and he assumes the textbook writers do as well. He is unhappy with the amount of *time* it takes to come up with supplemental resources, and imagines that many teachers who do not have the drive or desire to search for these would wind up using a dissatisfying textbook as their only resource. When asked if he ever broadens his search for resources beyond the textbook, Kyle adds that it is a rare occurrence due to *time constraints*. When branching out beyond the textbook, Kyle draws on his own experiences and contexts to create real world connections to use with his students. Similar to our previous cases, Kyle *needs more resources* and *more time* to make the meaningful connections he knows are important.

As mentioned, Kyle finds most of his connections through using the respective course textbook. Previous cases have shown us that Elizabeth, Jessica, and Samantha are dissatisfied with the connections that textbooks provide, as the textbooks rely on *word problems* to fulfill their requirement of making real world connections. Kyle finds that *textbooks* try to make connections, especially when introducing a new topic, but that these are often not strong connections. Kyle adds that, because he uses the *textbook* as his main resource, in part to save time, it would make a big difference if the textbooks were more effectively and well written:

The tiny concepts that you teach section-to-section or chapter-to-chapter don't directly connect to any one big job or anything like that.

While he trusts that textbook writers are doing everything for a pedagogical reason, he finds that he sometimes ends up abandoning his resource, the *textbook*, as he goes through a course to suit his needs and the needs of his students. Kyle might decide that although the textbook says he should spend time on a specific topic, he may decide to abandon certain questions or even an entire section, or change the order that the textbook suggests he go in.

Apart from the mathematical curriculum covered in textbooks, students attain *transferrable skills* that can be considered another form of real world connection. A reminder that Kyle views these connections as creating context for students or finding something they can connect to, such as a *specific job*. Kyle feels that one skill that will be useful for all students, regardless of their post-secondary path, is *goal setting*. He aims to not lecture students about what they should have or could have achieved, but rather have students decide why they are taking his mathematics class and what they hope to gain from it. Upon reflecting, Kyle did not find he placed much emphasis on students building skills through real world connections beyond *goal setting*, as students are too different from one another to suggest that one skill will be useful for each student.

The survey results suggested that the majority of teachers (15 to 17 of 19) agreed or strongly agreed that connecting mathematics to the real world was important for Mathematics 8, Mathematics 9, both Mathematics 10 courses, and Apprenticeship

and Workplace Mathematics 11. However, the number of teachers who agreed or strongly agreed declined slightly for Foundations 11 and Pre-Calculus 11, as well as the two Mathematics 12 streams. Previous cases so far suggest that, contrary to the survey results, teachers feel it is just as important to make real world connections in *higher, more advanced courses* such as Pre-Calculus 11 and 12, as in younger or lower level courses such as Mathematics 8 or 9. Kyle agrees with previous interviewees, saying that the younger or lower level courses seem to be more applicable to life after high school, regardless of a students' path. These courses teach students a basic, working mathematical knowledge. However, Kyle is careful as to what he says to students surrounding this knowledge that he may deem to be a real world connection. Kyle acknowledges that what may seem real world to him, may not be real world to his students. Similar to Samantha, Kyle is concerned that if he claims students will need a skill for a certain job, what happens if they never pursue that job? That skill has just been removed from the real world connection category. An example Kyle gave was teaching students measurement in Mathematics 10. He worries that the real world connection often made is that measurement is something to be used in carpentry or construction, even though measurement can be used for many different tasks in many different ways, and inevitably a student will encounter measurement outside of their mathematics classroom at some point. However, Kyle feels that if a student is not planning on going into one of these trades, then the measurement task becomes as mundane as a *word problem* from the textbook.

When speaking specifically about making real world connections in more *advanced courses*, Kyle finds Pre-Calculus 12 most frustrating. Similar to Jessica, he finds that *word problems* seem to be the only resource available, and that they are usually for the trigonometry chapters on the topic of weather, tides, or as Elizabeth mentioned, a Ferris wheel. However, Kyle disagrees that these are not real world for a different reason than Jessica mentioned. Jessica did not like these scenarios because they were presented as word problems, but she had no issue with the scenario itself if it had been presented in another manner. Kyle does not like these problems because it is not how somebody would approach these types of problems in the real world, regardless of the way the scenario is presented.

To actually use that to figure out the tides is a ridiculous idea, because what do I do when I want to figure out the tides? Well I consult a tide chart, and I don't calculate it using formulas, nobody does that, nobody would ever do that. Even at the highest level of science people are going to go and Google it.

Kyle finds that the scenario itself devalues the question as being a valid real world connection. Students see it as just another problem to solve, and do not sit down to think about if it makes sense or why it works, or who would actually be doing this in the real world.

4.5. Chad

Chad has a unique perspective on real world connections. He has been teaching for seven years, and at the time of the interview, Chad was teaching five different courses. Working in a smaller school with low academic motivation and achievement has significantly influenced how Chad approaches real world connections.

Chad believes that real world connections make mathematics more *realistic*. Similar to Kyle, Chad believes that "learning should be *contextualized*". He finds it helps to show students what something looks like in the real world, and how it fits into a bigger picture. For Chad, a real world connection is something that has some experiential learning or *hands-on* piece to the activity. The example given was talking about the trigonometric ratios and ladders, and how much more it would help students if they had a physical ladder to see and manipulate. These connections are *tangible* things that students can touch and feel, which can be difficult when linking to the curriculum. Chad points out that:

If you want to encourage this kind of tangible experiential learning...then you have to understand that the students will come to those conclusions differently.

Chad's suggestion is that the *curriculum* needs to radically change, and possibly even that the British Columbia public school system needs to move away from a curriculum entirely. This is a view that is unique to Chad.

Continuing with the conversation of what constitutes a real world connection, Chad's views align with Jessica and Samantha in that conversations with students can become a personal real world connection:

For example, the grocery store has unit prices on their price tags and now you know what they're used or, you know what it means, that is a real world connection. But usually you don't plan for that, some kid will bring it up when you're just talking and I think that is how I want to do it...I want more of this to come from the students.

However, this is not in line with Chad's description of real world connection being a *tangible* learning experience. Chad here is describing activities such as how the grocery store has unit prices and showing students that is something in the real world, and he says "that is a real world connection" that presents itself when you are *talking* with students. He explains that this is real world because it comes from the students, and says he wants more of this. He likes being able to say to students "yeah, that is related". However, Chad doubts that simple descriptions of the real world are actually making a connection. Chad also mused as to whether *mathematics history* could be considered, as it has the potential to be *tangible*, but he was not sure if this could be considered real world for students. Chad is experiencing a tension between what is a real world connection and what is not.

As previously mentioned, Chad values when students bring up a topic in *conversation* as real world connection:

Some kid will bring it up when you're just talking and I think that is how I want to do it...I want more of this to come from the students.

Although Chad wants more real world connections and *conversation* to come from the students, it was interesting to hear his thoughts on how often he makes real world connections. Chad, similar to our other four participants, feels that he could be making more real world connections. His main complaint is that, because he is still relatively new to teaching, he often does not know what he is teaching until the beginning of the school year. As a result, he *lacks time* to plan or think about what meaningful connections can be made:

I have no time to do it or to think about new things I'm going to do... you can't be just innovating and doing new things all the time. I think it also takes a lot of passion and discipline to make new stuff and try new things.

Chad points out that while you want to be using innovative problems and activities to build connections, often you do not have the time to be making new activities. Additionally, once you have spent the time developing new experiences for students, you want to get the most use out of them that you can. Chad *needs more time* to think and prepare in order to be able to make as many connections in the classroom as he would like. He is not too concerned with his resource supply as he finds many of his connections spontaneous, which results in few experiential learning activities that need planning:

It's more relatively spur of the moment, just talking about something that is real... The real world connections do tend to come from spur of the moment, it's hard to plan for them unless you build an entire activity around an experiential learning piece.

Similar to Jessica, Chad finds other mathematics *teachers* to be an invaluable resource.

The participants I have discussed so far have expressed that the *textbook* leaves a lot to be desired in the context of real world connections. Chad's views align with this, saying the *textbook* can be confusing for students, and hinder their ability to connect ideas to a real world context. Seeing as this is Chad's motivation for making real world connections, it is not surprising then that Chad has a negative view of *textbook* questions. For example, he discussed the issue of scale diagrams and the inconsistencies of the textbook. Some questions instruct students to measure the diagram, a hands on task that fits Chad's definition of real world connection, while others prevent students from doing so. Chad also finds that often the *textbook* makes topics confusing by attempting to make a real world connection even when it is unnatural to do so. This causes many to lose their *authenticity*. He thinks the real world should fit the scenario rather than trying to force a scenario to fit into the real world. Similar to Kyle, however, Chad does feel like there is a place for the textbook in the classroom. He acknowledges that *textbook* questions have been used for a long time, and this has proven to "be sufficient for most students". However, he has an internal struggle

between how many real world examples are needed compared with how many questions from the textbook to use.

As mentioned in previous cases, participants discussed what types of skills they are building that they see as being a real world connection. Chad is very concerned with students' ability to use mathematical tools, and is one of the few participants to be very focused on something mathematical. He focuses specifically on students' ability to *measure*. One concern is that students can neither read rulers properly nor use a protractor properly:

You should probably know how to use a tape measure, or you should probably know how to use a protractor.

He feels that students have never used a compass or a level, or even know what they are used for. Chad focuses on these mathematics-based skills even though they are not necessarily included in the curriculum he needs to teach.

Chad also feels that process-based skills are necessary in the real world, but Chad finds that there are few he is able to spend much time focusing on with his students. Similar to Elizabeth, Chad emphasizes the importance of *presentation*, penmanship, and *neatness* with his students:

They interact with the world through screens and that's great because screens are neat. So they don't understand that the real world that they interact with here is not neat. Or in order for it to be neat somebody has to do something about it.

Chad feels that these process-based skills are *transferrable* across school subjects, and into a potential job. He also finds that students need assistance learning about organization and that many students need to learn how to interact with other people, in general, and adults in particular. Students are demanding, and need to learn how to reason and "give and take". This aligns with Samantha, Jessica, and Elizabeth, who also find it important for students to build their *communication* skills.

While Chad's views aligned with the previous four participants that real world connections are important in all course levels, he questions if the problem was the

curriculum itself. Similar to the views we have seen so far, he feels the *lower grade levels* and Apprenticeship¹¹ streams lend themselves more to making real world applications, than the Pre-Calculus¹² streams. He finds that connections are less apparent and common in Pre-Calculus streams because they are very theoretical and “less real things”. However, Chad questions the *curriculum* because of this. Chad related back to the “old principles 12” course, which he remembered as being theoretical, but there were still tangible parts, (which Chad sees as being a real world connection), such as “drawing graphs”. Alternatively, Chad sees “current math 12” as still theoretical, but “completely disconnected” and the “pieces don’t go together”. Chad feels that with a change in the curriculum, students would be able to make real world connections more easily in the more *advanced courses*.

4.6. Duncan

Over 15 years of experience in a wide range of courses has given Duncan a unique perspective on real world connections. Duncan strives to teach his students skills that they will need to be successful in the real world. Many of his students are not motivated to perform in academic subject areas. At the time of the interview, Duncan was teaching Mathematics 9, Apprenticeship and Workplace Mathematics 11, and Pre-Calculus 12. Duncan shared some interesting insights on the topic of real world connections that will show us an alternative way of looking at them.

Duncan is unlike the cases I have presented so far in his definition of real world connection. He views this as “a way of thinking and way of doing math”. Jessica, Elizabeth, and Samantha have expressed that real world connections are extending mathematics outside of the classroom, Kyle sees real world connections as relating to a

¹¹ Apprenticeship is referring to the two Apprenticeship and Workplace mathematics courses offered in grades 10 and 11 for students who are planning on going into an apprenticeship, trades program, or workplace education stream.

¹² Pre-Calculus is referring to the Foundations and Pre-Calculus Mathematics 10 course, as well as the Pre-Calculus 11 and 12 courses that are intended to prepare students for university calculus.

bigger picture, and Chad sees connections as being tangible. Duncan says the following about what he sees a real world connection as:

I will bring in real world problems sometimes, but mostly it is in the way that we do mathematics. You have to work collaboratively and reason with your partner, and you have to be able to explain and ask questions.

The attributes Duncan has just mentioned align with what other participants mentioned as being valued process-based skills. The difference here is that is that Duncan sees the way students do mathematics as being the connection in itself. The fact that mathematics is being done is irrelevant to the real world connections being made. In other words, students could be learning any subject in his room, and real world connections would still be made based on the way students are interacting with each other and with the subject itself.

Duncan does not bring many real world problems into his classroom because he has such diverse ability levels that he finds *word problems* to be more difficult and frustrating than helpful. Duncan, like Kyle and Samantha, enjoys making personal real world connections by *telling stories* students can relate to:

I like personal narratives. In a lesson yesterday, it was about taxis in New York City and how I am able to dazzle my friends about how many taxis are in New York City and involved combinatorics.

His preference is to have students engage in *group work*, which Duncan views as more of a real world connection than a real world problem. Students benefit from this perception because they can gain experience and *transferrable skills*. As we have seen with Jessica and Elizabeth, Duncan is motivated to use real world connections because they create *interest* and it is more *enjoyable* for the students. They learn more by *communicating* than when they are sitting in a lecture-based classroom. Duncan focuses on process skills such as *communication* and *collaboration*:

I want kids to kind of engage a little bit, and engage by talking and talking it through...to communicate their thinking to each other and to myself.

Duncan also has his students work on their *self-awareness*. Since he does so much group work he wants his students to be able to have *independence* as well. Students participate in self-reflection exercises as part of their course. The ability to be able to both participate in *group work* and exercise *independence* are ideas we have seen from other participants, namely Samantha, Elizabeth, and Jessica.

Aside from the process skills mentioned, Duncan does find that certain mathematics skills are easy to build into the way his students do mathematics. As such, they become a real world connection for him as well. *Estimation*, deductive *reasoning*, and *logical thinking* are skills students need for many areas. Duncan looks forward to the new *curriculum* that is being discussed, as there is an emphasis on skills like these.

I think these are all what you want your kids to be able to do when they leave. When kids graduate and they have gone through math, all I want them to be able to do is all those things and also enjoy math.

Duncan feels that the current *curriculum* is more focused on the mathematical processes, which are Communication, Connections, Mental Mathematics and Estimation, Problem Solving, Reasoning, Technology, and Visualization (British Columbia Ministry of Education, 2008), than the specific mathematical outcomes. Duncan feels that as a teacher you need to help students with the way they think about mathematics and listen to their responses.

Duncan had an interesting response to what barriers he faces when trying to integrate these into his classroom. Duncan's immediate response was that he finds he is not always *explicit with his students* as to why his classroom operates in the way it does. Students are not always clear that they are trying to build *transferrable skills* that will serve them in other situations, such as *communication*, *group work*, and *independence*. When students do ask why, which he finds is mainly in his more *advanced courses*, he is able to tell them that they will need to know how to build a supportive *community* once they are outside the comforts of high school.

I'm asking you to work with partners or with peers because I want you to be able to do that as you move out of high school... next year this is how you're going to be successful when you're at college or university or BCIT, or any other program you go to, or if you go to a job.

Duncan finds many of his students lack these skills, and so he finds this is the most useful real world connection he can give them. However, in order for them to fully benefit, he needs to be clear as to why he is building these skills.

Other participants cited that they need more resources and they need more time to be able to make the real world connections they desire. Similar to Elizabeth, Duncan feels that the resources are there, you simply need to look for them. He finds the resources for new group activities or communication building by talking to *other teachers*, like Chad or Jessica, and going *online*, like Elizabeth. However, he favours talking to *other teachers* as his primary resource. Duncan did add that he would like to bring in more real world problems, and that looking through these resources is most likely the best way to find one that breaks his barrier of diverse student abilities. While Duncan does not see time or resources as an issue, he does feel that more training or workshops are needed for teachers to know how to successfully integrate real world problems. For Duncan, this means training for teachers to be able to deliberately use real world skills as a vehicle to deliver the *curriculum*, rather than focusing on the mathematics and stumbling upon the real world skills. He believes this will help shift the way that teachers interact with their students.

Lastly, Duncan's views on real world connections across grade levels align with what we have seen so far. While he admitted he did not recall what his response to the survey had been, Duncan felt that if people believe in the importance of connections in *lower grades*, they should believe in the importance for *higher grades* as well. Again this is connected to his view that communication and group work are important regardless of grade level, and possibly "even more important for the grade 11 and 12s".

4.7. Kristen

With the 25 years of teaching at a mid-sized school with a wide diversity of students, Kristen has the most teaching experience amongst the interview participants. While usually focusing on the younger grades and less academic options, Kristen has also taught Pre-Calculus 11 and Foundations 12. Kristen's background includes training in

English as a subject, which has given her an extremely distinctive outlook on real world connections. Her standpoint makes her the outlier among the interviewees.

Dissimilar to the six other cases I have presented, Kristen does not believe real world connections are beneficial. Rather, Kristen sees mathematics as *beauty and art*. She does not feel the need to make connections to the real world, though she sometimes finds it comes naturally in her teaching. When she does, Kristen's motivation is the practicality of mathematics. When students ask why are they studying something, her reasoning is because mathematics is *beautiful*. Unlike Jessica, Elizabeth, and Samantha, she does not give students the reason that it can be used outside of the classroom or that they will ever need it. Problems such as how far a rock goes when you throw it are irrelevant, and do not help build students' mathematics tools. Kristen also dislikes real life applications, and specifically *word problems*, because they are contrived. These questions force students to perform calculations or solve problems that would never be asked of you in real life:

You know you've got your maximizing the space of the swimming area, which has nothing really to do with real-life. Because in real life you wouldn't be maximizing the area, you would be looking for safety or something else. Or how big does the cage have to be to keep the lions and the tigers away from each other? That's just something that you do, you don't get out your calculator to figure out how much more space the lions need than the tigers need.

If you want students to build real world skills, more relevant and *authentic* questions need to be asked of them. Instead, *textbooks* and other subject areas pose mathematics as a tool, to solve your problems, whereas Kristen wants to use mathematics because it is interesting. For example, she teaches her Foundations 12 students to find curves of best fit by sight, and subsequently analyzing it. She agrees that students will not need this as a skill in real life, because they will have tools like graphing calculators to solve these types of questions.

When asked to elaborate about her motivation for teaching mathematics as beauty and art, Kristen was very passionate about her answers. Kristen finds the numbers intriguing, and finds importance in the complexities of the numbers themselves.

To her, the connection is not to the real world, but rather the connection between students and the love and *beauty* of mathematics:

Kids will ask well why are we studying this, and I will say because it is beautiful. I will not say because you will need it...the real connection with math is the children connecting with the love and the beauty of it. That to me is the connection. Being able to talk to each other about an elegant proof.

She wants her students to appreciate an elegant proof, or to see that surface area is beautiful simply because it is interesting, without needing to have a real world connection. Thriving on the classroom culture and *community* she creates through this vision, Kristen is happy when her students enjoy coming into her room to learn about something beautiful. Like Duncan, Elizabeth, and Jessica, Kristen values *interest* and *enjoyment*.

Transferrable skills are the only aspect of “traditional” real world connections that Kristen finds necessary, though she does not make this real world connection often. When she does, her main focus is what students will need in their next mathematics course. Kristen favours algebra and graphing, and, if applicable, factoring. She feels that students are not prepared for their next course, and therefore ill equipped for the real world, if a teacher has missed these skills:

If it is not going to help them next year, then I am not that interested... I don't want to open a textbook that tells me how astronauts use math, because that is irrelevant. That is not real life to me. My students are definitely not astronauts. Yet. But if I don't teach them to graph and factor they will never be astronauts.

Kristen would like to help students make use of tools already at their disposal. For example, students have cell phones in their lives and, to prepare them for the real world, Kristen thinks we should be training students to use these devices to aid them in thinking mathematically.

There are some skills Kristen builds in her students to aid them in the real world that she did not view as being real world connections. However, she does agree that these are *transferrable skills* that are useful to students in their real world. Kristen's

main focus is integrity. She keeps them honest by using *goal setting* and self-assessment. Responsibility is key, as it builds students' *independence* and *self-awareness*. Additionally, Kristen uses "mindful minutes" to check their *self-awareness*. During a "mindful minute", Kristen asks students to stop what they are doing and asks them to think about if they have been using their time wisely to benefit their own learning.

4.8. Summary

As exhibited by the above cases, the seven teachers have varying views on real world connections. We can see trends among several of the responses; such as the motivations teachers have for making such connections. The table below, Table 2, summarizes the number of times a code is mentioned by each interviewee. When the number is in bold, this indicates that an interviewee spent a significant amount of time discussing the code, and was not only addressing it briefly.

Table 2 Codes mentioned by interviewees

Codes	Interviewees						
	Jessica	Elizabeth	Samantha	Kyle	Chad	Duncan	Kristen
Advanced mathematics	3	6	2	4	4	2	
Authenticity		2		2	1	1	1
Collaboration	1					2	
Communication		2	1			6	
Curriculum		1		1	6	5	1
Estimation						2	
Group work	1	1	1			4	1
Hands-on					6		
Independence	2	1	2			2	1
Measurement	1				8		
Motivate students					1	1	1
Need more resources	1	1	2	2	2	2	
Need more time	1	2	2	1	5	1	
Problem solving	2	1	1				
Reasoning/logic		1			2	2	

Codes	Interviewees						
	Jessica	Elizabeth	Samantha	Kyle	Chad	Duncan	Kristen
Self-awareness	1		3	2	1	1	4
Transferrable skills	3	3		1		3	1
Understanding	1						
Word problems	2	3	1	5	4	1	2
Art/Beauty of mathematics			1				4
Careers				3		1	2
Community	1		2			1	1
Explicit with students						3	
Goal setting				2			1
History			1		1		
Interest or enjoyment	1	1				3	1
Make mathematics realistic or relevant			1	1	2	1	
Online as a resource		1	1			1	
Planning connections	1	1	1		4		
Prerequisite mathematics skills				1			2
Presentation (neatness)		1			4	1	
Provide context			2	1	2		
Reading/literacy			3				
Relationships	1						2
Research skills		1	1				
Staff as resource	1				1	2	
Stories			3	1		1	
Talking or discussions	3	1			4	1	
Technology		2	1				1
Textbook	1		2	4	1		

In cases one through five, the participants all seem to have somewhat similar views. These five participants value creating context and understanding for their students through real world connections. They find advantages to making personal connections, such as building from student discussions or telling stories in order to make connections. The sixth case showed a slightly different view as to what a real world connection is, but this participant still aligns with many of participants one through five in the skills he

hopes his students will acquire. The seventh participant has a completely disparate view of real world connections, and does not see real world connections as a place of importance in mathematics classrooms. Several themes are apparent across these teachers' experiences and values; these will be described and analyzed in the next section.

Chapter 5. Cross-case Analysis

Throughout the seven cases, there were many common themes that emerged:

1. Teachers' Perception of Real World Connection (TP of RWC)
2. Personal Connections (PC)
3. Context versus Connection (C versus C)
4. Process-based Skills (PS)
5. Curriculum and Resources (C and R)
6. Textbook and Word Problems (T and WP)
7. Awareness of Connections (A of C)
8. Mathematics-based skills (MS)
9. Other (O)

Grouping similar codes together created themes. Codes that were similar in nature were combined together. Codes that had multiple references in NVivo were used. Multiple references means that three or more participants referenced the code. Some codes contributed to more than one theme. This was a subjective process where I had to make a decision as to whether certain codes belonged together, and in which theme codes should belong to. The names of the themes were also subjective, and created by my senior supervisor and myself as a descriptor of the codes contained within the theme. The number of codes within a theme does not indicate that a theme is more or less important than another. For example, Process-based Skills contains nine codes, whereas Personal Connections contains two. This does not mean that Personal Connections are less important or significant than Process-based Skills.

The table below (Table 3) gives the codes that were similar in nature and combined for each theme. The abbreviations for themes given in the above list correspond to the themes in the table.

Table 3 Codes that created each Theme

Codes	Themes								
	TP of RWC	PC	C versus C	PS	C and R	T and WP	A of C	MS	O
Advanced mathematics					✓	✓			
Authenticity						✓			
Collaboration				✓					
Communication				✓					
Curriculum					✓				
Estimation								✓	
Group work				✓					
Hands-on	✓								
Independence				✓					
Measurement								✓	
Motivate students	✓								
Need more resources					✓				
Need more time					✓				
Problem solving				✓					
Reasoning/logic								✓	
Self-awareness				✓					
Transferrable skills							✓		
Understanding			✓						
Word problems						✓			
Art/Beauty of mathematics	✓				✓				✓
Careers	✓								
Community			✓						
Explicit with students							✓		
Goal setting				✓					
History									✓
Interest or enjoyment			✓						

Codes	Themes								
	TP of RWC	PC	C versus C	PS	C and R	T and WP	A of C	MS	O
Make mathematics realistic or relevant	✓		✓						
Online as a resource					✓				
Planning connections							✓		
Prerequisite mathematics skills							✓		
Presentation (neatness)				✓					
Provide context			✓						
Reading/literacy									✓
Relationships			✓						
Research skills				✓					
Staff as resource					✓				
Stories		✓							
Talking or discussions		✓							
Technology									✓
Textbook					✓	✓			

As previously stated, codes were amalgamated to create the themes. Below is a brief description of each theme:

1. 'Teachers' Perception of Real World Connection' discusses what interviewees believe to be a real world connection and why they may make real world connections.
2. 'Personal Connections' is when a teacher makes an attempt to reach an individual student in their class by answering their question and building on this through discussion. Personal connections may also be teachers telling their own stories in the hopes to make mathematics more interesting for students who may not be innately interested in mathematics.

3. 'Context versus Connection' explores how teachers seem to use real world connections as a way to give mathematics context rather than seeing the connection as being important on its own.
4. 'Process-based Skills', which were discussed in 2.1, explores how teachers see skills such as communication, collaboration, and self-awareness, among others, as being real world connections in their classrooms.
5. 'Curriculum and Resources' looks at teachers views on their resources, as well as how they see the curriculum effecting their ability to make real world connections.
6. 'Textbook and Word Problems' discuss how teachers feel about using the textbook and word problems as a real world connection.
7. 'Awareness of Connections' was created based on observations of lack of examples throughout the codes, as well as participants' answers to the specific interview question of whether they made connections in their classrooms unintentionally. Are teachers making the connections intentionally, and are teachers being explicit with their students that real world connections are being made?
8. 'Mathematics-based Skills', which were discussed in section 2.1, explores whether teachers are making real world connections using mathematical skills.
9. The 'Other' theme was made of codes that fit a variety of categories. These included codes that may have had fewer than three references, but participants who referenced these topics found them important or placed emphasis on them were included. Some codes were interesting due to their lack of mention from multiple participants. I deemed these codes of interest despite not falling into a previous theme.

Teachers all had their own view of what a real world connection was, and they identified their motivations for making connections. Interviewees were all able to identify areas that could use improvement, and ways in which they could make more connections. Issues surrounding curriculum were commonly discussed, as were the types of skills teachers wished students would acquire and build in their classrooms. However, some themes were only present among a portion of the interview responses, yet were seemingly important to those interviewees. Some identified unique perspectives that were not found in other responses, but were interesting enough to be mentioned.

5.1. Teachers' Perception of Real World Connection

There was no consistent notion of what a real world connection is among the interviewees. While some beliefs aligned, there were multiple definitions of “real world connection” that arose during the interviews. As mentioned in the case studies, Jessica sees a real world connection as something students can use outside of the classroom and to *make mathematics relevant*.

I find that geometry is where I make the most connections because you can connect it to things they have at home or things that they might do at home...To me teaching them whatever concept you're trying to teach but have it connected to how can I use this at home? Or how could I use it elsewhere? (Jessica)

Elizabeth and Samantha agree, claiming that real world connections are anything students will use “after they get out of our classes”. Duncan and Chad added that they make these connections to *motivate students*. Kyle sees a real world connection as connecting the mathematics to a bigger picture, such as a specific job or *career*.

When I think about real world connections, I'm thinking about how mathematics is used to, say, do engineering or do something bigger...like trigonometry, for instance...what is that used for? What am I learning this for? And you go, well you would use this later on if you were an engineer. (Kyle)

Duncan sees real world connection as “a way of thinking and doing math”, rather than looking at the mathematics itself. Chad's perspective was especially unique, believing that a real world connection is some sort of “tangible learning”, such as when students are able to touch and feel the mathematics (*hands-on*), or do a physical activity. Kristen did not provide an interpreted definition of real world connection, as she finds them “irrelevant” and prefers to focus on the *beauty of mathematics*.

There was no clear definition that teachers were able to come up with, especially between Chad's definition and Kristen's avoidance of real world connections. If we focus on the other five interviewees, it seems as though they agree that real world connections seem to have sort of importance outside the classroom, whether that is something students will use directly in their lives or potentially use in the future. These

definitions all fit within the broad range of definitions of real world connection provided in the literature. Businskas (2008) found that for teachers in her study, real world connections were anything students may encounter outside the classroom that they can relate to. This fits well with Samantha, Jessica, and Elizabeth's definitions. Kyle and Chad's definitions fit into Gainsburg's (2008) list of possibilities for real world connections, including *discussion* of mathematics in society and *hands-on* representation of mathematics concepts. Duncan was the one participant whose definition fit into seeing real world connection as being a way of learning. Businskas (2008) and Boaler (1993) suggested that we are teaching students skills that they can apply to their real life and that we are teaching them in a real world environment, respectively. These six participants' definitions all fit within my working definition of real world connection formulated after reviewing the literature: connecting to something students will, or could, encounter outside of their current mathematics classroom. This may not necessarily be a mathematical encounter, but rather anything that students could experience or make use of.

5.2. Personal Connections

When students ask a question and it turns into *discussion*, teachers have made a real world connection that is personal for their students. Jessica tries to connect mathematics to something students might see at home, or something they might encounter elsewhere in their lives. Jessica, Chad, and Samantha like to build on students' comments or questions to create *discussion* that makes the connections *relevant* to students' personal lives. Chad finds that most of his connections, contrary to his definition of real world connection, come from students and their questions or *discussions* that arise spur of the moment.

I think for myself it's more relatively spur of the moment kind of thing, just talking about something that is real...it's so realistic that I can see this is what happens...For example, the grocery store has unit prices on their price tags, and now you know what they're used for, you know what it means, that is a real world connection. (Chad)

Chad adds that he wants “more of this to come from the students” rather than be some activity that he has planned. Duncan tried making personal connections by telling *stories*, usually about himself or his experiences.

In a lesson yesterday, it was about taxis in New York City and how I am able to dazzle my friends about how many taxis are in New York City and involved combinatorics. Another one was my favourite gelato place. (Duncan)

Kyle creates personal connections by bringing in popular videos from YouTube or examples that he knows they will connect with based on the conversations he has had with his students and the relationships he has formed with them, such as telling *stories* about bike riding.

5.3. Context versus Connection

It seems that they use real world connections as a vehicle to deliver *curriculum* in a way that will *interest* students. While Kristen was an outlier in her views on real world connections, she does find that sometimes these connections are made naturally in her teaching, when she needs to emphasize “the practicality of math”. She disagrees that students need to be told when they will later need something that they are learning, or that a *context* needs to be provided to make the mathematics meaningful. Elizabeth had claimed that she wants to increase student *interest*, while Jessica cited *interest* and *understanding* as to why she makes real world connections.

My motivation is you want students to be interested in the topic. You want them to see that there is use of this math and their learning. (Elizabeth)

Duncan also finds that using his method of real world connections, by doing mathematics in a *collaborative* environment, enhances student *interest* and *enjoyment*.

I find it is a more interesting way of teaching...kids gain some experience and some transferable skills that way. And I think it's probably more enjoyable for the students. (Duncan)

Kyle directly states that he uses real world connections as a way to build *context* for his students. Chad says, “the main motivation is to give them some context” and that “it makes [mathematics] more realistic”. It seems that participants are making connections in order to engage students and increase *understanding* of existing curricular topics, rather than teaching real world connections because they are a benefit in and of themselves. Teachers are making real world connections as a way to contextualize curriculum rather than seeing an importance in the real world connection on its own.

5.4. Process-based Skills

It was common for teachers to have a longer list of acquired process-based skills than mathematical topics in their responses. Teachers were able to identify many process-based skills that they wish their students would build in their classrooms, and few were able to identify real world connections that consisted of mathematical knowledge. When asked if there are skills they see themselves trying to develop in students specifically because these skills will serve students in real life, interviewees tended to answer with process-based rather than mathematics-based skills. They mentioned skills such as *communication*, persistence, and self-reliance (or *independence*), among others. In order to gain insight into specific mathematical knowledge that teachers see as important for students’ real lives, teachers often had to be specifically asked about mathematics skills. However, every teacher interviewed readily identified process-based skills that they saw as important for students to build in their classrooms.

Communication was a skill that was mentioned most commonly, by Jessica, Elizabeth, Samantha, Chad, and Duncan. Elizabeth finds that the students “can do the math but often they can’t explain it”, motivating her to have students practice this skill. Duncan finds that “kids learn more by discussing with each other than they do by just sitting there listening”. Interviewees consistently mentioned *group work*. Jessica, Elizabeth, and Duncan use *group work* with the explicit intention of making the connection to real world.

You have to work collaboratively and reason with your partner and you have to be able to explain and ask questions. (Duncan)

Continuing on this theme, Jessica, Duncan, and Samantha value *community* and relationships. They build this through *group work*. For Jessica, this builds through vertical surfaces and random groupings, as she finds that “the sense of community develops in the classroom and relationship that the students build are very good”.

Students learn to build *independence* as a real world skill, which Jessica and Elizabeth passively develop as by-products of other aspects of their classrooms, as Elizabeth says that even though *group work* is important, students “still need to solve problems on their own and not always rely on others”. Samantha and Duncan spend more time actively instilling this in their students, and reinforcing the importance of this skill outside of their classrooms. Samantha finds that by building this *independence*, students also develop persistence when encountering a tough problem. Jessica passively develops *problem solving* and *self-awareness*. Duncan also views these as important real world connection skills he actively builds in his students.

One of the skills I have been trying to work on with my students as I move forward is being self-reflective. I just gave my grade 12s a project that is half reflective and half research as a final cumulative kind of thing...I wanted to have them be reflective about their learning.
(Duncan)

Kristen also works on *self-awareness* in her classrooms, by integrating “mindful minutes” for students to reflect. Kristen does not see this as a real world connection. Even though *group work* was mentioned often as a significant process-based skill for students to be able to participate in, *independence* and *self-awareness* are also viewed as skills of importance.

Some skills were only briefly mentioned, or scarcely brought up, by interviewees. Kyle and Kristen work on *goal setting* with their students, and view this as a real world skill that students will use beyond their classroom. Elizabeth and Chad mentioned organization, *presentation*, and *neatness*:

I think being neat about things is missing from a lot of students...they interact with the world through screens and that’s great because screens are neat. So they don’t understand that the real world that they interact with here is not neat. In order for it to be neat, somebody has to do something about it. (Chad)

Elizabeth also tries to build in a *research* project in each class where students will learn how to *research* and *present* in a professional manner. Samantha has tried to build *research skills* in her students as well, but often finds the resources for this limited. Many of the skills mentioned here were interrelated and relied on one another. For example, group work fostered communication, but many interviewees saw these as separate skills.

5.5. Curriculum and Resources

There were many ideas and comments about how the various aspects of curriculum affect how a teacher makes real world connections. The type of content we are required to deliver in our various courses is also a factor as to how often we make connections, in what way we make connections, and how important we find making connections to be. Teachers discussed their views on whether they feel they are making enough connections, and what they feel they need in order to make more.

5.5.1. Resources for Connections

A common response was that *more time* and *resources* are needed to make more connections in mathematics classrooms. Except Kristen, all of the interviewees said *more time* would be beneficial in order to make more real world connections. Elizabeth thought that the set *curriculum* hinders her ability to make connections in the way she wants to. Kyle added that limited experience prevents him from making more connections:

What we know is very narrow. I can't connect it to the real world most of the time because I don't know anything outside of my own little world. So I have a lot of trouble going and connecting those kinds of things effectively. There are some things I can do that with, there are some things I can't. (Kyle)

Kyle adds that he would need more experience or knowledge about other jobs and *careers* to make connections to them, as this is what he views as being a real world

connection. Duncan thought that teachers need more training on how to deliver the mathematics in a way that will foster real world connections.

The interviewees were in disagreement about *lack of resources*, as some, including Duncan and Elizabeth, said that resources are available if you look:

The resources are out there, there are lots of resources...I don't think that resources and time are an issue, I think you can work around that. Honestly, though, I would love to have more resources and time.
(Duncan)

Chad did not find resources to be an issue, either, as he finds that many of his connections are based on student *conversation*, and making personal connections. Jessica, Kyle, and Samantha claimed that *more resources* would be beneficial. Needing more resources may set these teachers up for failure. The likelihood of resources that suit each of their individual definitions and motivations surrounding real world connections being developed is low.

Many interviewees, including Jessica, Chad, and Duncan, noted that other *teachers are a good resource* for finding new ways to make real world connections. For Duncan, this was his primary resource. The *textbook was a primary resource* for Kyle, Jessica, and Samantha. Other resources were *online resources*, such as blogs, and or books other than the provided textbook.

5.5.2. Older versus Younger Students

Teachers found that making connections in the more *advanced grades*, such as Pre-Calculus 11 or 12, is more difficult than in the lower grades, such as Mathematics 8 or 9. The survey results suggested that teachers do not find it as important to make connections in *advanced courses*. However, the interviewees determined that it was no less important to try to make connections in *advanced courses*. Chad raised a new point that perhaps the problem is not simply between higher versus lower courses, but within the *curriculum* itself, citing that the new Pre-Calculus grade 12 course is much more abstract than it used to be (Principles 12), and that the topics within the course are disconnected from each other.

The curriculum has to be radically changed. It's almost like you need to move away from a curriculum. (Chad)

It was also pointed out by Elizabeth that students who have chosen to take the more *advanced courses* are more likely to appreciate the *beauty of the mathematics* and not need the real world connections as often as in younger grades. However, this is contrary to Kristen's entire view on real world connections, in that the *beauty of mathematics* can be appreciated by all ages and grades of students.

Teachers find it difficult to answer the question students ask about "when will we use this?" in courses like Pre-Calculus 12. Even the teachers do not feel like these courses are meant for making real world connections, but rather to prepare students for Calculus.

I always tell my students when they ask "when are we using this in real life"; you're not. We're here for Pre-Calculus to learn how to do Calculus. In Calculus there are ways to use it in real life. But some of these skills there's no way you're going to do that directly, it's to [be able to] go to Calculus. (Jessica)

It is difficult in *younger grades* to assume students will use a skill in a later course, as not all students will continue in the same path. As such, Samantha and Kyle comment that it can be difficult to use prerequisite skills as a real world connection, because it may not be true for all students. Alternatively, Kristen sees *transferrable skills* that students will need in their next mathematics course as the only beneficial real world connection.

When asked for examples of real world connections that teachers make, they listed topics that come from the younger, less *advanced courses*. Surface area, volume, and trigonometry were common topics that emerged. Both Jessica and Elizabeth cited surface area examples, which are topics in Mathematics 8, Mathematics 9, and Foundations and Pre-Calculus 10.

For example, surface area and volume, those are very easy to make connections, and percent. When we get to algebra, sometimes it's harder. (Elizabeth)

Kyle mentioned specifically the *measurement* chapter in Foundations and Pre-Calculus 10. These participants are identifying inherently real world mathematics topics and citing these as real world connections they are making.

5.6. Textbook and Word Problems

For some interviewees, the *textbook* is a prime resource, with Jessica, Samantha, Chad, and Kyle claiming to use it. Our textbooks are directly related to the curriculum we deliver. As mentioned in Chapter 2, the use of textbooks as a resource for real world connections often means the word problems that the textbooks contain.

5.6.1. Textbook

Because the textbook is often our only provided resource, teachers tended to comment on how this affects their ability to make connections. As the *textbook* was Samantha's main source for finding real world connections, she pointed out that it was difficult to use because it was not cohesive, and contained mostly *word problems*.

I mean right now all we are using is the textbook; it's segregated. It doesn't seem cohesive no matter how you slice it. I know this is a chapter on this, but it's not cohesive. (Samantha)

Kyle furthered this idea by supposing that the authors of the textbooks have "the same limited experience with the real world" as he does, meaning that they can only do so much to make real world connections within the textbook. Kyle also feels that the textbooks try too hard to make connections that are not there, so these are "poorly done". Both Samantha and Kyle pointed out that the *textbook fails* to make the tiny sections connect to a big idea or concept. Chad argued that the *textbook* can be confusing, and questions the book's *authenticity*.

It doesn't make any sense. Why would you purposely make these diagrams not to scale just so the kids can't measure them? Shouldn't they just be able to measure them? (Chad)

Chad did state that he felt some of the word problems were “fairly good”, but that not every single one will be. Overall, teachers seem to feel that the textbook is an inadequate resource, and most of the real world connections are word problems. The issue around word problems is discussed in the next section.

5.6.2. Word Problems

Word problems themselves are not a real world connection, according to the interviewees. Jessica made clear that there must be a discussion around the *word problem* in order to make it a connection:

I think it is a real world connection, but I wouldn't say: “here's a word problem, do it.” I wouldn't just hand them or just give them a problem and tell them to do it. I think talking about it we would have a conversation about it and how it is connected and how it makes sense... Just giving the word problems is not making the connection. (Jessica)

Elizabeth says she sees *word problems* as “a story that is trying to assess certain skills”, rather than a connection to the students' real world. Samantha finds that the *word problems* are *inauthentic* and contrived. Kristen expands that *word problems* such as how far a rock will go when you throw it are not real world connections, as they do not help build students' mathematics skills or real world skills. Kristen also finds these types of problems to be *inauthentic* and contrived.

As Jessica clarified, *context* must be considered and discussed when trying to use a word problem as a real world connection. In more *advanced courses*, Jessica finds this especially important.

I think talking about it we would have a conversation about it and how it is connected and how it makes sense...giving the word problem is not making the connection. (Jessica)

Word problems that are unrealistic seem to be the only option for making connections in the *advanced courses*, such as tides and Ferris wheels as mentioned by Kyle and Elizabeth. As mentioned in Kyle's case, these questions devalue any connection being made, as “nobody would ever do that”. Interviewees are in agreement that the more

advanced courses need better options for real world connections than *word problems*, but at the same time these types of courses do not lend themselves well to making these connections.

5.7. Awareness of Connections

In one of the interview questions participants were asked if they made connections unintentionally. This caused participants to really slow down and think about their teaching practice. A common answer was not that they could think of, but other participants were able to identify skills or connections being made that were not necessarily explicit to the students or intended by them, the teacher, as a real world connection. Chad finds that he has students explain their reasoning for why they want something, and tries to teach them self-efficacy.

I don't intentionally talk about it, but self-efficacy within reason. You can advocate for certain things to be done certain ways, but what is your justification for that? When you are demanding, you are not justifying...having them reason out real world functions and have that give and take. (Chad)

Jessica finds that her use of vertical spaces naturally develops a sense of *community* in her classroom. Upon reflecting, she notes that this is a real world connection that is a by-product of her teaching style, but not the reason she chooses to use vertical spaces. She finds that students are naturally building *problem solving* skills due to the nature of her classroom.

I have less and less students coming in after school because they're asking each other. So if they have a question they ask their friends. They're not coming to me because they're actually building those connections and they feel comfortable with each other, so I like that a lot and that's a good skill to have. (Jessica)

Participants' inability to give specific examples about the connections they make also speaks to how intentional their connections are. For example, Kyle had difficulty stating specific examples when he claimed that he uses *stories* or YouTube videos to make personal connections with students. This brings up the question of whether he is

intentionally making these connections or if they just happen in passing. Even when asked if there are connections being made unintentionally, participants had difficulty identifying which connections were possibly being made in their classrooms without the intention of them being real world connections.

Additionally, teachers discussed whether the students were aware they were making real world connections or not. Jessica tries to have students consciously find ways they can connect mathematics:

Things they have at home or things that they might do at home...have students think: how can I use this at home? Or how could I use it elsewhere? (Jessica)

Samantha intentionally tells her students they need to be persistent in their work and learn to be *independent*. She makes students aware that they need to be able to *communicate* and work in *groups*. Duncan claims he needs to be more explicit with his students, especially in *advanced grades*, that the reason they are working in *groups* is because when they graduate and take courses in university, or to a job, they will need to be able to work with peers or colleagues.

5.8. Mathematics-based Skills

As in the discussion of Process-based Skills, there were few participants who referenced a mathematical connection actively being built in the interviewees' classrooms. Chad was one of the only interviewees who cited mathematical knowledge as something he is trying to build as a real world connection in his classroom. He teaches students to *measure* and use protractors and compasses. Duncan also cited mathematical knowledge such as "*estimation, deductive reasoning, and logical thinking*". Elizabeth mentioned *logical thinking* as well, but did not view it as a mathematics skill that she actively builds in her students, rather one that she thinks her students happen to possibly gain. It was rare that interviewees mentioned mathematics skills on their own, as they did with the process-based skills. Often, these mathematics skills were viewed as secondary to the process-based skills in importance of what teachers hope their students will acquire in their classes.

5.9. Other

Some topics were brought up infrequently, either only being mentioned by one participant, or only mentioned in passing by multiple participants. However, when viewed together, we can see that these topics reflect teachers' beliefs surrounding real world connections, possibly as a result of their own mathematics background and experiences. For example, Samantha and Chad both mentioned *mathematics history* as being a potential real world connection, but they were unsure as to how they could elaborate on this and make mathematics history relevant for students.

For example, very loosely defined, if I were to start talking about the history of the triad, that could be a real world connection, and in the end it doesn't really fall in math. So is that a real world connection or is that another thing? (Chad)

They may see *mathematics history* as being a real world connection because it is not an abstract problem, but rather a concrete example of something that has happened in the real world outside of their classrooms. However, students may not see *mathematics history* as a connection to their real world, and therefore may find it irrelevant.

During her entire interview, Kristen reiterated that real world connections are not important to her, but rather the *beauty of mathematics* is what is important. Students need to learn to “appreciate the complexities” of mathematics, and see the *beauty* in an interesting problem. Chad was the only interviewee who mentioned *measurement* as being a real world connection. By measurement, he was meaning physically being able to measure mathematical objects or do mathematical measurement problems, and using “math tools”. Samantha finds that *literacy* is necessary for students to be successful in the real world, and that this skill can be built in mathematics classes. However, she finds that since the *textbook* is her only provided resource, she must spend the time finding resources that support building *literacy* in a mathematics classroom. Elizabeth is the only interviewee who mentioned trying to have students use current *technology* as a way to connect to the real world. For example, she uses the Desmos website and graphing app for students to create more complex graphs than would be possible by hand. These can also be used to solve problems that would be difficult without technology. These are all ideas that are valid to consider, and could be integrated into

the idea of real world connections. These topics need to be elaborated on or discussed further to see if they are true for the greater teacher population.

Despite the commonalities in the interviewees' responses to the above topics, Kristen was an outlier with few similar views to the other participants, and did not fit into many of the above themes. Other participants did not reference the majority of the codes used for Kristen. While Kristen does build process-based skills in her students to benefit them in real life, *self-awareness* and *goal setting*, she identified one real world connection for mathematical purposes: building *transferrable skills* students can use in the next course they will take. Instead, Kristen focuses on the *beauty of mathematics* and tries to instill in her students that numbers do not need a purpose to be important or interesting.

5.10. Summary

From the above analyses, it is evident that teachers value a variety of skills and activities as related to real world connections. All of the teachers identified process-based skills, such as *collaboration* or *independence*, as being important for students to build and considered these as being a form of real world connection. There was no consistent definition as to what constitutes a real world connection, though a common definition was that real world connections are something students can use outside of the mathematics classroom. Teachers had a variety of motivations for using real world connections, however, creating *context* was widely identified as a motivator. Additionally, few teachers identified mathematics skills, such as *measurement* or *estimation*, not necessarily included in the curriculum. Teachers spend time developing these skills in their students anyways. Personal connections were commonly identified as a way to make real world connections, by responding to students' questions or telling *personal narratives*.

The issue of real world connections and the *curriculum* was a widely discussed topic. Teachers agreed that more *advanced courses* such as Pre-Calculus are more difficult to make real world connections in, and are not always possible due to the nature of the courses. However, teachers did agree that making connections in these courses

are still important. In addition to courses, teachers discussed the issue of a *word problem* being used as a real world connection, and how our *textbooks'* reliance on word problems hinders our ability to make meaningful connections. Finally, teachers also commented on whether the *curriculum* prevents them from making more connections, and that, overall, they feel they *need more resources* and *time* in order to increase the effectiveness of the real world connections they are making.

Chapter 6. Conclusions

I began this research in an effort to better understand how secondary mathematics teachers view and approach real world connections in the hopes that it would help me understand and incorporate connections in my own teaching practice. This research provides some insight into teachers' views on real world connections, and perhaps sheds some light on where flaws are in teaching practices, resources, and training.

6.1. Addressing the Research Questions

The main intent of the study was to investigate how and why teachers use real world connections in their secondary mathematics classrooms, and what they view real world connections to be. After an in-depth analysis of teacher interviews through analytic induction, the research questions stated in Chapter 2 can now be addressed.

1. *What do teachers view as being a real world connection?*
2. *How and why do teachers make use of real world connections in secondary mathematics classrooms?*

6.1.1. What is a Real World Connection?

Even at the conclusion of the interviews, there was no consistent interpretation of what a real world connection is. As discussed at the end of 2.1.1, these many interpretations vary as greatly as using 'real world connection' as a verb or as a noun: a connection being something we do versus a connection being something we have. However, a common definition was that real world connections are something students can use outside of the mathematics classroom. Also included in the definitions were that a real world connection is a hands-on, tangible learning experience, a real world connection links a mathematical concept to a bigger picture such as a job or career, and that a real world connection is a way of doing mathematics. Additionally, one participant declined

to provide a conventional real world connection definition, stating that instead she saw mathematics through beauty and art and that to her, that was her real world connection.

6.1.2. How do Teachers use Real World Connections?

There was no standard way in which the teachers interviewed used real world connections in their classrooms. However, it was clear that most teachers focused on process-based, non-mathematical skills as important for their students in the real world. Even Kristen, who did not view real world connections as being important at all, finds herself building independence and self-awareness. There was an abundance of skills listed by interviewees, including communication, goal setting, group work, and collaboration. Every interviewee mentioned process-based skills that they found important, though some interviewees like Jessica, Elizabeth, and Samantha, had more skills listed than others. Duncan views these skills as being the definition of real world connection, seeing these as a “way of doing math” and instilling in his students an ability to function effectively in the real world.

Few teachers identified mathematics skills that they emphasize with their students. Chad was perhaps placed the most importance on mathematics skills, focusing on measurement skills specifically. This could have in part been due to the nature of the courses he teaches, working with Apprenticeship and Workplace students and younger grades. Elizabeth and Duncan also mentioned logic skills as being important, but did not provide examples or see this as being as important as the non-mathematical, process-based skills they build in their students.

In addition to focusing on skills, both mathematics and process-based, as a way to make real world connections, some teachers mentioned using personal connections. Jessica, Chad, and Samantha like to use student-initiated discussion as an opportunity to make real world connections that are then inherently personal to individual students. Kyle tries to relate mathematics to students by finding examples that have to do with something students are interested in, which he learns by forming personal relationships with students. Duncan uses personal narratives and stories to make connections with

his students. These are all examples of teachers making real world connections by connecting them with the students' personal lives or experiences.

6.1.3. Why do Teachers Make Real World Connections?

Teachers seemingly make connections for a variety of reasons, though most common appears to be to create context and interest for students. Kyle and Chad cited context as their motivation for making real world connections, while Jessica, Elizabeth, and Duncan claimed that motivating students and creating interest for them is a big part of why they make real world connections. Even though Kristen does not believe there is an importance in making real world connections, she says that when she does make them, it is to emphasize that mathematics can have a “practicality”. Samantha makes connections for similar reasons, in that she wants to show students that people do mathematics outside of school and a practicality can exist.

Whether or not teachers make real world connections and why they do so seems to be somewhat dependent on the course(s) they are teaching. When discussing the curriculum and their ability to make connections, teachers stated that they did not find it any less important to make connections in more advanced or older classes, but that it was more difficult. As such, teachers make connections in the younger or less advanced courses because it is easier to do.

In addition, teachers make connections if they have the resources and time. The interviewees were in disagreement as to whether they had adequate resources to make enough connections as Duncan and Elizabeth claim the resources are there, you just have to look. Samantha was concerned that the resources are school dependent, and that sometimes the textbook is the only resource you are given, which she feels is inadequate. However, interviewees all agreed that more time would allow them to make more connections in more meaningful ways and that sometimes the reason they do not make connections is that they do not have the time.

6.2. Research Considerations

Teachers make real world connections for a variety of reasons in a variety of ways. It is unclear if there is a one-size-fits-all method of making real world connections that would benefit all students and fit all teachers' teaching beliefs and styles.

6.2.1. Limitations

Due to the small scale of this study, with 19 survey respondents and seven interviewees, perhaps with a larger study we would see even more of a range of definitions for real world connection, as well as more ways teachers make real world connections in secondary classrooms. Teachers were not observed in their teaching practice, so data is based on teachers' own belief of their practice rather than an objective party interpreting their teaching practice. Additionally, all interviewees were taken from the same school district, and thus may reflect a district trend of inconsistent views. Rather, if teachers were interviewed from across a variety of districts, a more cohesive view on real world connections may emerge, or alternatively we may see an increasingly diverse range of interpretations.

6.2.2. Implications

Future research might look on a larger scale at how teachers are implementing real world connections in their classrooms, possibly through observations, and if this is meeting the requirements for real world connections to be beneficial for students. Can we find a way of making real world connections that fits teacher motivations and beliefs but will fully benefit students? Looking into whether there is a reason that teachers are not emphasizing mathematics skills and connections, and if this were affecting how students are learning, would be a possible avenue for future research. In addition, it would be interesting to look at teachers who cited that more resources would enable them to make more connections. If teachers were given more resources, would their practice actually change?

I find it interesting that there are no implementation strategies given to teachers when the importance for students is stressed in previous research as well as British Columbia Ministry of Education documents. In addition, the study highlights the issue that official documents require real world connections without specifying what these are or how to include them in the curriculum. As found in the interviews and literature, teachers find they lack resources and time. Perhaps an improvement in teacher training and education would increase teacher confidence in their ability to make real world connections without increasing resources.

6.3. What I Have Learned

6.3.1. As a Teacher

As a newer (first five years) teacher, I agree with the participants that more time and resources are needed to make more connections, however I previously thought this was precisely because I am a newer teacher. I also wondered whether I was the only teacher who had difficulty making real world connections in the more advanced courses, such as Pre-Calculus 12, and that I was the only one who found the textbook word problems to be insufficient at accomplishing this. I was pleased to encounter other teachers who find the same difficulty, and also reassured that it is not always necessary to try to make a connection when there may not be one to make. Rather, the mathematics itself may be beautiful, or be a stepping-stone for the students to a later course or topic. However, this means that perhaps some resources need to be developed to help teachers make meaningful connections in these more advanced courses, as there is a trend that the textbook word problems are not sufficient, yet it is time consuming and difficult to make efficient connections without the necessary resources or training.

Although the literature had concluded that there was no consistent definition of real world connection, I was surprised at how consistent the participants' responses were in their definitions, despite there only being seven interviews. If there were to be a study with more participants, I would be interested to see if this trend would continue, or if the definitions would become increasingly diverse. I feel as though due to the variety

of responses and views exhibited by the participants, I have had my eyes opened to new possibilities in exposing my students to real world connections, and thus hopefully fulfilling the British Columbia Ministry of Education documents' requirements to a higher degree. However, I feel as though I have learned that "real world connection" is extremely subjective and there is not necessarily a right or wrong way for it to be interpreted.

6.3.2. As a Researcher

Throughout this process of researching and writing a thesis, I have learned that I am able to be a self-motivated, autonomous learner. I was able to benefit from qualitative feedback from my supervisor, such as comments on my progress and edits on my writing. I learned that I am able to complete something when I put my mind to it, and I was able to prioritize completing the research and writing of this thesis. I spent many weekends and much time during the summer trying to complete as much as possible, and chose this over other activities. I used previous masters theses to help me with my weaknesses, such as transitions, introductions, and conclusions as a guide to improve my own writing.

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Appendix A.

Teacher Online Survey



SIMON FRASER UNIVERSITY
FACULTY OF EDUCATION

SIMON FRASER UNIVERSITY

ONLINE SURVEY FOR BURNABY (SD#41) TEACHERS

Title: How and Why Teachers Make Real World Connections in the Secondary Math Classroom

Investigators: Suzanne Wuolle

School: _____

Best way to contact you (OPTIONAL): _____

Should you be selected for an interview, would you be willing to participate in such?

(Please clearly write YES or NO): _____

What grades/courses do you currently teach?

What other grades/courses (if any) have you taught in the past 3 years?

Questions

For each statement below, please select one of the following answers:

Strongly Agree, Agree, Disagree, Strongly Disagree, N/A

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
1. Connecting math to the real world is extremely important in Math 8.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Connecting math to the real world is extremely important in Math 9.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Connecting math to the real world is extremely important in Apprenticeship & Workplace 10.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Connecting math to the real world is extremely important in Foundations and Precalculus 10.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Connecting math to the real world is extremely important in Apprenticeship & Workplace 11.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Connecting math to the real world is extremely important in Foundations 11.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Connecting math to the real world is extremely important in Precalculus 11.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Connecting math to the real world is extremely important in Foundations 12.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Connecting math to the real world is extremely important in Precalculus 12.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Please check each method you use to connect math to the real world.

- Telling stories
- Assigning tasks to be completed outside of the classroom (for example, at home)
- Relating math to careers or jobs
- Assigning real world problems
- Relating math to student interests or lives
- Assigning students hands-on activities or projects that replicate a real scenarios (for example, design and build a cereal box with certain Surface Area or Volume)
- Bringing artifacts into the classroom (for example physical products or real data)
- Relating math to a historical event, person, or discovery

Please select the 3 methods you use most often to connect math to the real world. Number them 1-3, 1 being the most often.

- Telling stories
- Assigning tasks to be completed outside of the classroom (for example, at home)

- Relating math to careers or jobs
- Assigning real world problems
- Relating math to student interests or lives
- Assigning students hands-on activities or projects that replicate a real scenarios
(for example, design and build a cereal box with certain Surface Area or Volume)
- Bringing artifacts into the classroom (for example physical products or real data)
- Relating math to a historical event, person, or discovery

Do you assign tasks to your students where the *process* is a connection to the real world? For example, you may ask students to collaborate with one another, which is something they will inevitably be asked to do outside of a school setting, in the real world. Can you think of other tasks where the *process* is the connection to the real world?

Appendix B.

Sample Teacher Interview Questions

Note: Surveys will help inform additional interview questions. Participants' responses to existing questions may prompt additional questions or clarifying questions. Having said that, below are anticipated questions that will be asked. Any further questions will be similar.

Questions about Participant's Teaching History

1. How long have you been teaching for?
2. What courses are you currently teaching?

Questions about Making Connections

1. What is your motivation for connecting mathematics to the real world?
2. What would help you make more connections to the real world in your classroom?
3. What is the most common reason you decide to make a real world connection?
4. Where do you find resources to support making connections?
5. Are there skills you see yourself trying to develop in students specifically for the purpose of serving them in real life?
6. Are there skills you just happen to develop in the teaching of mathematics that you think will also serve them in real life?