

**SOCIETAL VIEWS OF MATHEMATICS AND MATHEMATICIANS
AND THEIR INFLUENCE ON ELEMENTARY STUDENTS**

Jennifer Hall

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Thesis Advisor: Dr. Christine Suurtamm

Thesis Committee Members:

**Dr. Richard Barwell
Dr. Sharon Cook
Dr. David Trumpower
Dr. Joel Westheimer**

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Abstract

Prior research has shown that negative attitudes toward mathematics are linked to decreased achievement and participation, but it is unclear what factors influence children's attitudes toward mathematics. Thus, the overarching goal of this study was to understand the relationship between outside sources and children's views. Specifically, this study investigated elementary students' experiences with and views of mathematics and mathematicians, and the ways that their views may be influenced by popular media representations, parents' views, and teachers' views of mathematics and mathematicians. Additionally, the study examined whether there were differences between girls' and boys' views and between younger (Grade 4) and older (Grade 8) elementary students' views of mathematics and mathematicians.

Framed by a social constructivist and feminist epistemological stance, the study employed a multi-method framework comprised of questionnaires ($n = 156$), drawings of mathematicians ($n = 94$), and focus group interviews (five interviews, involving 21 participants) with students; an analysis of children's media (43 examples across five media types); interviews with parents (11 interviews, involving 13 participants); and interviews with teachers (nine interviews, involving 10 participants). In terms of their relationships with mathematics, the student, parent, and teacher participants' views were encouraging, both in terms of perceptions of themselves as learners of mathematics and of the utility of mathematics. However, the manner in which the participants conceptualized mathematics tended to lack breadth, often focusing on arithmetic and financial mathematics. Similar conceptions of mathematics were evident in the media representations. Moreover, media portrayals of mathematicians and mathematically proficient people tended to perpetuate stereotypes. Despite their awareness of these stereotypes, the participants often lacked alternative representations to challenge these views. Indeed, the lack

of exposure to a variety of representations of both mathematics and mathematicians contributed to the participants' reliance on views that were often narrow and stereotypical.

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CHAPTER 1: INTRODUCTION

It all started with a pair of pyjama pants. While that may be an unusual first sentence for a Ph.D. thesis in Mathematics Education, it is indeed the case: My inspiration for investigating this topic was incited by discovering a pair of pyjama pants at a women's clothing store that were repeatedly emblazoned with the phrase 'I'm too pretty to do math'. I was appalled by the message on these pyjama pants, and I wrote to the company to complain about what I perceived to be a terrible lack of judgement, as well as sexism and stereotyping (Notably, I never have received a response, even after sending multiple messages to the company). To begin, I was disgusted by the notion that one's physical attractiveness (which, of course, is completely subjective) would be linked to one's ability – or, at least, one's choice – to do mathematics. The message on the pyjama pants seemed to suggest that those (women) who do mathematics are not attractive. I found the phrase problematic for two further reasons. First, I questioned why mathematics was the subject of choice, as opposed to, for instance, printing the pyjama pants with phrases like 'I'm too pretty to read' or 'I'm too pretty to do [any other subject]'. As I will discuss next, it has become socially acceptable in North America to claim a lack of competency and a strong dislike for mathematics, while a parallel certainly does not hold true for reading. That is, innumeracy is socially acceptable (and even, to an extent, promoted by various technological tools that eliminate the need to do even the most basic mathematics), while its complement, illiteracy, is not. My other concern pertained to the fact that the pyjama pants were sold in a women's clothing store. I highly doubt that a pair of pyjama pants emblazoned with the phrase 'I'm too handsome to do math' would ever be sold in a men's clothing store. As will be discussed, the continued tendency to link mathematics with men and masculinity perpetuates societal acceptance of women's discomfort with and dissociation from mathematics.

While I have always been conscious of media and societal messages about mathematics, mathematically proficient people, and gender, I became even more so through experiences in my graduate-level studies. My master's thesis explored the experiences of women who were enrolled in undergraduate mathematics degree programs, investigating the factors that contributed to their selection of and perseverance in the field. During my doctoral comprehensive examinations, one of my papers focused on feminist research methodologies in mathematics education. Through these academic experiences, as well as further reading and research, I have become particularly attentive to the gendered relationships involved in mathematics education and, as I will discuss in the Theoretical Framework chapter, the use of gendered language.

Beyond my academic forays into the topic of gender and mathematics, the fact that I am a young woman involved in university-level studies in mathematical fields (Applied Mathematics in my undergraduate degree and Mathematics Education in my graduate degrees) makes me susceptible to being exposed to comments that reflect societal biases and stereotypes. When I inform people of my area of study, I am nearly always met with a strong reaction, which typically is either 'Oh, you must be so smart!' or 'I never liked/was good at math'. While these two comments could be perceived as linked, the former type of comment likely relates more to the notion that mathematical ability is linked to high levels of intelligence in general.

Beyond the messages about gender and mathematics, mathematics phobia, innumeracy, and stereotypes about mathematically proficient people, one further message to which I am often exposed is the notion that, since I enjoy, study, and do well in mathematics, I must be a 'math geek'. While the term 'geek' has been reappropriated (Galinsky, Hugenberg, Groom, & Bodenhausen, 2003), it tends to be related to notions of being socially awkward, obsessed, and interested in topics that are deemed 'uncool' by most people. Yet, I have several times been

called this term to my face (upon mentioning my association with mathematics), sometimes by complete strangers. The most troubling instance occurred at an airport, when I was dealing with a border security agent. Upon informing the agent that my reason for travelling to the U.S. was to attend a mathematics conference, he responded, “I guess you’re a big geek then”. I was completely taken aback and didn’t know how to respond to this highly unprofessional comment. I eventually sputtered out, “Yeah, I guess I am”. After completing the rest of the standard questions, I was permitted to depart, upon which the agent bid me farewell by saying, “Bye, Miss Nerdy!” I shot him a dirty look and carried on my way, troubled by the encounter – both at his immediate perception that, as someone attending a mathematics conference, I must be a geek, and that addressing me, a stranger and ‘customer’, as such was somehow appropriate. Upon relaying this story to my friends who are involved in mathematics fields, I learned that such encounters with complete strangers are certainly not uncommon. Next, I discuss this cultural milieu more generally and provide justification for the necessity of my study.

Context

In many Western nations, including Canada, people tend to fear and/or dislike mathematics and fail to see its relevance to their lives, yet feel unashamed (or even proud!) of their lack of mathematical skills (Boaler, 2008; Burns, 1998; Paulos, 1988). Similarly, mathematicians are viewed in a negative and stereotyped manner, as White, middle-aged men who are socially inept and unattractive (Hersh & John-Steiner, 2011; Mendick, Moreau, & Hollingworth, 2008; Picker & Berry, 2000, 2001). These views are perpetuated by Western media, which portray mathematics as a difficult subject only understood by a select few (Applebaum, 1995; Mendick, Epstein, & Moreau, 2007); these ‘few’ are often portrayed as the negative stereotypes mentioned above. Since most people have neither met a mathematician in

‘real life’ nor studied mathematics beyond secondary school, they do not have any means to challenge the media representations¹. These negative representations are problematic because they may unduly influence children’s views of mathematics and mathematicians before they have a chance to form their own opinions, based on their own experiences. Several studies (e.g., Ma, 1999; Singh, Granville, & Dika, 2002) have shown that negative attitudes toward mathematics are connected to decreased participation and achievement, which, arguably, leads to low enrolment in mathematics-focused fields of study at university and in related careers, such as the current situation in Canada.

At the university level, there have been substantial declining trends in participation in mathematics and related fields in recent years. Enrolment in mathematics, computer science, and information science² (herein referred to as ‘mathematical fields’) at Canadian universities decreased by 26.4% from 2001/2002 to 2006/2007 (Statistics Canada, 2010a). This stands in stark contrast to enrolment in all other fields of study, which had an increase of 21.7% in this time period (Statistics Canada, 2010a). Only 8,547 students graduated from mathematical fields in 2007, a mere 3.54% of all Canadian university graduates (Statistics Canada, 2009).

Participation in mathematical fields of employment is even lower: In Ontario, for instance, only 0.056% of adults employed in 2006 were in the mathematical careers of mathematicians, statisticians, and actuaries³ (Employment Ontario, 2009; Statistics Canada, 2010b). Although the proportions of university students in mathematical fields of study and adults working in mathematical fields are quite low, high levels of mathematics education are necessary for a wide variety of fields, scientific and otherwise. As our society becomes progressively more technologically focused, having a highly mathematically-skilled workforce will become increasingly necessary. Indeed, even in today’s challenging economic times, public

and private agencies struggle to find workers who are sufficiently qualified for mathematics-focused jobs (i.e., those in STEM – science, technology, engineering, and mathematics – fields) (Wladawsky-Berger, 2012).

Statement of the Problem

As demonstrated by the university and employment statistics, participation in mathematical fields is extremely low, which poses two problems. First, since there are so few adults in these fields (which do not have much public exposure to begin with), there is a lack of ‘real life’ role models for children, which leads to an increased reliance on media representations of mathematicians. Second, this situation suggests a lack of interest in the fields, which may stem from negative attitudes toward mathematics and mathematicians. Negative attitudes are a concern, as they impact achievement and participation in mathematics. Children’s attitudes toward mathematics tend to become more negative in the pre-teen/early teenage years, and the changes in attitude tend to be more pronounced for girls (Chouinard & Roy, 2008; Ma & Cartwright, 2003; Thompson, 1995). Thus, it is important to examine what factors influence children’s attitudes toward mathematics in this critical age range.

Overview of Study

The purpose of my study was to investigate elementary students’ views of mathematics and mathematicians, and how these views may be influenced by children’s media⁴, parents⁵, and teachers, in order to better understand the complex interplay between outside sources and children’s views. Specifically, my study sought to address the following research questions:

- 1) What images of mathematics and mathematicians exist in a child’s world as:
 - a) produced by media portrayals?
 - b) produced by parents’ views?

- c) produced by teachers' views?
- 2) How do elementary students view mathematics and mathematicians?
 - a) Are there differences between boys' and girls' views?
 - b) Are there differences between middle (Grade 4) and senior (Grade 8) elementary students' views?
- 3) What is the relationship between elementary students' views of mathematics and mathematicians and:
 - a) media portrayals?
 - b) parents' views?
 - c) teachers' views?

To address these research questions, I collected three types of data from Grade 4 and Grade 8 students: 1) Questionnaires about their media habits and their views of and experiences with mathematics and mathematicians, 2) Drawings of mathematicians with written explanations, and 3) Interactive focus group interviews (with media prompts) about mathematics and mathematicians. Based on the student participants' media habits, as reported in the questionnaires, I conducted a document analysis to investigate portrayals of mathematics and mathematicians in children's media. Parents' and teachers' views of and experiences with mathematics and mathematicians were obtained through individual interviews. All data types were combined to address Research Question #3.

Contributions of Study

This study contributes to the extant body of mathematics education research in several ways. First, it provides a detailed description of representations of mathematics and mathematicians in children's media sources, providing a better understanding of how societal

views are co-constructed by the media, and how these views may influence young people's views. Second, the study increases our understanding of elementary students', parents', and teachers' views of mathematics and mathematicians. Specifically, this study provides insight into how students' views may change from the middle to upper elementary school levels, and the role that gender plays in students' views. These understandings may suggest ways to increase young people's interest in mathematics, which could lead to increased achievement and participation in mathematics. Furthermore, this study contributes to what is currently a very small body of literature, both within Canada and worldwide, that has investigated young people's views of mathematicians. Finally, as far as I am aware, this is the first study to investigate representations of mathematics and mathematicians in media sources that are popular with young people, as opposed to analyzing media that are already known to include representations of mathematics and mathematicians (e.g., movies where a mathematician is a main character).

Thesis Outline

The remainder of the thesis is divided into six chapters. Chapter 2 (Theoretical Framework) discusses my social constructivist and feminist epistemological stance, plus the theories about gender and media in which the study is couched. Additionally, my conceptual framework is provided, in which the 'actors' in the study (i.e., students, parents, teachers, and media) are conceptualized in producer-consumer relationships. Chapter 3 (Literature Review) begins by addressing studies that investigated students' views of mathematics, mathematicians, and gender. I then justify my choices of 'actors' (i.e., the general public, media, parents, and teachers). The chapter then considers studies that explored the messages produced by these actors about mathematics, mathematicians, and gender. The chapter concludes with a review of

studies that investigated the production of more generalized messages about gender, as a way of positioning the often-gendered messages about mathematics and mathematicians.

The remaining chapters deal with specific aspects of my study. Chapter 4 (Methodology) addresses the various methodological aspects of the study – from design to data collection to analysis. Chapter 5 (Findings) details the findings separated by data type (i.e., questionnaires, drawings, focus group interviews, children’s media, teacher interviews, and parent interviews). For each type of data involving the students, gender and grade-level comparisons are made, in order to address the research questions. In contrast to Chapter 5, Chapter 6 (Discussion) considers broad, emergent themes that encompassed multiple data types. The thesis concludes with Chapter 7 (Conclusions), in which the research questions are addressed, with links drawn to the extant literature. The chapter also discusses the contributions and limitations of the study, and concludes with a consideration of remaining questions and concerns.

CHAPTER 2: THEORETICAL FRAMEWORK

In this chapter, I outline the theoretical stances that framed my study in all respects (i.e., research design, data collection, and data analysis). I begin at the broadest level, discussing my epistemological stance, which encompasses both social constructivism and feminism. I then focus my discussion on gender, addressing theories of gender development and links between gender and mathematics. My alignment with certain theories about gender plays a key role in any gendered comparisons I draw between the girls and boys in my study, as well as my analysis of gendered portrayals in the media. Next, I address media theories and discuss the important role that media play as an agent of socialization, thereby providing a clear conception of my stance regarding my participants' relationship with the media. The chapter concludes with the presentation of my conceptual framework. In this presentation, I show how my epistemological stance and the selected theories of gender and media consumption underpin my conceptual framework, which describes the relationships amongst media representations, parents' views, teachers' views, and children's views of mathematics and mathematicians.

Epistemological Stance

I assume a social constructivist and feminist epistemological stance; accordingly, I view the discipline of mathematics and conceptions about mathematics and mathematicians as socially constructed, gendered, and historically and culturally situated. In the following sections, I provide an overview of social constructivism and feminism as epistemologies, and discuss stances of each with which I align myself and by which my study is framed.

Social Constructivism

Generally, constructivism “describes knowledge not as truths to be transmitted or discovered, but as emergent, developmental, nonobjective, viable constructed explanations by

humans engaged in meaning-making in cultural and social communities of discourse” (Fosnot, 2005, p. ix). That is, knowledge is a human construction, closely tied to social interactions, cultural norms, personal developmental schemas, and, as I will discuss in the next section, gender. In contrast to such epistemological stances as post-positivism, constructivism argues that there is no one ‘true’, objective reality that exists and that therefore can be known by humans:

Constructivism derives from a philosophical position that we as human beings have no access to an objective reality, that is, a reality independent of our way of knowing it.

Rather, we construct our knowledge of our world from our perceptions and experiences, which are themselves mediated through our previous knowledge. Learning is the process by which human beings adapt to their experiential world. (Simon, 1995, p. 115)

While these descriptions address the epistemological stance in a broad, encompassing manner, a great number of specific schools of thought fall under the auspices of constructivism.

Generally speaking, constructivist schools of thought can be placed on a continuum ranging from a focus on the individual to a focus on social interactions. That is, knowledge can be conceptualized as residing in the mind/head, as in radical constructivism, or in society/the world, as in sociocultural theory (Prawat, 1996). Radical constructivism is most commonly associated with von Glasersfeld, whose ideas were heavily influenced by Piaget. According to radical constructivism, knowledge is viewed as individual cognitive reorganization, and is defined as “conceptual structures that epistemic agents, given the range of present experience within their tradition of thought and language, consider viable” (von Glasersfeld, 1992, p. 381). Essentially, knowledge forms via reorganization of cognitive structures, which happens when perturbations occur to existing cognitive schemas. In light of perturbations, either assimilation, in which there are no changes to existing schemas, or accommodation, in which schemas are

altered, occurs (von Glasersfeld, 1995). An individual's knowledge is formed based on his or her unique experiences, but people can communicate since meanings are 'sufficiently compatible' (Steffe & Thompson, 2000).

In contrast, sociocultural theory focuses on knowledge as a co-construction by interacting individuals. Sociocultural theory is most commonly associated with Vygotsky, who contended that "all higher order functions originate as actual relations between human individuals" (1978, p. 57). According to this theory, learning can be seen as the acculturation of 'novices' into cultural systems. First, an understanding of various signs and symbols that exist in society must be garnered, and then learning is viewed to occur via acculturation, in which accepted cultural practices are internalized through interactions with others. According to Vygotsky's general genetic law of cultural development, these functions of an individual's cultural development appear first between people and then within the individual (i.e., from an interpsychological level to an intrapsychological level). Vygotsky (1978) argued that the transformation between levels involves a developmental process in which culturally-mediated entities became internalized.

Having situated my discussion by addressing two schools of thought that could be conceptualized as opposite ends of a constructivism spectrum, I turn to a more centrist stance, social constructivism – the stance with which I align myself. Due to its centrist positioning, social constructivism arguably has the greatest variety of interpretations. Ernest (1999) describes two stances of social constructivism as being a 'Piagetian theory of mind' or a 'Vygotskian theory of mind', with the former prioritizing radical constructivist tenets and the latter prioritizing sociocultural tenets. A third stance is a 'complementarist position', in which multiple theoretical perspectives are adopted and shown to be complementary. In this case, neither individual nor social aspects are given primacy, but both are seen as equally important. It is this

third, and arguably most centrist, social constructivist stance with which I align myself, as I believe that neither radical constructivism nor sociocultural theory sufficiently explains the full process of coming to know. While radical constructivism does not adequately account for knowledge that is built in conjunction with others, sociocultural theory does not adequately explain how interpsychological knowledge becomes intrapsychological knowledge (i.e., how knowledge between individuals becomes internalized). As I next discuss, Cobb's (1994) arguments for the complementary nature of these two positions account for the inadequacies of each theory. Using both positions allows for a better conceptualization of how learning occurs.

Although Cobb's (1994) complementarist stance was posited with respect to mathematics learning, I apply this stance to learning in a general sense. His stance co-ordinates radical constructivist and sociocultural perspectives by viewing learning as "both a process of active individual construction and a process of enculturation into the mathematical practices of the wider society" (p. 13). Active individual construction, a radical constructivist principle, refers to the development and change of an individual's cognitive structures (i.e., schemas) in response to perturbations, which often arise through interactions with others. Sociocultural theory principles regarding learning as a process of social enculturation are incorporated by recognizing that knowledge originates from interactions between people and then becomes internalized. In sum, according to social constructivism (as per Cobb, 1994), during interactions, we not only appropriate sociocultural practices, but we also experience perturbations to our individual cognitive schemas that are remedied through assimilation or accommodation.

Feminism

Feminism can be seen as aligning with a broader social constructivist stance due to the understanding of gender as a key factor in the construction of knowledge. As discussed by Campbell and Wasco (2000) in their interpretation of constructivism,

Social factors, such as gender, race, class, culture, and economics are not merely lenses through which we see reality, they are agents shaping how we construct our visions of what constitutes our individual realities. There is no 'real' reality, no single truth, but multiple truths that are individually constructed. (p. 780)

Certainly, feminism is a complex term with many interpretations and schools of thought. As contended by Brimstone (2001), "there has never been, nor should be, a single 'grand theory' of feminism. What we have, instead, is a dynamic interplay of feminist approaches" (p. 72). Indeed, the term 'feminisms' may be more fitting, as it encapsulates the multitude of viewpoints. Over the past few decades, feminist research and activism have become increasingly differentiated, with sub-groups focusing on particular needs and interests. These sub-groups arose in response to the recognition that much of the early feminist research and activism tended to focus on the concerns of White, heterosexual, able-bodied, middle- to upper-class women and presume an essentialized 'woman's experience' (hooks, 2000; Olesen, 1998). Feminists and feminist researchers now recognize that gender is not isolated from other factors, such as ethnicity, class, and sexuality (Brooks & Hesse-Biber, 2007; Code, 2000); the complex intersections of these factors play a key role in defining a woman's sense of self and her experiences in the world.

Among those who ascribe to feminism generally, members of sub-groups may hold beliefs that may be seen to oppose each another, be it on a theoretical, epistemological, and/or methodological level. Although Tong (2009) argues that, "feminist thought resists categorization into tidy schools of thought" (p. 1), she also recognizes the utility of such categories: "They

signal to the public that feminism is not a monolithic ideology and that all feminists do not think alike.” (p. 1). There is no one feminist school of thought with which I align myself fully; rather, there are aspects of several schools of thought with which I strongly agree, and aspects of other schools of thought with which I vehemently disagree. For instance, I reject such schools of feminism that assert that women are fundamentally, biologically different from men (e.g., gentler and kinder, as per cultural feminism; cf. Alcoff, 1995) and those that assert that only women and/or lesbians can be feminists (e.g., separatist feminism, lesbian feminism; cf. Frye, 1997; Hoagland, 1988). In both cases, I feel that biology is given far too much weight, women are essentialized as a homogeneous group, and cultural/social influences are insufficiently addressed. Moreover, while I agree with the goals of liberal feminism (i.e., political and legal equality for women and men in social systems, such as voting and education), I do not feel that it sufficiently challenges the patriarchal structures in which we live and the narrow, hegemonic gender roles to which all people are subjected. Finally, while I do align myself with such stances as atheist feminism (which opposes religion due to its sexist and patriarchal nature), they are not relevant to this research project.

Therefore, in eschewing association with a particular label of feminism, I use hooks’ (2000) comprehensive and open-ended definition of feminism: “A movement to end sexism, sexist exploitation, and oppression” (p. 1). This definition can be seen as positioning feminism as a movement that addresses sexist issues within a patriarchal society, one in which hegemonic masculinity leads to the oppression of women and girls. More specifically, I align myself with Lather (1988) who posited that, “Feminism argues the centrality of gender in the shaping of our consciousness, skills, and institutions as well as in the distribution of power and privilege” (p. 571). Although gender underpins essentially every facet of our lives, the ways in which gender

plays a role differ based on several intersecting factors, such as age, ethnicity, sexual orientation, and ability. As will be discussed later, hooks' (2000) and Lather's (1988) views of feminism provide a useful framework with which to unpack the ways in which mathematics was historically (and in many cases, continues to be) conceptualized.

Importantly, although I consider myself to be a feminist researcher, the current study does not purport to be a feminist study. That is, the manner in which the study was conceptualized and, consequently, the ways in which the data were collected and the analysis conducted are not focused on feminism (e.g., a feminist lens, feminist literature). Rather, the study's conception, implementation, and analysis include gender as a key factor, and the manner in which this gendered analysis is conceptualized is both indicative of my feminist stance and informed by feminist theory.

Summary

In alignment with my epistemological stance, I view the discipline of mathematics and views of mathematics and mathematicians as socially constructed and gendered. Through social interactions and cognitive reorganization, we construct knowledge about what the discipline of mathematics is, what it means to do mathematics, and what it means to be a mathematician. Due to mathematics' historical status as a 'male domain', the construction of such knowledge is highly gendered in nature. Our understandings of societal values and beliefs about mathematics and mathematicians are formed in similar ways.

Gender

As stated by politician Shirley Chisholm, "The emotional, sexual, and psychological stereotyping of females begins when the doctor says, 'It's a girl'" (Hoard, 1973, p. 36).

Consistent with my feminist stance, I argue that such stereotyping equally applies when the

doctor says, ‘It’s a boy’. The world in which children grow up is one in which they are gendered and gender-policed, and these genders are typically narrowly defined as a binary. I first discuss theories of gender development as a way of understanding how children come to see themselves, others, and the world in which they live as gendered. Next, I address the manner in which I conceptualize the terms ‘sex’ and ‘gender’, as a way of positioning my stance on these key topics. Finally, I consider how conceptions of gender may impact interactions with mathematics.

Gender Theories

For more than a half-century, researchers from various fields have investigated how children develop understandings of gender. I focus on Bussey and Bandura’s (1999) Social Cognitive Theory (SCT) of gender development and differentiation, which is based on the notion that “human functioning cannot be fully understood solely in terms of sociostructural factors or psychological factors” (p. 694). SCT recognizes the importance of gender in social organization and the impact that it has from birth – both in the way babies are treated and the way they interact with others in gendered ways, long before the babies have an understanding of gender. Notably, SCT recognizes the roles that parents, peers, media, and educational practices play in gender development. These external influences are not seen as unidirectional or deterministic: “People contribute to their self-development and bring about social changes that define and structure gender relationships through their agentic actions within the interrelated systems of influence” (p. 676).

As argued by Kimmel (2011), “the social environment is filled with gendered messages and gendered activities. Even if the child possesses no fixed and permanent gender role, social arrangements will continually reinforce gender differences” (p. 104). Researchers contend that the influence of gender stereotypes may be particularly salient at certain developmental periods

in childhood. Comstock and Scharrer (2007) explain that, around kindergarten age, children tend to develop an understanding of gender constancy and become very interested in “information that is relevant to the rules and norms that govern the establishment of ‘appropriate’ behaviors for members of their gender” (p. 256). Thus, it is argued that portrayals of gender by the media, parents, teachers, or other sources will have a particular impact during this time period. Ideas about gender may also have a particularly significant impact during early adolescence, when young people’s identities are developing and changing (Singer & Singer, 1994). During this time, young people develop “internalized socialization through fantasy and imagination about possible social and sex roles, career choices, adventure, and romance” (p. 98). Essentially, early adolescents are exploring how gender will play a role in their adult lives. Delamont (2001) reports that young people hold different levels of gender stereotyping depending on whether the stereotype is applied to themselves or others: “Children and teenagers are relatively relaxed about their own gender-related behaviours, relatively stereotyped about same-sex peers and highly rigid about opposite-sex peers” (p. 30). As an example, a girl may believe that it is acceptable that she become an engineer, but feel that it is inappropriate for other girls to do so, and definitely inappropriate for boys to become daycare providers.

My Position on ‘Sex’ and ‘Gender’⁶

Although there are inconsistencies in terminology, Pryzgoda and Chrisler (2000) note that sex is typically defined as referring to “the biological aspects of being male and female”, whereas gender is typically defined as referring “only to behavioral, social, and psychological characteristics of men and women” (p. 554). I begin by examining the term ‘sex’, which tends to be viewed as rather benign, as it is presumed to be a biological inevitability – a dichotomy between male and female, indicated at birth by the presence of male or female genitalia.

However, this term and the related dichotomy are not ‘natural’, but rather are quite loaded and socially constructed (Butler, 1999; Fausto-Sterling, 2000). This becomes abundantly clear when discussing intersex individuals, those who do not neatly fit into the presumed male/female dichotomy (e.g., ‘ambiguous’ genitalia, genitalia/chromosomal disconnect). Intersex individuals tend to face medical intervention at an early age, in order to ‘normalize’ them as female or male, thus allowing them to fit into (and, in doing so, maintain) the deeply engrained, socially constructed sex dichotomy. Indeed, this dichotomy is normalized every day, both in the medical profession and otherwise (e.g., male/female washrooms). In sum, while I define ‘sex’ as pertaining to biological aspects of being female, male, or intersex, I acknowledge that there is great variety within each of these categories. The categories themselves are a human construction, used as a way to simplify our complex and variable sexed bodies.

Conversely, ‘gender’ is more typically accepted as being a complex concept related to socially accepted norms. I align with Howard and Hollander’s (1997) definition of gender as “the culturally determined behaviors and personality characteristics that are associated with, but not determined by, biological sex” (p. 11, as cited in Glasser & Smith, 2008, p. 346). This definition highlights the role that the broader society and culture play in policing behaviours presumed ‘gender-appropriate’, with the understanding that being gendered as a boy/man presumes acting in a (perceived) masculine way and being gendered as a girl/woman presumes acting in a (perceived) feminine way. Notably, being gendered as a boy/man/masculine, for instance, tends to be associated with those individuals who have male bodies, but this link is tenuous.

Individuals may be gendered by others based on a presumed biological sex, but may self-identify (i.e., their gender identification) differently. I align with Butler’s conception (1999) of gender as a performative act: “As a shifting and contextual phenomenon, gender does not denote a

substantive being but a relative point of convergence among culturally and historically specific sets of relations” (p. 348). Over time and in various geographic locales, what it has meant socially to be a girl/woman/feminine or a boy/man/masculine has shifted and broadened, although many presumptions and stereotypes endure (e.g., women are nurturing; boys don’t cry). These social expectations are used to police behaviours that are viewed as gender-incongruent (e.g., a little boy who wants to wear dresses; a woman who is a bodybuilder), as a way to maintain an embedded social system. I would argue, however, that gender is viewed more flexibly than sex, with a greater variety of gender expressions being accepted (e.g., several ways to be a girl/woman/feminine compared to one way to be female), particularly in recent years.

Gender and Mathematics

Gender is a particularly relevant issue in mathematics, as the field has historically been considered to be a male domain, and seen by some as incompatible with femininity (Hanna, 2003; Leder, 1992). While part of this perception arises from the gendered composition of those involved in mathematical fields (i.e., predominately men, particularly historically), it is also related to the manner in which mathematics itself is perceived. Ernest (1998) argues that mathematics is typically perceived as a discipline that is “difficult, cold, abstract, theoretical, ultra-rational, but important and largely masculine” (p. 45). Additionally, unlike many other disciplines, mathematics is often depicted as ‘value-free’ and ‘objective’. However, as argued by Burton (1995), mathematical developments take place in relation to social, cultural conditions:

‘Important’ mathematical areas are identified, value is accorded to some results rather than others, decisions are taken on what should or should not be published in a society determined by power relationships, one of which is gender. Mathematical products can

then be seen as the outcome of the influence of a particular ‘reading’ of events at a given time/place. (p. 279)

When discussing the lack of success of interventions in encouraging girls and women in mathematics (particularly in terms of participation in non-mandatory levels), Mendick (2006) posits that “a main reason for the disappointing results of such strategies is that they have attempted to change the girls and women to fit into maths while being happy to leave maths fixed as it is” (p. 141). Such descriptions could be seen as drawing a parallel to liberal feminism, which attempts to work within the existing system, rather than challenging the system itself.

Due to the continued perception of mathematics as a ‘masculine’ discipline, scholars have suggested that doing mathematics is one way of doing gender. Mendick (2005) argues that being ‘good at mathematics’ is linked to stereotypical notions of being a ‘genius’ and a ‘nerd’:

These discourses are oppositional and gendered; they inscribe mathematics as masculine, and so it is more difficult for girls and women to feel talented at and comfortable with mathematics and so to choose it and to do well at it. (p. 217)

Indeed, the link between mathematics and a sense of gendered ‘belonging’ has been shown (e.g., Good, Rattan, & Dweck, 2012; Nosek, Banaji, & Greenwald, 2002) to impact women’s intent to continue in mathematics and their associations of mathematics with sense of self.

Media

Due to the current proliferation of media, children in recent generations are in an ‘audience’ role far more than prior generations (Comstock & Scharrer, 2007; Dill, 2013). However, this ‘audience’ role has become far more active, with the advent of new media types. Also, the ways that interactions with older media types (e.g., television) can occur have shifted.

The social category of the audience is not so prominent in the era of new media cultures... it is more accurate to speak of users or gamers or by some other name that identifies the activity of the former 'audience'. Even in forms such as television and film where the audience as social construct still makes sense, there is a fraying at the edges of what that definition now means. (Marshall, 2004, p. 103)

To situate my discussions, I first provide an overview of the progression of media theories regarding audiences, and then examine issues specific to young media users. I next argue for media to be viewed as a socializing agent, similar to other 'actors' in children's lives. In so doing, I justify my inclusion of media as one of the 'actors' in my study (i.e., one of the key outside influences). Finally, I explore how media can contribute to young people's understandings of gender.

Media Theories

Over time, the manner in which media users have been conceptualized has undergone a vast paradigm shift. Early research and theorizing in the field of audience research, such as structuralist media theory of the 1970s, denied the agency of viewers (Wilson, 2009). This theory posited a direct cause and effect relationship, claiming that viewers, who were depicted as passive, would succumb directly to any ideology put forth by media. Viewers were presumed to take away an identical, fixed message from a media source. Importantly, structuralist media theory "excludes from its model of the media recipient the latter's past as a person in society" (Wilson, 2009, p. 11). Essentially, according to the theory, individuals would solely be influenced by what they viewed, rather than their prior life experiences mediating their viewing experience.

In the early 1980s, Brunsdon and Morley proposed active audience theory, which stands in direct opposition to the structuralist media theory (Wilson, 2009). According to active audience theory, viewing is understood to be an “*interpretative* activity, taking place over time” (p. 20, emphasis in original). Viewing is seen as one of many experiences that occur in a person’s life, and each viewing experience is judged, unconsciously or consciously, in relation to prior experiences. Therefore, a cause-and-effect relationship cannot be ascertained with regard to the viewing of media, as this is mediated by our prior cultural experiences. Further, media are not presumed to have fixed meanings, as each viewer experiences media in a unique way, mediated by prior experiences, cultural ties, and other social factors. No single message or ‘essence’ can be attributed to a media source. As such, the message ascertained from each media source differs by individual, which thus alters any possible consequences of the viewing. Due to the claim of plurality and the ‘unfixed’ nature of messages in a single media source, active audience theory can be seen as poststructuralist in nature. I use this theory to frame my understanding of my participants as media audiences.

Children as a ‘Special Audience’

Although most media scholars reject the cause and effect notions of structuralist media theory, there is far less consensus regarding how young people should be conceptualized as media users. In fact, as noted by Buckingham (1993), some ideas about children as media users align with structuralist media theory, as children are positioned as lacking autonomy and being passive recipients of messages from the media, which are positioned as having singular, mostly negative impacts. In this view, children are innocent and vulnerable to ‘preying’ media that can ‘brainwash’ them. Thus, it is argued that children need protection from media’s potentially

damaging effects. As with the structuralist media theory, those who view children in this way tend to have a deterministic, cause-and-effect understanding of how media impact children.

As argued by Buckingham in his many publications (e.g., 1993, 2000), the manner in which young viewers are conceptualized is strongly linked to the way we conceive of childhood as a construct. When children are viewed as autonomous, active participants in constructing their own lives and identities in general, they are also understood to be active audience members and media users. Children's exposure to ideas by media sources is therefore seen as mediated by their life experiences and developmental levels. Moreover, Buckingham (2003) argues that key demographic variables, such as gender, age, and socioeconomic status, are highly influential in children's interactions with media, thus disrupting notions of children as a homogeneous group.

Media as Socializing Agent

Since the advent of television, children have been exposed to media ideas since birth. As no special skills are required, very young children can independently access audio-visual media. Conversely, when print media were the norm, parents had much more control over the 'outside' messages to which their children were being exposed, as they determined what was read to their children. It was not until children learned to read that they had the freedom to explore ideas outside those sanctioned by their parents, which had, by that point, arguably become sufficiently embedded as to provide a lens through which future media interactions are filtered (Roberts & Foehr, 2004). However, with television, even very young children could access outside messages "well before parents had time to firmly establish baseline definitions of the world" (p. 6).

Arguably, there is no way to clearly show cause and effect between children's exposure to ideas in the media and the ideas they hold. As discussed earlier, children's beliefs are influenced by many factors other than media, such as interactions with parents and peers.

Additionally, children's interactions with media are mediated by prior experiences with people, objects, and institutions in their lives. Due to the substantial amount of time and energy today's youth devote to media, "few mass media communication scholars hesitate to list mass media as equal in importance to most other socialization agents (e.g., parents, schools, churches)" (Roberts & Foehr, 2004, p. 2). Comstock and Scharrer (2005) argue that the media's powerful influence as a socialization agent is due to three key, interrelated reasons:

First, the media have an unparalleled ability to disseminate information about the culture... Second, individuals typically spend a considerable amount of time attending to the narratives of the media. Third, there is discernible homogeneity in many of the media's stories, which results in a degree of consistency in what individual audience members can learn about the social environment. (p. 243)

Comstock and Scharrer's (2005) first point is particularly salient for my study – both due to the interactive nature of the media to which the students are exposed, and the media's ability to provide representations of mathematics and mathematicians to which the students may not be exposed otherwise. With respect to the other points, as I will discuss in the Literature Review chapter, today's children and youth spend inordinate amounts of time with media and the messages to which they are exposed are indeed quite consistent in nature. Therefore, as with the role of parents and teachers, I viewed children's exposure to media as yet another socializing interaction, in which the dissemination of ideas can be interpreted in multiple, contested ways by each child, as per his or her prior experiences and existing cognitive schemas.

Gender and Media

Understanding how gender stereotypes shown in the media may impact children's beliefs is very complex. As noted earlier, children are gender socialized from birth by the people,

institutions, and objects in their lives. Thus, gendered stereotypes shown in the media are mediated by children's prior experiences with gender norms and stereotypes. Many of the gender stereotypes in the media are also present in general society, and the relationship between these groups tends to be one of co-construction. That is, media represent trends and beliefs in society, which then may re-present that representation; media can also present ideas about gender that are then taken up by society. When gender stereotypes shown in the media complement children's existing gender schemas, existing beliefs become further enforced and embedded. However, gender-atypical representations may either not have an impact on the existing gender schema, due to their rarity and mismatch with a child's existing beliefs, or act as a socializing agent that may disrupt existing beliefs (Lemish, 2007). Lemish discusses studies that show that regular exposure to programs with counter-traditional gender roles is linked to young people holding less stereotypical views about gender. However, he cautions that these findings may be moderated by the characteristics of the children (i.e., those who are more receptive to gender-atypical representations are more likely to watch shows with such representations) or their parents (i.e., non-gender-stereotyping parents would be more apt to encourage their children to watch such shows).

Conceptual Framework

Having situated my study in the context of my epistemological stance, social constructivism and feminism, and theories regarding gender and media, I conclude this chapter by presenting my conceptual framework. To begin, I discuss relevant theories that underpin specific aspects of my conceptual framework, specifically representation, consumption, and production. I next present the framework and then conclude by discussing its role in my study.

The theory of representation, the constructionist approach, is highly linked to social constructivism: “Things don’t *mean*: we *construct* meaning” (S. Hall, 1997, p. 25, emphasis in original). Representations of items in the ‘real world’ convey meaning about material objects and beings, rather than their inherently holding meaning. Representations by various actors, such as adults and media, can be disseminated both implicitly and explicitly. The strength of the influence of a representation is related to how closely it aligns with existing understandings in society. Media do not construct representations ‘out of thin air’, so to speak; rather, media representations are often reflective of ideas that are held by society at large (Lemish, 2007; Marshall, 2004). Lemish (2007) argues that media influence is stronger “when it provides complementary and consistent information with knowledge already obtained” (p. 106).

As discussed with regard to media consumption, no person is a passive recipient of ideas and information; consumers are actively involved in sense-making of the ideas presented to them (Bickham, Wright, & Huston, 2001; Huntemann & Morgan, 2001). Sense-making is highly individualized, based in previous experiences and current beliefs and understandings. Wilson (2009) notes that “the sense we make of a text will at no point be consensually singular, acceptable to all” (pp. 31-32). The ‘active recipient’ stance is particularly salient with regard to our relationship with media, which often conceives of viewers as passive. Comstock and Scharrer (1999) argue that viewers can “browse, momentarily ignore, assemble into a mosaic of contrasting bits, passively follow, attentively consume” (p. 61).

My conceptual framework (Figure 1) focuses on the various views and representations of mathematics and mathematicians that my study examines and uses double-headed arrows to represent the dynamic and reciprocal relationships amongst these multiple perspectives. Note

that all of the relationships depicted in this conceptual framework are understood as occurring in a world that is, as discussed earlier, highly gendered.

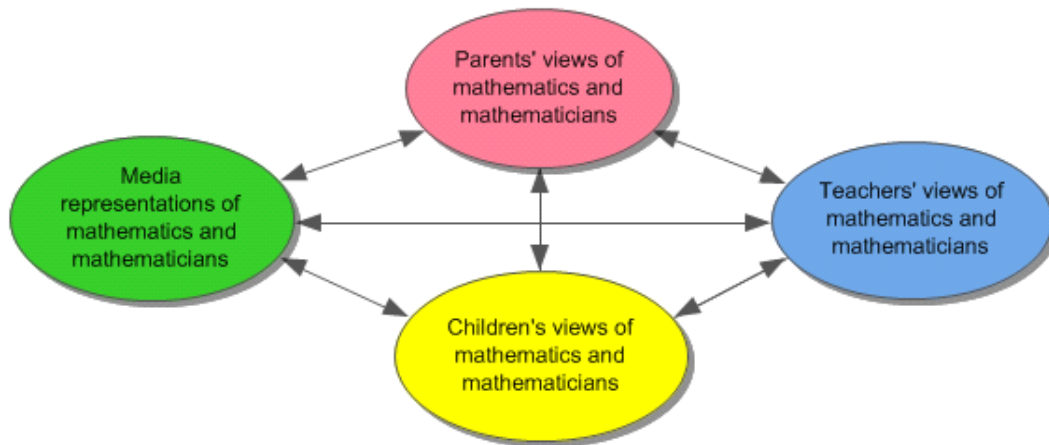


Figure 1. Conceptual framework, showing relationships among media representations, parents' views, teachers' views, and children's views of mathematics and mathematicians.

In a pairing, each actor plays the role of both producer and consumer of understandings about mathematics and mathematicians. For instance, children's views may both influence and be influenced by media representations, parents' views, and teachers' views. However, the influence of one actor on the other may not be equal in both directions, as the strength of the directional relationship between actors is arguably connected to unequal power relationships, which may be linked to hierarchies related to age, gender, knowledge, and/or experience.

In this conception, people's views and media representations construct meaning about mathematics and mathematicians. During social interactions, the producer may disseminate information or opinions about mathematics and mathematicians explicitly (e.g., a statement such as 'I didn't do well at math either, so don't worry about it') or implicitly (e.g., helping with mathematics homework) to the consumer. Regardless of the type of representation and actors involved, information is disseminated by a producer to consumer, who receives and interprets it. Notably, "Meanings and communication, however, are not consumed as finished products. The

consumption of messages, therefore, is simultaneously an act of production of meanings” (O’Sullivan, Hartley, Saunders, Montgomery, & Fiske, 1994, p. 244).

The ‘attentive consumption’ role is the focus in my framework. When a perturbation occurs during an interaction, the active consumer interprets the information and then assimilates it into or makes accommodations to existing cognitive schemas. The arrowheads in the diagram denote where assimilation or accommodation occurs. This is particularly relevant in the example of representations of mathematicians by media (the producer). During an interaction with media, people (consumers) may assimilate the representations into their ‘mathematician’ cognitive schemas, as they are solely comprised of prior media representations of mathematicians. Many people have no pre-existing schema about ‘real-life’ mathematicians, so they lack the capacity to challenge the media representations. This leads to the perpetuation of stereotypes about mathematicians, which is problematic due to their negative and power-laden connotations. Dyer (2000) argues that stereotypes “express particular definitions of reality, with concomitant evaluations, which in turn relate to the disposition of power within society” (p. 248), which holds true for mathematician stereotypes. By portraying mathematics and mathematicians in ways that are congruent with the (often stereotypical) ideas held by the general public, the popular media industry can be better assured that the representations will not be challenged as being unrealistic. Essentially, stereotypes “encourage an *intuitive belief* in their own underlying assumptions, and play a central role in organizing common sense discourse” (O’Sullivan et al., 1994, p. 300, emphasis in original). In this way, stereotypes are perpetuated about mathematics and mathematicians.

While my conceptual framework addresses producer-consumer relationships amongst four actors (i.e., children, parents, teachers, and media), I am only focusing on three specific

pairings – parents/children, teachers/children, and media/children – and one direction (i.e., toward the children) in my study. Recall that the purpose of my study is to investigate children's views of mathematics and mathematicians, and the ways that parents' views, teachers' views, and media representations may influence children's views. Although children's views certainly can influence the other three actors' views or representations, this is outside the realm of my study's focus. Additionally, there certainly are other actors (e.g., peers) who may influence children's views of mathematics and mathematicians. Speaking from a pragmatic point of view, my study needed to be limited in scope. I felt that the choice of parents, teachers, and media as key socializing agents was valid, given the evidence from the extant body of literature, as will be discussed in the next chapter. Herein, I will incorporate this producer/consumer conceptual framework in my discussions of the existing literature and my study's findings.

CHAPTER 3: LITERATURE REVIEW

This chapter provides a review of literature related to key aspects of my study. The chapter begins by considering prior studies that investigated the views that young people hold with regard to mathematics, mathematicians, and gender. After discussing young people's views, the remainder of the chapter is devoted to exploring the roles that key socialization agents (herein referred to as 'actors') play in young people's lives in producing messages about mathematics, mathematicians, and gender. First, I provide justification for my decision to focus on the general public, media, parents, and teachers as key socialization agents – both generally and with regard to these topics in particular. Then, I review studies that explored the messages produced by these four actors about mathematics, mathematicians, and gender. The chapter concludes with a review of studies that investigated the production of more generalized messages about gender, in order to better position the often-gendered messages about mathematics and mathematicians in the gendered cultural milieu in which young people grow up.

Young People's Views

This section addresses prior studies that investigated young people's views of mathematics and mathematicians. I begin at the broadest level, addressing studies that examined young people's views of mathematics and mathematicians in a general sense. This is followed by a discussion of young people's views of mathematics and gender, and their gendered relationships with the subject area. The section concludes by considering young people's views of themselves as learners of mathematics. Reviewing these studies provides an overarching understanding of the mathematics-related views that young people hold – and therefore, the

views that they may be disseminating to others. Furthermore, examining the views that young people hold arguably provides suggestions of the messages to which they have been exposed.

Young People: Views of Mathematics

Finnish children's views of mathematics were ascertained through a study (Perkkilä & Aarnos, 2009) that involved 300 children, ages six to eight, drawing pictures of themselves in 'the land of mathematics'. The children tended to draw themselves alone in a nature-based setting, with numerals or simple arithmetic facts. Perkkilä and Aarnos thus concluded that "the meaning of mathematics for these children seems to be: being alone, silent, producing numbers and arithmetical problems" (p. 9). Since most of the drawings were in nature settings, the researchers posited that children related their mathematics learning to settings outside school. Of the girls' drawings, 52.9% showed a 'joyful' face whereas only 4.5% showed a 'sad' face; conversely, approximately 20% of the boys' drawings were sad and 20% were joyful. Although the researchers claimed that this meant the girls had a 'joyful attachment to mathematics', they did not make any such claims regarding boys' drawings as the researchers found many of the facial expressions nonexistent or difficult to read. Thus, the gender differences in this study seem to be inconclusive and likely based on factors besides children's attachments to mathematics.

Young People: Views of Mathematics and Mathematicians

Hekimoglu and Kittrell (2010) investigated the impact that viewing a documentary, *The Proof* (about mathematician Andrew Wiles' proof of Fermat's Last Theorem), had on university students' views of mathematics and mathematicians, as well as their mathematics self-efficacy beliefs. Nearly 300 students from 13 undergraduate mathematics courses were shown the documentary at the beginning of the semester, after which a class discussion was held and individual reflection papers were completed anonymously that addressed whether there were any

changes in the students' views of mathematics and mathematicians or their conceptions of learning mathematics. For the majority of the students, their stereotypical perceptions about mathematicians were challenged, as they learned that 'real' mathematicians collaborate, work hard and struggle, and have great passion for and enjoyment in doing mathematics. The researchers admitted that one shortcoming of the documentary was that it confirmed stereotypes about a mathematician's appearance, as a "'nerdy white male' who most students would probably not aspire to be" (p. 310). Many students were surprised to learn that mathematics is always growing and changing, as opposed to being a 'finished' field with no further discoveries to be made. Importantly, "the documentary was successful in challenging many students' deeply held myth that people are born with or without a math gene" (p. 316), as students recognized that their lacking study habits, rather than an innate lack of ability, were the main contributing factor to their struggles. Throughout the semester, the students were more likely to take risks and work collaboratively. Moreover, the students' grades rose significantly while the drop rates for the course decreased. While these positive outcomes may not be wholly attributable to viewing and reflecting upon the documentary, further investigation into such interventions is warranted.

Young People: Views of Mathematicians

Studies that probed young people's views of mathematicians were strongly influenced by earlier research that investigated young people's views of scientists. In 1957, Mead and Metraux conducted a seminal study that examined over 35,000 high school students' views of scientists. Students wrote brief essays that compared their view of scientists in general with their view of scientists once they were personally implicated (i.e., becoming or marrying a scientist). From the essays, Mead and Metraux compiled a composite image of 'the scientist', which was highly stereotyped – a middle-aged or elderly man who was unkempt, very intelligent, well-educated,

and extremely dedicated to his work; as such, the scientist neglected his family, health, and social life. In effect, students' positive public images of the scientist were quite tarnished once their own future careers or marriages were implicated.

Based on Mead and Metraux's research (1957), Chambers (1983) conducted research from 1966 to 1977 to establish a useful tool to elicit children's views of scientists, which resulted in the Draw-A-Scientist Test (DAST). Very simply, the test consisted of students being asked to "Draw a picture of a scientist" (Chambers, 1983, p. 257). Chambers collected nearly 5,000 images drawn by children from Kindergarten to Grade 5 in Canada, the United States, and Australia. The images were analyzed based on the number of indicators of a stereotypical image of a scientist found in the drawings (e.g., glasses, lab coat). The stereotypical image of a scientist that was found in Mead and Metraux's study (1957) was also found in the children's drawings in Chambers' (1983) study, and the number of indicators in the drawings increased with the child's age. Only 28 drawings of the nearly 5,000 collected were women scientists, and all of these drawings were done by girls. Since its creation, the DAST (original format and variations) has been widely utilized in many countries, both in studies with children (e.g., Fung, 2002; Melber, 2003) and with others, such as teachers and high school and university students (e.g., Mason, Kahle, & Gardner, 1991; McDuffie, 2001). The vast majority of DAST studies found similar results to those of Chambers (1983). Over time, the proportion of women scientists drawn has increased, but they remain a minority (Thomas, Henley, & Snell, 2006).

Nearly two decades after the DAST was first published, the test was altered to obtain students' images of mathematicians. After reading about DAST studies, Rock and Shaw (2000) became curious about how children think about mathematicians, and subsequently devised an online questionnaire with three open-ended questions about what mathematicians do, the types of

problems they solve, and the tools they use. Children were also asked to mail in a drawing of “a mathematician at work” (p. 551). The researchers received 215 completed questionnaires from Kindergarten to Grade 8 students and 132 drawings from Kindergarten to Grade 4 students in the United States. The children tended to think that mathematicians did the same types of mathematics the children did in their classes; indeed, no child described a mathematician’s work occurring outside a classroom. Nearly 75% of the children thought mathematicians solved “hard problems that other people don’t know” (p. 552). The researchers thus concluded that children thought that mathematicians do the mathematics that nobody else wants to do, a perhaps dubious interpretation. Although the hard problems are not known by ‘other people’, it does not necessarily indicate that nobody wants to do these problems. For the mathematician’s tools, children named items they used in class (e.g., paper, pencils), with the second most common response from middle school students being the brain. Kindergarten and Grade 1 children’s drawings tended to feature women smiling while working on basic number facts. Grade 2 to 4 students drew equal numbers of women and men; the mathematician was often smiling and in a classroom. Somewhat questionably, Rock and Shaw extrapolated that, due to the many smiling mathematician drawings, the children have a positive relationship with the subject area and enjoy their mathematics classes. It may simply be the case, as has been found in other studies involving children’s drawings of people in general (e.g., La Voy et al., 2001), that a smile is the default facial expression drawn by children. Another possible explanation is that the smiling face indicates the mathematician’s happiness while doing mathematics, as opposed to the child’s relationship with the subject area.

Picker and Berry (2000; 2001) built on Rock and Shaw’s (2000) research by investigating students aged 12-13, ages at which negative attitudes toward mathematics tend to form (Ma &

Cartwright, 2003; Thompson, 1995). Nearly 500 students in the United States, United Kingdom, Finland, Romania, and Sweden completed a questionnaire in which they were instructed to “Draw a mathematician at work” (Picker & Berry, 2000, p. 70), explain the drawing, and describe when one might need a mathematician’s services. One-fifth of the drawings depicted mathematicians as teachers and many students left the ‘services’ question blank, which led the researchers to posit that students have “a lack of clear understanding of what a mathematician actually does” (2000, p. 71). Seven common themes were found in the drawings: mathematics as coercion, the foolish mathematician, the overwrought mathematician, the mathematician who can’t teach, disparagement of mathematicians, the ‘Einstein effect’, and the mathematician with special powers. Overall, the dominant image that Picker and Berry found was consistent with the DAST studies. In their U.S. study, Picker and Berry (2001) added 10 Likert-scale questions about students’ views of mathematics and mathematicians. Fewer than 25% of students thought a mathematician’s work looked like fun. While 60% did not view themselves as mathematicians, the same percentage reported that they did enjoy their mathematics classes. Picker and Berry concluded that a disconnect existed between classroom mathematics and the profession of the mathematician, and this disconnect needs to be addressed by classroom teachers.

Similar research has been conducted recently in Canada (Gadanidis, 2011). A small-scale study involved 35 students in Grades 2 and 3 (ages 7-9) completing the same drawing task as the participants in the aforementioned studies. Similar to the findings of Rock and Shaw (2000) and Picker and Berry (2000, 2001), most of the young children in the Gadanidis study envisioned a mathematician in a teaching capacity. As in the Rock and Shaw study, the young participants in this study also tended to draw mathematicians with smiling faces, and a substantial proportion (7 of 18 drawings where the mathematician’s gender could be identified) were women. Notably,

these two findings stand in stark contrast to the findings of the Picker and Berry studies, which may suggest that views of mathematicians may be linked to students' ages.

Young People: Views of Gender and Mathematics

Since the landmark study by Fennema and Sherman (1977) that helped to shift gender issues research in mathematics education from a focus on biological factors to a focus on socio-cultural factors, emphasis has been placed on understanding students' views of gender and mathematics. Unfortunately, the stereotype of 'mathematics as a male domain' has persisted over the past few decades, with even recent studies finding that both elementary and secondary school students hold gender-stereotyped views. For instance, two studies (Cvencek, Meltzoff, & Greenwald, 2011; Steffens, Jelenec, & Noack, 2010) that explored elementary students' views using Implicit Association Tests found that implicit gender stereotypes (e.g., 'Math is for boys') were present in girls as young as eight and nine years of age. Cvencek and colleagues also found that boys were more likely than girls to strongly identify with mathematics; thus, the researchers posited that gender stereotypes about mathematics form before students' mathematical self-concepts.

Another study (Steele, 2003), conducted with girls in Grades 1 to 4, further parsed gender stereotypes about mathematics by considering the girls' views of children and adults separately. Steele discovered that the participants tended to view boys and girls equally with regard to mathematical ability and preference. In contrast, men were viewed more positively than women with regard to mathematics, and were more likely to be pictured as mathematicians. Although this was a small-scale study conducted strictly with girls, its findings are troubling, as they hint at the disconnect (and lack of role models) between school mathematics and mathematics as an occupation. Even when students explicitly claim that they do not adhere to gender-mathematics

stereotypes, they can be susceptible to the effects of stereotype threat, “the arousal, worrying thoughts, and temporary cognitive deficits evoked in situations where a group member’s performance can confirm the negative stereotypes about their group’s ability in that domain” (Rydell, Rydell, & Boucher, 2010, p. 883). A study with 200 middle school students in France (Huguet & Régner, 2009) involved students replicating a complex figure, with one group being told the task measured geometry abilities while the other group was told that the task measured drawing abilities. While boys performed equally well in both groups, girls in the ‘geometry’ group performed worse than both girls in the ‘drawing’ group and boys in the ‘geometry’ group. Moreover, girls outperformed boys in the ‘drawing’ group. The girls generally held counter-stereotypical beliefs, yet they still underestimated their geometry abilities (in a self-report measure) and performed worse in a stereotype threat condition. The researchers concluded that “neither the absence of gender differences in math performances, nor girls’ counter-stereotypic beliefs can be taken as sufficient evidence that ST [stereotype threat] is not operating” (p. 1027).

Young People: Views of Themselves as Learners of Mathematics

The mathematics self-identities that students form are crucial, since “the nature of participation in mathematics impinges on the relationship/identity a person develops with the subject” (George, 2009, p. 207). Mathematical identities relate to such topics as confidence in one’s mathematical abilities and perceptions about the relationship between one’s gender and mathematics. In my meta-analysis of data from several studies conducted in culturally-similar countries to Canada (e.g., England, Australia) and the Canadian province of Ontario (J. Hall, 2012), a consistent trend existed across the different geographic locales examined, as well as over time and across grade levels: Boys tended to have more confidence in their mathematical abilities and like mathematics more than did girls. Research with Canadian Grade 7 and 10

students (Lupart, Cannon, & Telfer, 2004) had similar findings: Boys were more likely than girls to claim that they are ‘good at math’, rank highly in their classes in mathematics, learn new mathematics concepts easily, and would do well in a mathematics-focused career. Conversely, girls were more likely than boys to agree with the statement ‘No matter how hard I try, I feel I just cannot understand math’, even though girls also were more likely to report doing ‘the best [they] can’ in mathematics. Grade 7 students consistently reported having more positive views than Grade 10 students toward mathematics and toward themselves as learners of mathematics; however, this finding should be couched in the generalized finding that younger students tended to have more positive dispositions toward academics overall than did older students. Gender differences in students’ confidence in their mathematical abilities were also investigated as part of an examination of a large, nationally-representative dataset (Early Childhood Longitudinal Study – Kindergarten Class of 1998-1999; ECLS-K) from the U.S. that involved approximately 21,000 students throughout the duration of their elementary schooling. The researchers (Lubienski, Robinson, Crane, & Ganley, 2013) found that boys consistently reported more confidence in their mathematical ability than did girls. Notably, these gender differences in confidence could not be explained by gender differences in mathematical achievement.

Summary of Young People’s Views

Over the past few decades and across several countries, numerous studies have found that young people tend to hold stereotypical views of mathematics and mathematicians, such as mathematics as being arithmetic and mathematicians as being nerdy White men. Even when young people view mathematics in a favourable light and/or relate the career of a mathematician to positive traits (e.g., intelligent, dedicated), their views of mathematicians become negative when they are personally implicated (i.e., becoming or marrying a mathematician). Generally, a

disconnect was found between young people's views of school mathematics and their views of mathematicians. Recent studies have shown persistent gender differences in young people's views of themselves as learners of mathematics (e.g., confidence). Even when young people purport to hold gender-neutral views about mathematics, stereotype threat appears to impact girls' relationships with the subject area. The findings from the studies examined suggest that more exploration is needed into these topics, in order to better understand how young people form views of mathematics and mathematicians, and the sources that may influence their views.

Selection of 'Actors'

Before turning to the messages that are produced about mathematics, mathematicians, and gender, I address my decision to focus on the general public, media, parents, and teachers as key 'actors' (i.e., socialization agents) in young people's lives. To begin, literature involving these four actors was selected to align with the focus of my study; while other actors, such as peers, undoubtedly produce messages about mathematics, mathematicians, and gender, they are beyond the scope of my study. The aforementioned four actors play key roles in the socialization of young people with regard to their views about mathematics, mathematicians, and gender. Historically, parents and teachers have been posited to be key socialization agents in young people's lives (Roberts & Foehr, 2004). Parents play a main role in the socialization of children – perhaps more than any other actor, due to parents' continued presence and relatively constant messaging (Gunderson, Ramirez, Levine, & Beilock, 2012). Although the role peers play in socialization increases during adolescence, studies have found that parents remain a highly important socialization agent (Arnon, Shamai, & Ilatov, 2008). While teachers do not typically have the enduring presence in young people's lives that parents do, teachers can substantially influence young people's views of gender and mathematics. Namely, the impact of teachers

regarding gendered messages is significant due to the gendered nature of nearly all schools. Due to the enduring perception of mathematics as simply a school subject, teachers may be viewed as the most important figures with whom young people interact concerning mathematics. Although it is perhaps a more difficult ‘actor’ to define, society in general also needs to be addressed. I use this term to refer to the general public, which includes the aforementioned actors, as well as other socializing agents, both people and institutions, with whom and with which young people interact. The remainder of this section focuses on the justification of my choice of media as an ‘actor’, by discussing young people’s high levels of media use in recent years.

Today’s youth are growing up in a world very different from the one experienced by their parents, particularly with regard to media use and exposure. Young people born after 1990 are often referred to as the second generation of ‘digital natives’, in regard to their life-long exposure to ‘new media’, such as web 2.0 internet (Helsper & Eynon, 2010). Growing up in such a high-tech and ever-changing media atmosphere provides a variety of challenges and opportunities unique to this generation. Dill (2013) claims that “media use is by far the most common way human beings spend our free time in the modern world” (p. 3). Due to media’s ubiquitous presence in our lives, it is a vital socialization agent that needs to be further examined. As argued by Roberts and Foehr (2004), “without an accurate mapping of children’s and adolescents’ patterns of media use, we can never fully understand the role of mass mediated messages in the lives of youth” (p. 2). Below, I present findings from studies that addressed young people’s media use in Canada and the United States. To enable later comparisons, I specifically focus on data regarding the five media types in my study: television, movies, video games, reading materials, and the internet/websites. Wherever possible, I present data about young people similar in age to the participants in my study (Grade 4, ages 9-10, and Grade 8, ages 13-14).

Since 1999, the Kaiser Family Foundation has conducted a detailed survey every five years about young people's media use. A nationally representative (U.S.) sample of approximately 2,000 students in Grades 3 to 12 (ages 8 to 18) completed the in-class survey in 2009 (Rideout, Foehr, & Roberts, 2010). Findings are reported for both total media exposure, "the sum of time spent with all media" (p. 2) and total media use, "the actual number of hours out of the day that are spent using media, taking multitasking into account" (p. 2). For instance, if a child plays video games while listening to music for an hour, total media exposure is two hours whereas total media use is one hour. Total media exposure has risen each year the study was conducted, from an average of 7:29 per day in 1999, to 8:33 in 2004, and to 10:45 in 2009. In comparison, total media use was virtually identical in 1999 and 2004 (6:19 and 6:21, respectively), but sharply rose in 2009 to 7:38. As the study's authors point out, young people spend nearly as much time with media each day (7:38) as a typical adult spends at a job, but the media use occurs daily for youth, as opposed to a typical five-day work week. Clearly, media are a pervasive force in young people's lives due to their nearly ubiquitous, and increasing, presence.

With regard to specific media types, use has increased over time in all categories except print media, which has very slightly declined. Television continues to retain its position as the top type of media used, comprising more than half the time young people spend with media each day (4:29 per day). Older students (11-14 years old) watch substantially more television than do younger students (8-10 years old): 5:03 compared to 3:41 per day. Boys watch slightly more television than girls, by approximately 20 minutes per day. Data regarding watching movies at a theatre show a slight decrease from the younger to older age groups, the converse of television watching. As with watching television, boys spend more time watching movies than do girls. Computer use more than doubles from the younger to older age group, from 0:46 to 1:46 per day

outside of schoolwork, and boys use the computer more than girls (1:37 versus 1:22 per day). Similar results are found for video game use: On average, boys spend far more time than girls (1:37 versus 0:49), and older children spend more time than younger children (1:25 versus 1:01) playing video games daily. Print media is the only media type to show a decrease over time in the amount of use (0:38 in 2009 compared to 0:43 in both 2004 and 1999). Younger children spend approximately 10 minutes more per day reading outside of schoolwork than do older children. A gender difference of 10 minutes per day is also shown, with girls spending more time reading. The trends across the five media types discussed are summarized in Table 1.

Table 1
Media Use Trends, by Age Group and Gender (2009 Kaiser Family Foundation Study)

Media type	Group using each media type more	
	Age group	Gender
Television	older (11-14)	boys
Movies	younger (8-10)	boys
Computer	older (11-14)	boys
Video games	older (11-14)	boys
Print media	younger (8-10)	girls

As indicated in Table 1, older children tend to use interactive media (i.e., computers and video games) more than younger children do, which may be related to an increase in maturity, skill level, and independence. Older children also watch more television, on average. For every type of media but print media, boys use/watch more than do girls.

Media use by young people in Canada has been reported by two sources associated with Statistics Canada: the Census at School survey and the Health Behaviour in School-Aged

Children (HBSC) survey. Although the Census at School survey is a volunteer survey and is thus not representative of all Canadian children, the large sample size of approximately 30,000 student participants annually lends utility to the data. The HBSC survey, conducted every four years in over 30 countries worldwide, features random, representative data sampling, with 1,500 participants of each age level (11, 13, and 15 years of age) from Canada.

Census at School is an international in-class primary data collection program for elementary and secondary students. From 2004/2005 to 2006/2007, the Canadian version of the survey featured questions about students' media use. Although there were some changes to the questions asked and the manner in which the results were reported each year, a few gendered trends emerged (No age-level trends can be discussed since Grade 4 to 8 students' results are provided in aggregate). Namely, girls and boys tend to report similar time spent viewing television shows and movies, while gender differences occurred with regard to reading and playing computer and video games. On average, girls spend more time reading than do boys, while boys spend more time than girls playing computer and video games.

The second source of Canadian data on young people's media use is the Health Behaviour in School-Aged Children (HBSC) survey, which is conducted once every four years in more than 30 countries, including Canada. In 2009/2010, findings (Currie et al., 2012) were reported with regard to percentages of 'heavy viewers' – participants who reported watching two or more hours of television on weekdays. For both 11-year-olds and 13-year-olds in Canada, a higher proportion of boys than girls reported being heavy viewers: 64% compared to 56%, and 65% compared to 60%, respectively. Notably, the proportion of heavy watchers increases with age, with a higher proportion of 13-year-olds than 11-year-olds being heavy viewers.

As discussed, all three surveys examined feature questions about media use and provide gender data, while age-group data are provided only for the Kaiser study (8-10 and 11-14 year-olds) and the HBSC study (11- and 13-year-olds). According to the Kaiser study, both media use and exposure have increased substantially over the past decade. In nearly all the data examined, boys were shown to be heavier media users than girls with regard to watching television and movies, as well as playing computer and video games. In contrast, girls were consistently shown to use print media more than boys do. Older students tended to watch television, use the computer, and play video games more than younger students do, while the reverse was true for watching movies and reading print media, although these latter differences were small.

Messages Produced about Mathematics, Mathematicians, and Gender

To better understand the views young people hold about mathematics, mathematicians, and gender, messages that are produced by external ‘actors’ – namely, the general public, media, parents, and teachers – need to be considered. In the following sections, I address the messages produced by each of these actors about mathematics and mathematicians, both in a general sense and related to gendered portrayals.

General Public: Messages about Mathematics, Mathematicians, and Gender

Lim investigated the general public’s images and opinions of mathematics through questionnaires from a diverse sample of 548 adults in the United Kingdom (Lim, 1999; Lim & Ernest, 1999). Although half the participants reported that they liked mathematics, one-third reported that they disliked mathematics, with the highest proportions of negative views being in the youngest age group (17-20 years of age) and students in non-mathematics majors. These negative views “raise concern because these groups represent the future workforce of the nation” (Lim & Ernest, 1999, p. 3). Although most participants held the stereotyped views that

mathematics is difficult and that is it only for a select few, only 20% of the participants agreed with the stereotype that mathematics is a male domain. Lim concluded that the main factor influencing people's views was their mathematics experiences in school.

Mendick, Epstein, and Moreau (2007) also investigated public perceptions of mathematics and mathematicians, but did so with a purposeful link to popular culture. They sought to “explore how popular culture images of mathematics and mathematicians impact on the relationships learners form with the subject” (p. 15). Through questionnaires, textual analysis, focus group interviews, and individual interviews with secondary school and university students from the United Kingdom (the findings of which are reported in Epstein, Mendick, & Moreau, 2010; Mendick, Epstein, & Moreau, 2007; and Mendick, Moreau, & Hollingworth, 2008), the researchers found that mathematics is “simultaneously invisible and ubiquitous in popular culture” (p. 18). When asked to list two representations of mathematics and mathematicians in popular culture, 25% of participants left the first example blank and 49% left the second example blank. Nearly all participants, including mathematics students, saw mathematicians as elderly, middle class, White men, “positions of power and ones that draw on some common popular culture tropes of obsessiveness, geekiness, madness and social awkwardness” (p. 19). Most participants recognized that their images and ideas were clichés (e.g., mathematical ability as a sign of general intelligence), but lacked alternative ideas from their own schooling experiences or from alternative media. The researchers suggested that these stereotypical images (and the disidentification from mathematics that can result) may be challenged in a classroom setting, thus opening up mathematics to more people.

Morge's (2006) research also addressed the interplay among mathematics, gender, and the popular media. Her questionnaires and focus group interviews with U.S. college students

showed that most participants viewed men and women as having equal mathematical ability. Some of the women participants reported losing interest in mathematics in middle school, partly due to concerns about popularity and femininity. Although over 80% of participants reported that the popular media had not influenced their beliefs about mathematics, this was contradicted by the questionnaire and focus group data. Morge attributed this to the fact that the participants were not used to linking mathematics with popular media, and that they “separated the mathematics they did at school from the mathematics they saw on television” (p. 203). Most participants who recalled seeing media representations of mathematically proficient people described them as ‘nerds’, which is consistent with the negative, socially awkward images found in other studies. To combat this negative image, Morge suggests that “reflecting in a mathematics class on media representations of mathematics and people who are good at mathematics may encourage students to question the gender differentiated world that exists inside and outside of schools” (p. 217).

Other investigations into the general public’s views included a focus on mathematics education. Lucas and Fugitt (2009) explored the views of residents of a rural town in the Midwestern U.S. The participants generally viewed mathematics as an important component of college preparation and occupational success. While the participants bemoaned mathematics teachers who made mathematics classes “a boring, repetitious, mentally painful experience” (p. 53), they also tended toward traditional views of mathematics education, criticizing today’s practices as too focused on technology and lacking in sufficient emphasis on ‘the basics’ (i.e., arithmetic). An Australian study (Leder & Forgasz, 2010) reported similar views of the general public regarding the importance of mathematics for future success and concerns about the use of technology in mathematics learning. This study also probed views of gender and mathematics, and found that the greatest proportion of participants felt that boys and girls were equally strong

at mathematics. However, of the participants with a gender-specific stance, nearly twice as many viewed boys as superior compared to those who viewed girls as superior.

Professional mathematicians have reflected on how societal views of mathematics relate to its view within their own community. Furinghetti (1993) posits that mathematics “may be loved or hated, understood or misunderstood, but everybody has some mental image of it... [Mathematics] constitutes the main unifying educational elemental across different cultures” (p. 34). She argues that adults’ images of mathematics, more than any other school subject, have been almost wholly conditioned by the school experience due to “the almost total lack of obvious external referents that makes the school mathematical experience transferable only with difficulty to other environments” (p. 37). Furinghetti concludes that, in order to help with mathematics’ image problem, it needs to be approached in school as a set of human activities that are not simply defined by rigid rules. Malkevitch (1997) agrees with Furinghetti’s claims, and argues for increasing the focus on discrete mathematics, which includes “matrices, graphs and digraphs, difference equations, codes, and counting techniques” (p. 92). Malkevitch argues this would engage students in mathematics by seeing how it relates to ‘real life’ with its link to such issues as optimization, fairness, risk, and growth. By focusing on discrete mathematics, he believes we can “transform the perception that mathematics students get in primary and secondary schools, while at the same time providing a steady stream of students to pursue careers in mathematics and science” (p. 96), which is necessary for today’s technology-driven society.

Media: Messages about Mathematics, Mathematicians, and Gender

Ideas about mathematics can arise through fictionalized portrayals of mathematicians or mathematically proficient characters. The aforementioned large-scale study by Mendick and colleagues explored popular culture representations of mathematics and mathematicians. Based

on questionnaire responses, the researchers compiled a list of popular culture representations of mathematics and mathematicians, and then conducted document analysis on these sources. They found that mathematics was portrayed as “a secret language, possibly a code, which is difficult to ‘crack’” (Epstein, Mendick, & Moreau, 2010, p. 49), which is linked to the notion of being ‘obsessed’ with mathematics. Related to the notion of mathematical genius is the depiction of mathematics as a difficult, intellectual pursuit that is mystifying to the ‘average’ person (Mendick, Epstein, & Moreau, 2007). On a positive note, the researchers also found portrayals of mathematics as aesthetically beautiful (e.g., linked to patterns in nature) and utilitarian (e.g., used to solve crimes). Conversely, mathematics was portrayed in less positive ways in other examples, such as reductive depictions (e.g., simply numbers and ‘rules’) (Mendick, Epstein, & Moreau, 2007). For instance, reductionist tendencies are apparent in the title of the television show *Numb3rs*, but the voice-over at the beginning of each episode describes mathematics in much broader ways, related to real-life applications, patterning, and predicting (Epstein, Mendick, & Moreau, 2010).

Portrayals of mathematicians in the media are highly gendered – both in terms of the number of men and women shown, as well as the gendered ways in which men and women mathematicians are characterized. Popular media representations of mathematicians are overwhelmingly men (Mendick, Moreau, & Hollingworth, 2008), and these men are nearly always portrayed in negative, stereotyped ways. Commonly, mathematicians are portrayed as having mental illnesses, with an obsession with mathematics often being attributed as an underlying cause (Goff & Greenwald, 2007; Mendick, 2004). Additionally, an obsession with mathematics is linked to mathematicians’ ‘geekiness’ and social ineptitude (Epstein, Mendick, &

Moreau, 2010). Men mathematicians are also portrayed as geniuses who are ‘naturally’ gifted with incredible mathematics abilities (Mendick, Moreau, & Hollingworth, 2008).

While overall, mathematicians are infrequently featured in popular media, women mathematicians are particularly rare. In contrast to men mathematicians, women mathematicians are not typically shown in such stereotyped, negative ways with regard to mental illness, social ineptitude, or obsession (Mendick, Moreau, & Hollingworth, 2008). However, women mathematicians are positioned in negative, gendered ways that are subject to societal norms of gender and power. Namely, women mathematicians tend to be shown in supporting roles, such as students and daughters, with their mathematical contributions downplayed (Mendick, Moreau, & Hollingworth, 2008). Although a few emerging representations of attractive, mathematically talented girls and women were found in the study by Mendick and colleagues (2008), concerns were raised by the researchers about “the dramatised tensions between feminine heterosexuality and mathematics and the hyper-attractiveness of these characters” (p. 12). In other words, it is as though the characters were made ‘hyper-feminine’ in other aspects to compensate for being a mathematician (i.e., masculine). Even when real-life mathematicians are discussed (e.g., documentaries), their lives are viewed through gendered lenses. For instance, a woman mathematician’s marital status and children tend to be a focus, while such familial matters tend to be downplayed in similar reports of men mathematicians (Goff & Greenwald, 2007).

Professions in STEM (science, technology, engineering, and mathematics) fields more generally were explored in a study (Smith, Choueiti, Prescott, & Pieper, 2013) that examined gendered representations of occupations in family films, prime-time television shows, and children’s television shows. While the overall representation of characters working in STEM fields was generally illustrative of actual labour market statistics, women were underrepresented.

Specifically, the representation of women in STEM occupations in family films was 16.3%, compared to 21.1% for prime-time shows, and 12.5% for children's shows. Although the proportion of women shown in STEM occupations in the prime-time shows is highest, it still does not reach the actual statistics: 24.5% of STEM jobs in the United States are held by women (Beede et al., 2011), compared to 22.0% of STEM jobs in Canada (NSERC, 2010).

In an earlier research project (J. Hall, 2008), I investigated the representations of mathematics in magazine advertisements. Specifically, I explored one year of publications from six monthly magazines targeted at varied audiences: *Parents*, *Popular Science*, *Report on Business*, *Runner's World*, *Seventeen*, and *Vogue*. Notably, I only found 12 relevant advertisements (i.e., those that featured a message about mathematics, not simply numbers or statistics; although using numbers and statistics to increase the 'clout' of an advertisement is certainly a message in itself, it was beyond the scope of my project) across more than 70 magazine issues. This finding indicated that mathematics tends to be treated as an invisibility in our culture, which is reflected by the magazines. Although the advertisements were mixed between mathematics-related products (e.g., educational DVDs) and non-mathematics-related products (e.g., cars), the messages were quite consistent overall: Mathematics was represented in very stereotypical ways, as a difficult, boring, and/or stressful subject area. Additionally, both the content and style of the advertisements indicated that most were targeted at men. The few advertisements targeted at girls and women tended to portray mathematics in a negative manner (e.g., a link between doing mathematics and stress in a deodorant advertisement in *Seventeen*).

In addition to fictionalized representations of mathematics and mathematicians in the media, messages, particularly about gender and mathematics, are also portrayed in the news media when reports of scientific studies and large-scale assessments are publicized. In the 1980s,

amidst Eccles and Jacobs' longitudinal study that explored the socialization of girls' and boys' attitudes toward mathematics, an article was published in *Science* that reported on controversial claims from a study by Benbow and Stanley (1980), who proclaimed a biological basis for differences in girls' and boys' mathematics ability (based on gifted children's scores on the SAT-Mathematics test). The findings were widely disseminated in the popular media, with references being made to a 'math gene' and to boys' 'inherently superior ability'. Eccles and Jacobs (1986) asked the parents in their study whether they had been exposed to these news stories, and then compared their exposure to their gendered attitudes about their children and mathematics. While mothers who had been exposed to the news stories ('misinformed') tended to view their daughters more negatively with regard to mathematics than did mothers who had not been exposed to the news stories ('uninformed'), misinformed fathers tended to feel more positively about their daughters' mathematical abilities than did uninformed fathers. However, misinformed fathers of sons tended to increase in their gender-stereotyped attitudes. Eccles and Jacobs thus concluded that media exposure to ideas about gender and mathematics appears to influence parents' attitudes, although the impacts depend on the gender of both the parent and the child.

In a more recent example, Coupland and Wood (1998) examined news reports about girls' overall superior performance on assessments (in a variety of subject areas) that take place at the end of high school in the Australian state of New South Wales. From the early 1980s to the mid-1990s, girls' average total scores on the assessments increased, while boys' averages scores decreased; in the 1990s, the gap between girls' and boys' scores was considerable. Each year, the results for the top students and their schools are published, and intense media scrutiny is paid to the results, particularly to gender differences. Newspaper reports claimed that girls were unfairly advantaged due to the recent decision to include scores in English and humanities subject areas,

as well as deliberate encouragement of girls in mathematics and science, while boys were seen to be disadvantaged and discouraged from these subject areas and from school in general. The researchers analyzed both initial articles and letters to the editor, and found that members of the public were more balanced in their interpretations of the results than were the newspaper reporters. Coupland and Wood stated that they were shocked “that people thought there was something to be concerned about now that girls were doing *better* than boys, while for many years the status quo of boys doing better was simply accepted as the natural order of things” (p. 243, emphasis in original). Although the media attempted to create controversy about the girls’ superior performance, the general public appeared well-informed about the issue and generally did not buy into these simplistic ‘girls versus boys’ tropes; as a result, the manner in which the results were discussed in subsequent articles was altered. The researchers concluded that “it is unlikely that more reports with a ‘girls versus boys’ flavour will be well received” (p. 244). In this instance, the general public’s reaction impacted the media reporting, whereas the previously discussed study (Eccles & Jacobs, 1986) found that media reporting impacted parents’ views. It is difficult to predict what type of response media reports related to mathematics and gender will have on those who are exposed to them, as no clear trends are apparent in the studies examined.

Parents: Messages about Mathematics and Gender

Due to a paucity of literature about parents’ views of mathematicians, this section solely focuses on parents’ views of mathematics and gender. Studies of parents’ views of mathematics as a male domain tend to show significant differences between mothers’ and fathers’ views, as well as differences between the views of parents with sons and parents with daughters. In a study of parents of children in upper elementary school grades, fathers were more likely than mothers to hold the view of mathematics as a male domain, as were (all) parents of boys (Leedy,

LaLonde, & Runk, 2003). The mothers and fathers in this study also tended to hold different views about mathematics, with mothers more likely to view mathematics as being used in everyday life and for calculations, whereas fathers were more likely to view it as a language or a tool in science-related fields. Results from a longitudinal study that followed primary schoolchildren for nearly a decade aligned with the gender-stereotyped views found in the study by Leedy and colleagues. Jacobs and Bleeker (2004) collected questionnaires annually from parents and children about their views of mathematics, as well as the parents' interactions with their children in mathematics- and science-promoting activities. Specifically, (all) parents were more likely to purchase mathematics- and science-promoting items for boys than girls, which suggests that boys may be advantaged due to their greater exposure to and practice with mathematical ideas and concepts. These purchases were found to have longer-term effects (two to six years) regarding the children's involvement and interest in mathematics. Although parents were more likely to purchase such supportive items for boys, both mothers and fathers were more likely to be involved with girls' mathematics and science activities. Although this involvement may be viewed in positive, supportive ways, it could also suggest to the girls that they are in need of assistance (i.e., that they are not capable of exploring mathematics and science without parental support, whereas boys are capable of independent exploration).

Other studies explored the influence of parents' gendered views of mathematics on their interactions with their children and their children's views. Tiedemann's (2000) study of Grade 3 and 4 students, parents, and teachers in Germany found links between parents' gendered views of mathematics and other mathematics views, as well with the children's views. Specifically, parents who held gender-stereotypical views of mathematics were found to perceive their daughters to have lower ability in mathematics than their sons; the children of such parents were

found to have lower perceptions of their mathematical abilities, regardless of their achievement in mathematics. Parents' gender-stereotyped views of mathematics have also been found to impact their interactions with their children and homework. Bhanot and Jovanovic (2005) explored 'intrusive support' with homework (i.e., uninvited overseeing or assistance) involving parents of children in Grades 5 to 8 in the United States. Boys reported more intrusive support than did girls, which was linked to parents' perceptions of boys' lower abilities (in mathematics and English). Although girls reported less intrusive support, the intrusions related to mathematics were troubling: Parents who intruded on girls' mathematics homework tended to hold gender-stereotyped views of mathematics, and this parental intrusion was linked to girls having lower confidence in their mathematics abilities. The researchers purported that these gender-specific findings for mathematics may be related to stereotype threat: "When parents intrude with math homework, girls are reminded of their minority status in math" (p. 604). When women are reminded of gender/math stereotypes (particularly if linked to biologically-based explanations), they tend to perform worse on mathematical tasks (e.g., Dar-Nimrod & Heine, 2006; Quinn & Spencer, 2001; Rydell, Rydell, & Boucher, 2010; Spencer, Steele, & Quinn, 1999). Other studies have shown that subtle reminders of their gender (i.e., gender priming) shift women's views toward more stereotypical outlooks regarding mathematics (e.g., Steele & Ambady, 2005). Recent research (Zhang, Schmader, & W. Hall, 2013) has found that stereotype threat can be reduced for women completing mathematics tests through the use of a pseudonym (regardless of the gender of the name) rather than the participant's own name. These findings suggest that self-reputation threat is a significant component of stereotype threat.

Teachers: Messages about Mathematics, Mathematicians, and Gender

Literature regarding teachers' views of mathematicians is sparse. One concern raised is that teachers fail to view students as young mathematicians, which is arguably linked to teachers viewing children's capacities for mathematical exploration in limited ways (Gadanidis, 2012). A study (Cirillo & Herbel-Eisenmann, 2007) that followed eight Grades 6 to 10 teachers for a year found only 14 references to the word 'mathematician' in the mathematics classes observed, and all but one of these utterances were made by high school teachers. These references typically related to historical mathematicians and justifications for using mathematical conventions ('That's how mathematicians do it'). Notably, two of the elementary teachers who expressed concerns about their mathematical content knowledge never mentioned mathematicians.

A lack of confidence in one's mathematical abilities can have serious consequences for students. A study (Beilock, Gunderson, Ramirez, & Levine, 2010) that examined Grade 1 and 2 teachers' mathematics anxiety found gender differences in the outcomes of the students in mathematics-anxious teachers' classes. Girls' mathematics achievement decreased over the year in such teachers' classes, while the girls' (stereotypically) gendered beliefs about mathematics increased. Notably, no such changes were seen in the boys in the same classes; thus, the researchers concluded that it was not simply the case that mathematics-anxious teachers were poorer teachers overall. Rather, a specific gendered interaction was occurring. The researchers suggested that girls may be influenced by a same-gender role model, as children "model behaviors they believe to be gender-typical and appropriate" (p. 1862).

As demonstrated by Gunderson, Ramirez, Levine, and Beilock (2012) in a review of several studies, teachers tend to hold gender-stereotyped beliefs about their students and mathematics. However, these findings are certainly not conclusive and vary with the population and situation studied. For example, a study (Leedy, LaLonde, & Runk, 2003) of elementary

teachers who were either coaches of their school's mathematics team or 'regular' classroom teachers (i.e., non-coaches) found significant differences in the teachers' gendered views based on coaching status. Namely, mathematics coaches were less likely to view mathematics as a male domain than were non-coaches. However, no differences based on coaching status were found with regard to the teachers' views of mathematics more generally. Additionally, the coaches generally purported that they saw no gender differences in the manner in which girls and boys prepared for mathematics competitions. In contrast, a study of Grade 3 and 4 teachers in Germany (Tiedemann, 2002) found that teachers tended to hold gender-stereotyped views. However, these views were specific to the students' achievement level: Teachers tended to view students' achievement in gender-stereotyped ways (particularly with respect to attributions for achievement, such as effort versus 'natural' talent) only for low- and middle-achieving students. The reasons for the lack of gender stereotypes regarding high-achieving students are unclear.

Messages Produced about Gender

As demonstrated in my earlier discussions about young people's views of mathematics and mathematicians, gender plays a key role in the way that young people envision mathematics, mathematicians, and themselves as learners of mathematics. Therefore, it is vital to examine more generally the messages about gender to which young people are exposed. By reviewing studies that investigated representations of and messages about gender in a general sense, a greater understanding of the gendered world in which young people grow up can be garnered. As with the prior section, I begin broadly, discussing messages about gender produced by the general public. I then address messages about gender distributed by the media. I conclude by addressing messages about gender that are disseminated to young people by parents and teachers.

General Public: Messages about Gender

Children's lives are rife with gendered expectations from the moment they are born. The first question people usually ask when a child is born, even before "How are baby and mother doing?", is "Is it a boy or a girl?". From birth, children are gender socialized and often gender patrolled into a strict sexual dichotomy of 'male' and 'female', with 'masculine' and 'feminine' gender traits expected to align (Lipkin, 2009). In a landmark study, Seavey, Katz, and Zalk (1975) investigated how adults interacted with a baby that was identified as a boy, a girl, or not identified by gender, under the guise of studying how babies react to strangers. Although the same baby, wearing the same outfit, was used with each participant, the participants interacted differently with the baby based on what they were told about the baby's gender. Namely, the manner in which they handled the baby and the toys they used with the baby were gender stereotyped. Participants who interacted with the baby in the 'unidentified' condition were asked to guess whether it was a boy or a girl; regardless of their choice, participants could find cues that supported their guesses (e.g., a strong grasp for a 'boy' guess, fragility for a 'girl' guess). This study demonstrates that, even within three minutes of interacting with a heretofore unknown baby, adults' gender stereotypes are enacted. The researchers also found that many participants in the 'unidentified' condition wanted to know the baby's gender and appeared stressed when it was not provided.

The tendency to 'need' to know a child's gender was fictionalized in *X: A Fabulous Child's Story*, an article by Lois Gould published in *Ms.* magazine (1972; published in 1978 as a storybook). In the story, a 'Secret Scientific Xperiment' is undertaken in which the Joneses raise their child as X, not identifying X as a boy or girl. With support from the 'Official Instruction Manual', the Joneses provide X with a variety of stereotypically feminine and masculine activities and experiences, and X thrives socially, emotionally, and academically. At school and

out in society at large, X and the Joneses are not accepted and face teasing and constant questioning about X's gender. However, the other children eventually realize that X is essentially having twice as much fun and twice as many experiences as they are, and they began acting in non-gender-stereotypical ways. This causes much stress and grief for their parents, who in turn complain to the school about X being a bad influence, demanding X be tested and forced to behave like a boy or a girl. The story concludes with experts testing X and concluding that X is not a mixed-up child at all, and the other children taking on X's androgynous clothing and activities.

This issue resurfaced in popular media recently, with the story of a Toronto couple who decided not to divulge their child's sex (Poisson, 2011). The parents, Kathy Witterick and David Stocker, hope to allow their baby, Storm, to have more freedom to grow up to be who (s)he is, rather than be constrained by social norms about gender. This decision was met with harsh criticisms from both friends and strangers. In a follow-up to the initial story, which was published online in the *Toronto Star*, author Catherine Porter reports that the story "has received more hits and vitriol than any other story ever published on thestar.com" (2011, p. 1). The criticisms are partly related to the notion that the parents are performing an 'experiment' on their child, who has no say in the matter, but mainly related to the notion that gender is linked to sex, so Storm needs to know which sex (s)he is in order to know how to act. One poster's comments summarize the criticisms: "There are males and there are females throughout the natural world, each has it's [sic] instinctive roles to play and conforms to the identity that was determined long before it was born" (coco1982, posted May 28, 2011). It speaks volumes regarding our lack of progression in society regarding conceptions of gender that the same strong reactions are elicited regarding raising a child this way in 2011 as in a fictional story from the 1970s. In both

instances, people are upset and feel as though they can't really know who the baby is without knowing his/her sex. This indicates presumptions about personality traits and preferences of boys and girls, such as those presumptions found in the study by Seavey and colleagues (1975).

This differential treatment is exacerbated with time and with children's experiences in our highly gendered world. In nearly every aspect of their lives, children face societal, peer, and familial pressure to conform to gendered expectations regarding their behaviours, dress, and other lifestyle choices. A walk through any children's clothing store or toy store makes these gendered expectations readily apparent – Girls wear pink and purple, lace and ruffles, and play with dolls, whereas boys wear 'stronger' (i.e., non-pastel) colours, clothing free of decoration (save for images of sports items, cartoon figures, etc.), and play with trucks and building blocks. Indeed, research (Delamont, 2001) has shown that products for children (e.g., clothing, toys) have become more gender-binaries/stereotyped than they were in the past.

For instance, when I searched the Canadian website for Toys R Us, a large international toy retailer with approximately 70 stores in Canada, I found that toys are separated by 'Boys' Toys' and 'Girls' Toys' categories. The 'Boys' Toys' include action figures, vehicles, and building sets. A sub-category is 'Boys' Role Play', which includes costumes for such occupations as a doctor and a train conductor, as well as a variety of superhero roles. Conversely, the 'Girls' Toys' category features dolls, stuffed animals, and related accessories. Interestingly, the parallel to 'Boys' Role Play' is called 'Girls' Pretend Play and Dress Up'. While this may seem like a minor difference in terminology, it in fact signals that boys are emulating adult roles, such as viable careers (e.g., doctor, military personnel), whereas girls are merely 'playing pretend' and 'dressing up', both of which have a lesser significance. Indeed, the vast majority of the options provided to girls for their 'pretend play' are princess costumes and toy kitchen

appliances, pretend food, and other ‘housewife’-related items. Of the 112 items listed under ‘Girls’ Pretend Play’ (as of June 7, 2011), only four relate to careers outside the home (not counting being a princess, which is not a viable option for most girls) – costumes for a veterinarian, doctor, firefighter, or train conductor. Nearly all of the items slot girls into the ‘princess’ or ‘housewife’ role from a very early age. Importantly, boys are also not given options outside the ‘masculine job’ or ‘superhero’ role. They are not provided with ways to play with household items (thus modelling how men contribute to a household) or to pretend they hold some role outside those aligning with hegemonic masculinity.

Similar representations were found in a study of young children’s (ages three to five) favourite toys and DVDs, as reported by their parents (Francis, 2010). The children’s favourite toys were strongly gender-differentiated, with all but two (of 32) items selected being highly gender-stereotypical. Furthermore, the boys’ favourite playthings (both toys and DVDs) were shown to have far more educational value than the girls’ favourites. Indeed, educational products for children have been shown to be gender stereotyped, with imbalanced representation (Comstock & Scharrer, 2007). A study of 43 highly-rated educational software packages for children aged three to six (Sheldon, 2004) found that the programs were significantly more likely to contain male main characters than female main characters. While female characters were more likely than male characters to engage in counter-stereotypical behaviours, female characters were also more likely to be gender-stereotyped in appearance. This type of characterization is “confusing at best and destructive at worst. Girls learn that no matter what their behaviors, they should appear ‘appropriately feminine’” (Sheldon, 2004, p. 440). A study of 889 characters found in 56 colouring books (Fitzpatrick & McPherson, 2010) targeted at boys, girls, or all children also found more male than female characters. The characters tended to be engaged in

behaviours that were gender-stereotypical. Males were more likely to be shown as adults whereas females were more likely to be shown as children; the researchers suggest that this may result in a lack of adult role models for girls using colouring books. Additionally, of the three categories (for girls, boys, or all children), colouring books directed at girls contained the most stereotypes. In sum, Francis (2010) argues that, “boys and girls are being inculcated to different gendered worlds due to their distinctive gendered consumption of toys and leisure resources” (p. 340). The distinctions drawn between ‘boys’ and ‘girls’ toys and playthings provide children with a message about what is perceived to be ‘normal’ for boys and for girls.

Media: Messages about Gender

As detailed earlier, young people spend a great deal of their time interacting with mass media; it consequently is viewed as an important agent of socialization (Roberts & Foehr, 2004). Young people’s exposure to gendered representations in the media contributes to their understanding of what is seen as appropriate and socially accepted for their gender (Scharrer, 2013). In this section, I discuss findings from studies related to representations of gender in children’s media, according to the media types in my study: television, movies, video games, and reading materials. Websites are not discussed as I was unable to find any studies that were pertinent to the websites featured in my study (i.e., the ‘top choices’).

Television

Research regarding gendered representations on children’s television programs consistently demonstrates a paucity of female characters (Lemish, 2010). When female characters are shown, they tend to be portrayed in stereotypical ways, presenting “boys as active, aggressive, and adventurous and girls as passive, nurturing, and subdued” (Comstock & Scharrer, 2007, p. 83). Similarly, television tends to categorize men as ‘doing’ in the public

sphere, whereas women are relegated to ‘being’ in the private sphere (Lemish, 2010), which is linked to men being defined by action and women being defined by appearance. Male characters in children’s television shows are often depicted as the heroes, solving problems and undertaking adventures. Conversely, female characters are both underrepresented and underdeveloped, and frequently depicted as needing to be ‘rescued’ by male heroes (Lemish, 2010).

A large-scale study of approximately 1,000 children’s television shows that aired in 2005 found that the ratio of male to female characters was 1.67 to 1 (Smith & Cook, 2008). When compared by the show’s rating, the shows targeted at the youngest children had higher male to female character ratios than the shows targeted at older children. Additionally, shows targeted at older children presented “a more balanced treatment of characters by gender and in roles of familial responsibility” (p. 19). When comparing live-action and animated children’s shows, the researchers found the latter to portray females in more sexualized, stereotypical ways than males. A recent study (Smith, Choueiti, Prescott, & Pieper, 2013) that examined prime-time television shows and children’s television shows that aired in 2011 and 2012 had similar findings: The prime-time shows, most of which are targeted at teenagers and adults, had a higher proportion of female characters than did the children’s shows. Specifically, 38.9% of the speaking characters on the prime-time shows were female, compared to 30.8% for children’s shows. Additionally, nearly twice the proportion of the children’s shows compared to prime-time shows were considered to be ‘extremely male centric’ (i.e., 0-25% of the cast is female): 39% versus 20%. Similar outcomes were found in a study of cartoons aired from 1930 to 1996 (Klein & Shiffman, 2009), where female characters accounted for only 16.4% of the characters overall. Although the proportion of female characters has been generally increasing since the mid-1960s, the highest proportions (which occurred in the 1930-1934 and 1985-1989 time periods) are still only

approximately half of females' actual proportion of the population. Even if the proportion of female characters reached 50%, it would not be sufficient; female characters need to be portrayed in varied, non-stereotypical ways.

Children are keenly aware of the gendered representations in cartoons. Through interviews with four- to nine-year-old children, Thompson and Zerbinos (1997) discovered that the vast majority of the children were aware that there were more males than females in cartoons and that males had more speaking roles. Children who noticed stereotypical behaviours of the cartoon characters were more likely to report gender-stereotypical job aspirations for themselves. While this finding does not imply causality, it suggests that the gender stereotypes shown in children's cartoons may contribute to children's understandings of gender, possibly in negative ways. Very young children have been shown to have a strong awareness of gender and to hold stereotypes. When shown incomplete television segments and asked to predict whether a man or woman would complete the activity or occupation (and whether a man or woman would do it better), four- and five-year-old children's responses revealed strong gender stereotypes, particularly with regard to stereotypically masculine activities (Durkin & Nugent, 1998). The researchers claimed that these gender stereotypes were formed through a combination of television viewing and social interactions with other people (e.g., parents, peers); such claims reflect a conception of media as a socializing agent. Similar to the findings of the study by Thompson and Zerbinos (1997), this study found a statistically significant relationship between children's views of television characters and their own perceptions regarding future careers. When asked if they would be able to do the activities or careers when they grow up, most children felt they would be capable of both the female- and male-stereotyped tasks. However, when children stated that they would not be capable of performing a task or occupation, it was

with regard to those demarcated as strongly gender-stereotyped. Notably, this study solely focused on whether the children thought they would be able to do a task or occupation, not whether they actually wanted to, thus measuring perceived competence rather than preferences.

Related to the aforementioned studies about cartoons, non-human characters in children's programming are presumed to be male unless demarcated by a 'feminine' physical trait, such as a hair bow or lipstick (Lemish, 2010). As such, Lemish posits that female characters are demonstrating a deviation from the dominant male norm, as per de Beauvoir's theory of women as the 'second sex'. Besides the shows' characters, television shows and commercials targeted at children also invoke other gender stereotypes in backgrounds, colour choices, and symbols. For instance, glitter, pastel colours, flowers, and baby animals are almost exclusively linked to female characters and used in television commercials for products aimed at girls.

It is estimated that the average child will be exposed to 600,000 television commercials in the first 20 years of his or her life (Black, 1997, as cited in Larson, 2003). While a great deal of research has been conducted regarding television commercials targeted at children, it often focuses on obesity and consumerism (e.g., Halford, Gillespie, Brown, Pontin, & Dovey, 2004; Valkenburg, 2000). However, a few studies have examined gendered portrayals in commercials aimed at children. Larson's (2001) study of nearly 600 commercials that aired during children's programs in 1997 and 1998 had mixed findings with regard to gender representations. On a positive note, nearly equal numbers of boys and girls were shown in the commercials overall, with slightly more boys-only commercials (i.e., those with only male actors or characters; 59%) than girls-only commercials. This is a marked improvement from findings in similar research from the 1970s and 1980s, where the ratio of boys to girls ranged from 6:1 to 2:1 (Larson, 2001). However, girls were portrayed in stereotyped ways: playing co-operatively in domestic settings.

A recent study (Kahlenberg & Hein, 2010) similarly analyzed children's commercials, although it only focused on one network, Nickelodeon, which has been found to have more progressive and gender-egalitarian programming. An analysis of 455 commercials that aired on Nickelodeon in 2004 found gender-stereotyped representations of toys and children's play. This was particularly the case in girls-only and boys-only commercials, which heavily featured gender-stereotypical products (e.g., dolls, action figures). Although approximately equal numbers of boys and girls were shown in the commercials, their representation was highly stereotyped. The researchers thus concluded that the gender stereotypes featured in the commercials "outweighed the democratic [*sic*] and empowerment given to girls within the programs themselves" (p. 843).

Movies

Analyses of children's movies tend to provide evidence of a similar gender imbalance to that found in television shows. In an examination of 90 top-grossing G-rated movies from 1990 to 2005, only 28% of characters and 17% of narrators were found to be female (Smith, Pieper, Granados, & Choueiti, 2010). These proportions remained stagnant over the time period studied. Women were portrayed more positively than men with respect to intelligence, 'goodness', and appearance. Additionally, there were no gender differences with regard to the frequency of employment, although women were more likely to hold gender-stereotypical jobs. A similar study (Smith & Cook, 2008) examined 400 top-grossing movies from 1990 to 2006, although all types of films were included (i.e., G, PG, PG-13, and R rankings). Regardless of the inclusion of different types of films, the outcome was nearly identical: 27% of characters were female, with no change over time in their representation. The ratio of males to females increased with the movies' rankings (from G to R), but this increase was small (ranging from 2.5:1 to 2.9:1). Female characters tended to be positioned as either highly sexualized or traditional (e.g., a stay-

at-home mother). Smith and Cook (2008) also examined 13 heroines from G-rated films, and found that these characters tended to be valued for their appearance, focused on finding love, and lacking in long-term goals and ambitions for themselves. On a positive note, the perception of these characters as ‘damsels in distress’ was found to not hold true for most of these heroines, who were often positioned as being brave and heroic. Finally, the most recent study by this research group (Smith, Choueiti, Prescott, & Pieper, 2013) aligned with the previous findings: An examination of nearly 6,000 speaking characters in family films released between 2006 and 2011 found that only 28.3% were female. Additionally, 50% of the films were shown to be ‘extremely male centric’, meaning that 25.0% or fewer of the cast members are female. These continued stereotypical representations and underrepresentation of girls and women in film are troubling, particularly given equal population distribution and changing gender roles in society.

Video Games

Video games have the potential to influence young people’s views more than television shows and movies, due to the highly interactive and repetitive nature of video games (American Psychological Association, 2006). Although great advancements have occurred in the graphics, realism, and technological capabilities of video games in the past decade, parallel advances have not been seen regarding gendered representations. Not only are the games themselves gender-imbalanced, with stereotypical representations, advertisements about the games lack the presence of female actors (Comstock & Scharrer, 2007). An early study of Nintendo and Sega Genesis games (Dietz, 1998) found that 30% of the games with characters did not include any female characters. When female characters were included, they were depicted in narrow, stereotyped roles: damsel in distress/victim, sex object, or evil/obstacle. These representations of women are

“detrimental to both girls and boys inasmuch as both may internalize these expectations and accept the idea that women are to be viewed as weak, as victims, and as sex objects” (p. 438).

More recent studies of video games, game characters, and gaming magazines (Dill & Thill, 2007; Downs & Smith, 2010; Miller & Summers, 2007) show little improvement in the depiction of female characters, who are underrepresented and/or represented in stereotypical, hypersexualized ways. When comparing characters by the Entertainment Software Rating Board (ESRB) rating, games targeted at ‘Everyone’ (ages six and up) had a higher proportion of male characters than did games rated ‘Teen’ or ‘Mature’ (Downs & Smith, 2010). When female characters were included, they were often not ‘playable’, which again denigrates their role (Miller & Summers, 2007). Young people are keenly aware of these stereotyped portrayals of video game characters. Undergraduate students in Dill and Thill’s (2007) study described typical male and female video game characters in ways highly congruent to their actual representation. This was the case even if the participant had limited or no experience with video games, which provides evidence of the ubiquitous nature of video games in popular culture. Notably, the video gaming industry is notoriously male-dominated and “overall has been resistant to acknowledging the importance of gender” (Kafai, Heeter, Denner, & Sun, 2008, p. xx).

Reading Materials

As argued by McCabe, Fairchild, Grauerholz, Pescosolido, and Tope (2011), “Gender is a social creation; representation, including that in children’s literature, is a key source in reproducing and legitimating gender systems and gender inequality” (p. 218). In these researchers’ examination of more than 5,500 children’s storybooks published in the 20th century in the United States, gender disparities were indeed found, with nearly twice as many males as females in titles and 1.6 times as many males as females as central characters. Although males

were always represented more often, differences occurred by character type, with animals having the most inequitable representations and children having the most equitable representations.

While the trend over time has been a move toward gender equity, male characters remain the majority. Similar findings occurred in a study (Hamilton, Anderson, Broaddus, & Young, 2006) that investigated gendered representations in 200 popular children's books published in the 21st century: Nearly twice as many males as females were title characters and central characters. Stereotypical gendered occupations and roles were also found. In contrast to earlier studies, which found that all authors tended to feature boys, Hamilton and colleagues found this to be true only for male authors; female authors showed near gender parity in their characters.

Gendered representations were investigated in a study that focused on a different source: early school readers (i.e., 'learn to read' books) used in New Zealand between 1950 and 2000 (Jackson & Gee, 2005). The findings demonstrated few changes over time in gendered representations of characters. Namely, women were typically depicted narrowly, as caregivers and homemakers, while men were shown in a variety of occupations and activities. Conversely, the representation of girls' activities became more varied over time, while boys' activities remained narrow in range. However, "the representation of girls or boys acting outside of traditional masculinity or femininity was highly contradictory" (p. 125), such as a girl climbing a tree in a pink dress. Such representations serve to remind the reader of traditional markers of femininity, even while the character undertakes a traditionally masculine task.

When considering books targeted at older children, many gender inequities are also found. Dieckman and Murnen (2004) examined two types of mid-elementary level novels – those considered non-sexist (10 books) and those considered sexist (10 books), as classified by prior researchers and publishers. Regardless of the classification, the books tended to portray

female characters as having stereotypical personality traits and engaging in stereotypical activities. Although the non-sexist books portrayed more female characters with masculine-stereotypical personality traits, engaging in masculine gender roles, no books featured male characters in a complementary position. These findings may hint at the broader social acceptance of girls and women in ‘masculine’ roles, but a lack of progress toward accepting boys and men in ‘feminine’ roles. These findings align with trends found in a study that examined gendered representations in contemporary (published from 2004 to 2006) Canadian children’s literature (Robinson, 2009): Girls were shown to be a “feisty, fine bunch” (p. 215) with a variety of personalities and interests, where boys were depicted in more narrow, stereotypical ways. Gender stereotypes were also present in the covers of the books, with highly feminized and masculinized covers directing young readers to select ‘gender-appropriate’ books. Interestingly, two of the selections examined were non-fiction books that attempted to address and challenge gender norms overtly. However, Robinson found that even these books “offer a re-inscription of normativity in the very moment that they attempt to challenge it” (p. 207), by, for instance, providing different, gendered advice to girls and boys when encountering a challenging situation.

Gender inequities are also prevalent in other types of reading materials, such as magazines and comics. Massoni (2004) examined a year of issues of *Seventeen* magazine, which is targeted at teenage girls, for gendered representations of occupations. Of the more than 1,000 representations of 40 occupations, 70% of the jobs were held by men, and men were depicted as holding the power in the work world (e.g., a man as an administrator and a woman as an assistant). The vast majority of the examples showed men and women working in gender-stereotyped fields. The single example of a young woman associated with non-gender-stereotypical fields (engineering and architecture) was in a short story, wherein the young

woman was turned away from the fields by a guidance counsellor because of her gender. Overall, the examples in *Seventeen* magazine are “retelling a very familiar and enduring tale about power relations in a gender hierarchy” (p. 62). Similarly, Glascock and Preston-Schreck’s (2004) investigation of gender roles in daily newspaper comics (an examination of a month’s worth of 50 daily comics) found that women characters were less likely than men characters to have a job, and when they did, it was at a lower job status. Women were also portrayed in other stereotypical ways, such as being at home, being with children, or dressing provocatively. More generally, over 60% of the more than 1,000 characters examined were boys or men. Notably, only 11% of the writers and cartoonists of the 50 comics examined were women. When women were involved in creating a comic, the gender representation of characters was much more equitable, indicating the importance of the gender of those involved in the creation of media.

Symbolic Annihilation of Girls and Women in the Media

The term ‘symbolic annihilation’, first conceptualized by Tuchman (1978) with regard to women’s representation in the media, refers to “the way cultural production and media representations ignore, exclude, marginalize, or trivialize a particular group” (Merskin, 1998, p. 335, as cited in Klein & Shiffman, 2009, p. 57). Klein and Shiffman (2009) numerically define symbolic annihilation as the prevalence of a group in the media being less than one-quarter of its actual representation in society (compared to simply being ‘underrepresented’, which Klein and Shiffman define as being less than one-half the actual representation). Since females comprise approximately 50% of the population, their representation would be considered symbolic annihilation if only 12.5% (one-quarter of 50%) or fewer of the characters in a television show were female. By either not including members of a certain social group, or representing them in a negative manner, the media send a message to viewers about the social worth and acceptability

of that group. When these groups are not shown, viewers receive the symbolic message that these groups are ‘others’ and unworthy of media attention.

While the examples discussed above in the various types of children’s media highlight the lack of female characters, in most cases, the proportion of female characters does not reach the level of symbolic annihilation, as defined numerically by Klein and Shiffman (2009), but rather are at the level of underrepresentation. However, taking Merskin’s (1998) broader definition into account, females arguably are symbolically annihilated in the media, as they are both excluded and trivialized, a concerning finding.

Parents: Messages about Gender

As discussed earlier, children are gendered from the moment they are born, and parents are a key socializing agent with regard to children’s gendered views. Evidence from a meta-analysis (Tenenbaum & Leaper, 2002) of 43 studies conducted with parents and children of a wide variety of ages suggests that parents’ gender schemas influence their children’s self-concepts and attitudes about gender. For instance, children of parents with very gender-traditional views tend to also hold narrow gendered views – both of themselves and others. A study (Ex & Janssen, 1998) of adolescent girls and their mothers supported the findings of the meta-analysis: Mothers with gender-traditional orientations were associated with daughters with similar orientations. Higher-educated mothers generally held less traditional gender orientations and less conformist parenting styles, factors that were seen to influence the daughters’ views.

Interestingly, even when parents purport to hold mainly non-gender stereotyped views, children may still be receiving gender-stereotyped messages about their parents’ views. Freeman’s (2007) study involved three- and five-year-old children identifying stereotypical toys (e.g., tea set, skateboard) as either ‘boys’ toys’ or ‘girls’ toys’. Although all children sorted the

toys along stereotyped lines, older children held stronger views. When asked to predict whether their mothers and fathers would approve of their playing with gender stereotyped toys or cross-gender toys, few children reported that their parents would approve of cross-gender toys, with similar responses provided by boys and girls. The children's viewpoints stand in stark contrast to the purported views of the parents. Notably, similar to the representations discussed in some of the media examples above (e.g., Jackson & Gee, 2005), the few areas where a substantial proportion of the parents showed gender-stereotyped views tended to be with regard to boys and stereotypically feminine activities, such as playing with dolls. Parallel perceptions of girls were not found, which indicates that "these parents' expectations for their sons' genderized play behaviors were narrower than were their expectations for their daughters" (p. 362).

Teachers: Messages about Gender

Gender is an ever-present focus in nearly all school settings (See Hebblethwaite, 2011 for a discussion of a notable counter-example, a 'gender-neutral' preschool in Sweden). Although references to gender may seem banal, such as addressing students as 'boys and girls' or having students compete against each other in boys' and girls' teams, such actions are meaningful. By addressing students in a gendered way, their gender (and consequently, their difference) comes to the forefront, rather than, for instance, their similarities as students or their differences as individuals; similarly, competition between girls and boys encourages an 'us versus them' mentality. Researchers have found that such 'banal' gendering "causes boys and girls to develop the idea that gender is fundamentally oppositional, in ways the teacher has not mentioned or discussed" (Sparks, 2012, p. 15). Such gendering may explain why children become particularly rigid in their gendered views in the first few years of school – more so than either preschool

children or adults (Sparks, 2012). Gendering has also been found in mathematics-specific ways (Atweh & Cooper, 1995), as was discussed earlier.

Summary and Concluding Remarks

From the studies reviewed, several common themes emerge. Children's views of mathematics and mathematicians tend to be positive when they are young, but become more negative with increasing age, particularly around the pre-teen and early teenage years. Although young people tend to have fairly positive views of mathematics (both generally and with regard to their relationship with the subject area), they have much more negative and stereotyped views of mathematicians, particularly when they are personally implicated (i.e., becoming or marrying a mathematician). Adults' images of mathematics are strongly tied to their in-school experiences whereas their images of mathematicians are linked to (stereotyped) media representations, due to their lack of experience with non-school mathematics or with 'real life' mathematicians.

Mathematicians (and scientists generally) are represented and understood in stereotypical ways that are both negative and powerful. Since mathematicians are typically viewed as men, mathematics becomes seen as a field that is misaligned with femininity, which may discourage the participation of girls and women. Relationships that people have with mathematics are often highly gendered in nature – both in terms of the views they espouse and the ways in which they engage with the subject area. These gendered relationships with mathematics take place in a broader cultural milieu that continues to depict gender in narrow, stereotyped ways. Media tend to lack representations of girls and women in general, plus media representations perpetuate a strict gender binary. Although some challenges to gender stereotypes and improved levels of gendered representation have been shown in recent years, gendered representations in the media

remain highly contradictory in nature. Representations of gender disseminated by media, parents, teachers, and society at large have been shown to significantly influence young people's views.

These studies have played an important role in the design of my study, particularly the use of the 'Draw a mathematician' tool as a rich way to gather data about students' views of mathematicians. I also utilized questions from some of the studies examined in portions of my student questionnaire, as will be detailed in the Methodology chapter. Furthermore, the findings from these studies informed my thinking in terms of the varied ways that parents', teachers', media's, and the general public's views of and representations of mathematics, mathematicians, and gender may influence students' views. More generally, the findings from these studies have informed my understandings of the cultural milieu surrounding mathematics, mathematicians, and gender in which young people grow up.

Although much has been learned from these studies, the extant body of literature points to the need to examine representations of mathematics and mathematicians in children's media and discuss how these media representations relate to young people's views, as prior studies with regard to media representations were conducted with high school and university students. Prior research has not discussed references to mathematics and mathematicians that occur in media that young people are viewing and using; rather, studies have examined known examples of mathematics and mathematicians in the media. By examining the media sources young people are actually using and viewing on a regular basis, I am able to understand the messages about mathematics, mathematicians, and gender to which they are exposed.

Furthermore, studies that inquired into young people's views of mathematics and mathematicians tended not to explicitly focus on gender differences and age-related differences in their design, whereas I made these issues a priority, since children's attitudes toward

mathematics tend to become more negative in the pre-teen/early teenage years, and the changes in attitude tend to be more pronounced for girls (Chouinard & Roy, 2008; Ma & Cartwright, 2003; Thompson, 1995). My research contributes to the body of literature regarding Canadian children's views of mathematicians. To date, very little Canadian research has explored this topic. Indeed, a paucity of research exists worldwide on children's views of mathematicians and mathematically proficient people. Overall, my study contributes to the extant literature as it not only provides a detailed examination of media representations and parents', teachers', and young people's views of mathematics and mathematicians, but also explores how media representations and parents' and teachers' views of mathematics and mathematicians relate to young people's views.

CHAPTER 4: METHODOLOGY

This chapter provides detailed information regarding the methodology of this study. I begin by stating my research questions to provide context for my methodological choices. I then turn to an overview of the data collection methods, highlighting the connections to the research questions and participants. Then, I address my stance in conducting research with children, as well as the considerations of gender made in the research design, data collection, and data analysis of this project. After addressing these theoretical considerations, I discuss my research qualifications and relevant personal experience. In so doing, I am able to position myself as being well-suited and qualified for conducting such a study. A detailed description of the design of the instruments used in this study follows. Next, I delineate the manner in which recruitment took place, and then describe the study's participants. Subsequently, I outline the procedures by which data collection occurred. The chapter concludes by addressing the data analysis methods.

Research Questions

The purpose of the study was to investigate elementary students' views of mathematics and mathematicians, and the relationships between their views and a) media portrayals, b) parents' views, and c) teachers' views. Since attitudes toward mathematics tend to become more negative in the pre-teen/early teenage years, especially for girls (Chouinard & Roy, 2008; Ma & Cartwright, 2003; Thompson, 1995), I also investigated gender and age differences. The design of my study was guided by the following research questions:

- 1) What images of mathematics and mathematicians exist in a child's world as:
 - a) produced by media portrayals?
 - b) produced by parents' views?

- c) produced by teachers' views?
- 2) How do elementary students view mathematics and mathematicians?
 - a) Are there differences between boys' and girls' views?
 - b) Are there differences between middle (Grade 4) and senior (Grade 8) elementary students' views?
- 3) What is the relationship between elementary students' views of mathematics and mathematicians and:
 - a) media portrayals?
 - b) parents' views?
 - c) teachers' views?

Research Design

Due to the breadth of my research questions, a multi-method framework was warranted, which will be overviewed briefly here, and discussed in detail as the chapter progresses. The study involved Grade 4 (ages 9-10) and Grade 8 (ages 13-14) students, teachers, and parents, as well as document analysis of children's media. Teachers and parents took part in individual interviews about their experiences with and views of mathematics and mathematicians. Students took part in three types of data collection: online questionnaires about their media habits and their views of and experiences with mathematics and mathematicians; drawings of mathematicians with written explanations; and focus group interviews with media prompts.

In terms of the student participants, I elected to use several types of data collection, as prior research (e.g., Clark, 2004; Morrow & Richards, 1996; Punch, 2002) has shown that the use of many methods of data collection, both 'traditional' (e.g., interviews, observation) and 'child-friendly' (e.g., drawings, structured activities), best matches children's unique interests

and abilities. Accordingly, I included both types of methods with the student participants in my study, and made efforts to make the ‘traditional’ types of data collection more child-friendly. For instance, I made the questionnaires only available online with the hope of engaging students further and distancing the task from being seen as (school) ‘work’. Furthermore, prior research (e.g., Couper, Traugott, & Lamias, 2001; Sills & Song, 2002) has shown increased response rates from online questionnaires when participants are frequent internet users, such as the generation of children in my study (Rideout, Foehr, & Roberts, 2010). The second data collection method used with the student participants was considered child-friendly: drawings of mathematicians with written explanations. Drawing is often practised in elementary school, so the drawing of a mathematician matches children’s skill sets and is a task children typically enjoy doing (Greig, Taylor, & MacKay, 2007; Leitch, 2008). Drawings may also uncover beliefs and opinions that children are unable to verbally explain (Greig, Taylor, & MacKay, 2007).

The third data collection method used with the student participants was focus group interviews. Focus group interviews were selected because they aim to alter the adult-child power balance that might occur in a one-on-one interview (Nicholas et al., 2010). When engaged with peers, children typically have more confidence to voice their opinions and control the direction of the conversation (Hill, 1997; Mauthner, 1997; Punch, 2002). The focus group interviews were made more child-friendly through the inclusion of media prompts (i.e., clips from children’s television shows and student drawings of mathematicians), which helped move the students’ focus away from me as an authority figure. The television clips came from a list of top shows watched by the students who participated in the questionnaire. Thus, the focus group interviews were dependent upon the previous data collection, and were conducted later in the study. In addition to collecting information about the top media selections for use as prompts in the focus

group interviews, the top media examples were analyzed in order to learn how the media that students use portray mathematics and mathematicians.

With respect to the adult participants, I conducted individual interviews to learn about their views of and experiences with mathematics and mathematicians. I selected individual interviews for the adult participants, rather than focus group interviews, since I wanted to understand individual parents' and teachers' views and experiences. Adults tend to be comfortable in a one-on-one situation with a researcher, as there is not an age-related power differential like there is with children. However, if both parents of one child wished to participate in an interview together, I felt that was also appropriate, as the parents together determine how mathematics and mathematicians are represented to the child(ren) in their household.

To summarize, Table 2 provides an overview of the data collection methods, participants, and the research question(s) each data collection method addressed.

Table 2
Data Collection Methods, Participants Therein, and Research Question(s) Addressed

Data collection method	Participants	Research question(s) addressed
Online questionnaire	students	1a, 2
Document analysis	N/A	1a
Drawings of mathematicians	students	2
Focus group interviews	students	2
Interviews	parents	1b
Interviews	teachers	1c

In all data collection involving the students, I gathered information about their gender and grade level to enable gender and grade-level comparisons, thus addressing Research Questions

#2a and #2b. All data were combined to answer Research Questions #3a to #3c (relationship between students' views and each of media portrayals, parents' views, and teachers' views).

Appendix A provides a flow chart with further details of the data collection methods.

Conducting Research with Children

As much of this research was conducted with children, I feel it necessary to describe my position in conducting research with children, as this stance guided many of the choices I made throughout the research process. In alignment with my social constructivist stance, I view children as active, social, cognizing individuals. Christensen and Prout (2002) outline four possible perspectives on children in research: child as object, subject, social actor, and participant/co-researcher. I am in accord with the 'child as social actor' stance⁷ and thus designed my research project to reflect that stance. This stance recognizes children as "social actors with their own experiences and understandings" (p. 481) who interact with the social world around them and, in doing so, both change and are changed by it. Importantly, this stance does not view adults or children as homogeneous groups. Children are viewed as active members of society who learn and grow through social interactions, building their own understandings as a result. Each individual is recognized as having unique experiences, beliefs, and competencies, which lead to one's construction of knowledge and thus, co-construction of the social world.

Building on the 'child as social actor' stance, Christensen and Prout (2002) proposed the concept of 'ethical symmetry', meaning that researchers base their decisions on the foundational idea that "the ethical relationship between researcher and informant is the same whether he or she conducts research with adults or with children... each right and ethical consideration in relation to adults in the research process has its counterpart for children" (p. 482). Accordingly, any decisions in research should be related to the research question, the focus of the research,

and the unique nature of the participants in the study rather than any preconceived age-based notions. This ties to social constructivist tenets as ethical symmetry is based on conducting research in ways that are ethically sound based on individuals' unique capabilities, interests, and experiences rather than presuming that absolute truths exist about children or adults as groups.

In my research design, my alignment with both the 'child as social actor' stance and 'ethical symmetry' ideal are evident. For instance, I required both the child and his/her parent(s) to provide consent for participation in my study, rather than merely asking the parent to speak for the child, which is all that is legally required. The information letter for children was written in child-friendly (but non-patronizing) language so that they would fully understand the focus and requirements of the study. Similarly, the data collection instruments were written such that children should have been able to complete them independently.

The way I interacted with the child participants was a key factor in my establishment of rapport with them, and thus, the quality and quantity of data I was able to collect. As most children do not have experience participating in research, they tend to view researchers similarly to the key adults in their lives: as authority figures, such as parents or teachers (Punch, 2002; Strange, Forrest, Oakley, & The RIPPLE Study Team, 2003). Children tend to want to please adults and may not be accustomed to being asked their opinions and taken seriously (Mahon, Glendinning, Clarke, & Craig, 1996; Punch, 2002). In the focus group interviews, I tried to lessen my 'adult authority figure' status, and thus adopt a least-adult role (Mandell, 1988), by speaking with the children as peers/equals, treating them similarly to adults, dressing in casual clothing, and asking them to address me by my first name. I took these steps to attempt to disrupt the power dynamics that often exist in interactions between adults and children.

Considerations of Gender

Consistent with my feminist epistemological stance, I was cognizant of considerations of gender in several aspects of this project's design, data collection, data analysis, and reporting. When designing my data collection instruments for the student participants (i.e., questionnaire and drawing form), I included the statement 'I am a boy/girl' (with a checkbox by each gender) at the start of each instrument. By wording the statement this way, my hope was that the participants would indicate gender identification (i.e., an inner sense of being a girl or boy, regardless of biological sex). Significant others, such as teachers and parents, also identify the child as a girl or boy, and subsequently treat her/him differentially based on her/his gender. Thus, in asking my participants whether they are boys or girls, I am attempting to learn about the gendered world in which they live. While I acknowledge that there are more than two genders (i.e., further to the conventionally accepted boy/girl and man/woman gender categories, several genderqueer variants exist, such as agender and pangender; e.g., O'Neil, McWhirter, & Cerezo, 2008), given the age of my participants and the fact that my study was not focused on gender identity/queer issues, I made the pragmatic decision to only provide 'boy' and 'girl' as options. I recognize, however, that in so doing I may be excluding and/or misrepresenting those students whose gender identities do not align with 'girl' or 'boy' categories.

While I am cognizant that including a demographic question about a participant's gender could potentially lead to priming (i.e., reminding the participant of his/her gender could impact how subsequent questions are answered; e.g., Steele & Ambady, 2006), these possible negative impacts were outweighed by my necessity to have the information in order to complete comparisons by gender. While placing the demographic questions at the end of the data collection instruments would alleviate concerns about priming, it would also increase the likelihood that the questions would not be answered. This is particularly the case with the

questionnaire, which had multiple sections and took approximately 25 minutes to complete. By placing the gender question with other demographic questions, completing this section was hopefully viewed as a banal portion of the research activity. Notably, the two sections of the questionnaire about the participant's parents and views of gender and mathematics were placed at the end of the questionnaire to try to minimize the possibility of gendered priming.

In choosing to analyze the data by gender, I am aware that I could potentially be contributing to the notion of a gender binary, a notion to which, as discussed above, I do not subscribe. My decision to focus on gender as a way to analyze the data was based on the fact that gender is a particularly salient aspect of students' schooling experiences, particularly in a historically gendered subject like mathematics. Therefore, my choices were made with regard to the world in which the children live (i.e., one that currently involves a gender binary). I do not view 'girls' and 'boys' as homogeneous categories, although they are often treated as such. In my analysis, I thus was cautious not to simply focus on gender differences, but to acknowledge 'no gender difference' as a significant finding, as well as to examine each gendered category for in-category variance (i.e., to consider if the differences within the group of girls were statistically significantly different in magnitude than the differences within the group of boys).

As discussed by Damarin and Erchick (2010) and Glasser and Smith (2008), attention to gendered language choices is often overlooked in the reporting of gender-based research, which leads to the perception of inconsistencies (e.g., using 'sex' and 'gender' interchangeably may suggest that the conflation of these terms, which may stand in contrast to a researcher's reported theoretical stance). In all aspects of my research, I used the term 'gender' rather than 'sex', as I am concerned with social constructions rather than biological constructions. Wherever possible⁸, I was consistent with my use of 'gender' rather than 'sex' language (i.e., using the terms girl,

boy, woman, and man, rather than female and male). One additional consideration made throughout the study was the disruption of the common order in which the phrases ‘boys and girls’ and ‘men and women’ are written, in order to disrupt the unconscious ordering of the genders. For instance, on the questionnaire, the ‘gender’ question was ordered boy/girl, the parent questions were ordered mother/father, and the section about the participants’ views of gender and mathematics was titled ‘Girls, boys, and math’ but the responses were ordered boys/no difference/girls. In my data analysis and reporting, I also used varying orders, as I, like Thorne (1993) in her landmark book, *Gender Play: Girls and Boys in School*, want “both genders to be fully in view” (p. 8).

Researcher’s Role and Qualifications

My prior experience served me well in this research project. In the past, I have conducted interview-based mathematics education research with women enrolled in mathematics degree programs, elementary teachers, and women with non-traditional degrees. I also have experience creating a Likert-scale questionnaire to obtain adults’ views of mathematics and mathematicians, and conducting advanced statistical analyses of the data. Furthermore, I have conducted document analysis on magazine advertisements for representations of mathematics. I have also assisted with other researchers’ projects, in which I conducted individual and focus group interviews with high school students and teachers, transcribed interview data, conducted qualitative and quantitative analysis, and wrote research reports. From these prior experiences, I gained the necessary skills to competently undertake my current research project.

As my research project primarily focused on children, generalized research skills were not sufficient; researchers who work with children also need to have specific skills developed in interacting with children (Moore, McArthur, & Noble-Carr, 2008; Punch, 2002). I have a great

deal of experience working with children through several years of involvement in tutoring, teaching piano and violin lessons, coaching baton twirling, babysitting, and being a nanny. I have learned to position myself in a variety of ways and developed many skills in interacting with children of all ages, both individually and in groups. Through these varied experiences, I also gained experience dealing with parents, meeting with them to discuss their children.

I related well to the teacher participants, as I am a certified teacher and I have taught mathematics to elementary teacher-candidates (i.e., Bachelor of Education students). Thus, I understand teachers' roles, feelings, and experiences regarding mathematics in a way that a non-teacher researcher might not. As discussed, I also have prior experience interviewing elementary and high school teachers. Finally, due to my educational background and my experiences as a mathematics tutor, I have personal experiences to draw upon with respect to societal views and stereotypes of mathematics and mathematicians, as I have frequently encountered them.

Instrument Design

In the following sections, I provide detailed information regarding the design of each data collection instrument – the student questionnaire, the student drawing form, the student focus group interview protocols, and the parent and teacher interview protocols.

Student Questionnaire

The online questionnaire (Appendix B) regarding the students' media habits and views of mathematics and mathematicians was posted on *SurveyMonkey*, and featured open-ended and closed questions. The questionnaire consisted of four sections: 1) Demographic Information, 2) Media Habits, 3) Mathematics and Mathematicians, and 4) Comments. The Demographic Information section asked for the participant's gender, grade level, the name of his/her school, and the name of town/city in which the school is located. The Media Habits section asked about

the participants' frequency of use of five media types (i.e., television, websites, movies, video games, and reading materials) and asked participants to provide a list of three specific examples for each media type they view or use most often. For the 'use' questions, I provided specific ranged multiple-choice options for weekdays and weekends, rather than asking the participants to type in a response; better quality data are obtained from children when questions have fully labelled and detailed response options (Borgers, Hox, & Sikkel, 2003). For the most-viewed media sources for each type, this type of response option was not feasible due to the vast number of possible responses, so three blank spaces were left for respondents to type in their answers.

The Mathematics and Mathematicians section of the questionnaire consisted of four sub-sections: 1) Mathematics, 2) Mathematicians, 3) Parents, and 4) Gender. The Mathematics sub-section featured eight Likert-scale questions about the participants' experiences with and attitudes toward mathematics; most of these questions were taken from questionnaires used by other researchers investigating children's attitudes (*Fennema-Sherman Mathematics Attitude Scales* [F-S MAS], 1976; Picker & Berry, 2001; *Understanding Participation Rates in Post-16 Mathematics and Physics* [UPMAP] questionnaire, 2008). The Mathematician sub-section, which discussed the participants' experiences with and views of mathematicians, consisted of three open-ended questions, two yes/no/not sure questions, and five Likert-scale questions (drawn from Picker & Berry, 2001 and Rock & Shaw, 2000, primarily). The Parents sub-section addressed the participants' interactions with and perceptions of their parents and mathematics (10 Likert-scale questions – five about the participant's mother/woman guardian and five about the participant's father/man guardian; some drawn from the F-S MAS, 1976). The Gender sub-section addressed the participants' views of mathematics and gender differences, using seven questions from the *Who and Mathematics* instrument (Leder & Forgasz, 2002). I made minor

changes to the wording of the questions and simplified the responses to ‘boys’, ‘no difference’, and ‘girls’ (as opposed to ‘boys definitely’, ‘boys probably’, ‘no difference’, ‘girls probably’, and ‘girls definitely’) to make the questions more accessible to my young participants.

The questionnaire concluded with the Comments section, in which the participants were asked if they had help completing the questionnaire. Participants were also provided with the opportunity to offer comments about mathematics and mathematicians or the questionnaire itself.

Student Drawing Form

The mathematician drawing form (Appendix C) asked the student participants to ‘Draw a picture of a mathematician at work’. This wording was selected in order to enable comparisons to prior research (Picker & Berry, 2000, 2001; Rock & Shaw, 2000). Participants were asked to explain their drawings in writing (as per Picker & Berry, 2000, 2001) so that unfounded claims about their drawing from my adult perspective were not made. Leitch (2008) notes that very few studies have “used drawing as an innovative, alternative way to understand children’s knowledge and experience, and even fewer where children are invited to be co-interpreters (or narrators) of their own images” (p. 37). The drawings provided a different, visual manner for the student participants to share their views of mathematicians; as noted earlier, drawings allow children to express views that they may not be able to articulate (Greig, Taylor, & MacKay, 2007).

Student Focus Group Interview Protocols

The focus group interviews with students consisted of my showing media prompts (television show clips and sample student drawings of mathematicians) involving mathematics and mathematicians to the participants and then asking questions to investigate their reactions. The television clips were primarily selected from the top responses to the Media section of the questionnaire. The questionnaire responses were separated by grade level, which allowed me to

select age-appropriate television clips (as Grade 4 and Grade 8 students participated in separate focus groups). The clips were selected based on their focus on certain stereotypes and ideas about mathematics and mathematicians. Both the Grade 4 and Grade 8 students were shown a clip from *The Simpsons* that featured stereotypes about gender and mathematics. Grade 4 students were also shown a clip from *The Suite Life of Zack & Cody* that featured stereotypes about mathematically proficient people being ‘nerdy’. Grade 8 students were shown two other video clips: one from *Glee* and one from *The Big Bang Theory*. The *Glee* clip featured a mathematical error, while the clip from *The Big Bang Theory* featured the stereotype of mathematicians being ‘nerdy’ and unappealing as romantic partners. After I showed each clip, I asked the participants to summarize what happened and then I asked various questions about the specific content of the clip. I then turned to more general questions about the stereotypes and about their encounters with such ideas in real life. Although I had created interview protocols (See Appendix D for the Grade 4 interview protocol and Appendix E for the Grade 8 interview protocol), I did not always address all of the questions as I tended to follow the conversation and the participants’ ideas.

In all but one of the focus group interviews (due to time constraints), participants were also shown 10 sample drawings (Appendix F) completed by students who participated in the drawing portion of the study. The drawings were selected based on their representation of a character theme/occupation. Specifically, the drawings were classified as 1) Einstein-type teacher with a sleeping student, 2) Inventor, 3) ‘Cool guy’ office worker, 4) ‘Professional mathematician’ with a chalkboard full of equations, 5) Elementary teacher with happy students, 6) Sheldon-like character (a main character from *The Big Bang Theory*) in an apartment setting, 7) Stereotypical ‘nerd’, 8) Happy Einstein-like character, 9) Wacky character (colourful hair and

clothing), and 10) Wizard. The participants were asked to examine the 10 drawings, select the one they thought was most like their own image of a mathematician, and discuss why. I also asked some follow-up questions regarding which drawings they would discard as being mathematicians, similarities and differences they saw amongst the drawings, and their views of real-world mathematicians. These questions sought to explore the participants' views of who a mathematician is and their perceptions of 'real' and make-believe mathematicians.

Parent and Teacher Interview Protocols

The interview protocols for the parents (Appendix G) and teachers (Appendix H) were semi-structured, featuring questions about their experiences with mathematics as students and as adults, and their views of mathematics and mathematicians. Many questions were drawn from an interview protocol that I created and used in a pilot study with elementary teachers. The parent and teacher interview protocols were very similar, containing three identical sections:

1) Experiences with mathematics as a student; 2) Views of and experiences with mathematics, mathematicians, and the media; and 3) Current views of mathematics. A further section in both interview protocols inquired about participants' experiences with mathematics as an adult, both within and outside their careers. In this section, teacher participants were asked questions specific to their teaching philosophies and practices in mathematics. Parent participants, on the other hand, were asked questions in another section about their children and mathematics. The various sections of the interview protocols were included to provide information to complete participant profiles, as well as to understand the messages produced and consumed by the adult participants, and their current views.

Ontario Educational Context

Before discussing the study's participants, I provide some information regarding the context in which the research took place. In Canada, education falls under the purview of the individual provinces and territories (i.e., There is no national curriculum). In the province of Ontario, the provincial Ministry of Education operates 72 publicly-funded school districts: 31 English-language Public (i.e., secular, non-denominational) school districts, four French-language Public school districts, 29 English-language Catholic school districts, and eight French-language Catholic school districts. Across the 72 school districts, there are approximately 4,000 elementary schools and 900 secondary schools. Schools in these publicly-funded districts (as well as many of the province's more than 700 private schools) follow the Ontario Curriculum.

The most recent version of the Ontario Mathematics Curriculum for Grades 1 to 8 was published in 2005 by the Ontario Ministry of Education. The mathematics topics are arranged in five broad areas, called strands: 1) Number Sense and Numeration, 2) Measurement, 3) Geometry and Spatial Sense, 4) Patterning and Algebra, and 5) Data Management and Probability. Within each strand, seven process expectations should be addressed: 1) Problem solving, 2) Reasoning and proving, 3) Reflecting, 4) Selecting tools and computational strategies, 5) Connecting, 6) Representing, and 7) Communicating. These processes are understood as being interconnected and fundamental to students' experiences learning mathematics.

Assessment in mathematics aligns with the Achievement Chart provided in the curriculum document. Within each strand, four categories of knowledge and skills should be addressed: 1) Knowledge and Understanding, 2) Thinking, 3) Communication, and 4) Application. As discussed in the curriculum document, "the four categories should be considered as interrelated, reflecting the wholeness and interconnectedness of learning" (Ontario Ministry of Education, 2005, p. 19). Within each category, a student's achievement is assessed as

meeting one of four levels: Level 1 – ‘Limited’, Level 2 – ‘Some’, Level 3 – ‘Considerable’, or Level 4 – ‘Thorough’. For instance, a student may have a limited (Level 1) ability to communicate a solution to a problem, but a considerable (Level 3) understanding of the concept.

The Ontario Mathematics Curriculum aligns with current thinking in mathematics education research. It focuses on ensuring that students “develop mathematical understanding; learn important facts, skills, and procedures; develop the ability to apply the processes of mathematics; and acquire a positive attitude towards mathematics” (p. 3). Furthermore, the curriculum places importance on making connections – among mathematical topics, with other subject areas, and with students’ everyday lives. The use of various mathematical tools is encouraged, as is the use of varied means of instruction and assessment. By following such a curriculum, the goal is for students to not only gain a firm understanding of mathematics, but also to develop an appreciation for the subject area and confidence in themselves as learners of mathematics. Fundamentally, the Ontario Mathematics Curriculum is based on the belief that “all students can learn mathematics and deserve the opportunity to do so” (p. 3).

Recruitment of Participants

The first phase of recruitment began in April 2010, when eight publicly-funded Ontario school districts (four Public and four Catholic⁹) were asked to participate. Three districts agreed to take part (one Public and two Catholic). The Public school district allowed me to contact schools in groups of 10. Twenty schools from this district were contacted in this phase, during which Grade 4 and 8 students were asked to complete questionnaires and drawings, while parents and teachers were asked to participate in interviews. From this phase, enough parent and teacher interviews were conducted, but more questionnaires and drawings were needed.

In January 2011, the second phase of recruitment began. Eight additional publicly-funded Ontario school districts (four Public and four Catholic) and 48 private schools (religious and secular co-educational schools, primarily from Eastern and Central Ontario) were invited to participate in the student questionnaire and drawing portions. Three further school districts (one Public and two Catholic) and six private schools (one religious and five secular) agreed to take part in this phase of data collection. However, one Catholic school district did not have any students take part. Ten additional schools from the aforementioned Public school district were contacted in this round of data collection. From this phase, enough drawings were received.

In April 2011, the third phase of recruitment began in order to collect more questionnaires. Thus, 20 additional schools from the Public school district that had participated in the previous two phases were invited to participate in this phase of data collection.

In January 2012, the fourth and final phase of recruitment began. At this point, only the student focus group interviews remained. Two school districts that were contacted in the first phase were re-contacted, as they had indicated that they were potentially interested, but not at that time. However, these two districts again declined to take part. Fortunately, the Public school district that had participated in the previous phases of data collection allowed me to contact 10 more schools. This was the only school district that took part in this phase of the data collection.

Therefore, 16 publicly-funded school districts were invited to participate in the research project and five school districts participated, which represents a 31.25% response rate. Within the five participating school districts, the response rates of schools (i.e., the number of schools participating per the total number of invited schools) ranged from 5.2% to 20.0%, with an average response rate of 12.1%. With regard to the private schools, 48 were invited to participate

and six took part. This represents a 12.5% response rate, which is similar to the average response rate of the individual schools in the publicly-funded school districts.

Participants: Overall

The participants were Grade 4 and 8 students, parents, and teachers from Ontario public and private schools. All participating schools were co-educational institutions, with English-language, French immersion, and/or bilingual (French/English) instruction. As noted earlier, although six English-language school districts agreed to participate, one Catholic school district did not have any participants, which resulted in three Catholic school districts and two Public school districts taking part in the study. In Table 3, information regarding the participating school districts is shown, with the districts' pseudonyms referring to their geographical location.

Table 3
Demographic Information and Participation Details for Participating School Districts

School district	Catholic or Public	Population classification	School district size	Participation	Number of schools participating
Eastern 1	Catholic	Rural	Small*	T, P, Q, D*	Four
Eastern 2	Public	Urban/ Suburban	Large	T, P, Q, D, FG	Six
Southwestern 1	Catholic	Rural	Small	T	Two
Central 1	Catholic	Suburban/ Rural	Medium	Q, D	Three
Northern 1	Public	Rural	Small	Q, D	One

Note. The size of the school districts refers to the approximate number of elementary schools therein: small (20 or fewer), medium (approximately 40), and large (over 100). T refers to teacher interviews, P refers to parent interviews, Q refers to student questionnaires, D refers to student drawings, and FG refers to student focus group interviews.

In addition to the participants from school districts, three teachers and five students who were recruited through my family members took part in the study (These participants are herein referred to as ‘personal contacts’). Two of these teachers, from two different Southwestern Ontario schools (not in the Southwestern 1 school district), took part in a pair interview, while the other teacher, from Central Ontario (not the Central 1 school district), took part in an individual interview. The five students, all from one Southwestern Ontario school (not in the Southwestern 1 school district), took part in a focus group interview. Importantly, I had only met two of the teachers and two of the students prior to conducting the interviews, and I did not have a close relationship with any of these individuals. Consequently, the potential for their responses to be impacted by their relationship with me was quite minimal.

Across the five publicly-funded school districts that participated, 19 classes were represented. In all five school districts, the students were asked to participate in the questionnaire and drawing. In the first three school districts (Eastern 1, Eastern 2, and Southwestern 1), parents and teachers were asked to participate in interviews, which resulted in a sufficient number of participants when combined with my personal contacts. Consequently, the next two school districts (Central 1 and Northern 1) were only asked for participation in the student questionnaire and drawing portions; the private schools, which were asked to participate later in the study, were also only asked for participation in these two portions. Only the Eastern 2 school district participated in the student focus group interviews. In Table 4, information is provided about each participating class. The pseudonyms for the schools refer to their district and their ‘number’ within that district (e.g., E2S1 refers to the first school that participated in the Eastern 2 district).

Table 4
Demographic Information and Participation Details for Participating Public Schools

School	Grades offered	Language	Population classification	Grades involved	Participated in:
E1S1	JK-8	English	Rural	8	Q, D*
E1S2	JK-7	English	Rural	4	Q, D, T, P
E1S3	JK-7	English	Rural	4*	Q, D, P
E1S4	JK-8	English	Rural	4	Q, D, T, P
E2S1	JK-8	English, French Imm.*	Suburban	4, 8	Q, D, T, P
E2S2	JK-8	English	Urban	4	T
E2S3	JK-8	English	Suburban	4*	Q, D
E2S4	JK-8	English	Suburban	4*, 8	Q, D
E2S5	7-8	English	Suburban	8	Q
E2S6	JK-8	English, French Imm.*	Rural	4*, 8	FG
SW1S1	JK-8	English	Rural	4	T
SW1S2	JK-8	English	Rural	8	T
C1S1	JK-8	English	Urban	4	Q
C1S2	JK-8	English	Rural	8	Q, D
C1S3	JK-8	English	Rural	8	Q, D
N1S1	JK-8	English	Rural	8	Q, D

Note. At E2S1, the Grade 4 class was French Immersion and the Grade 8 class was English-language. At E2S6, two Grade 4 classes were English-language and one was French Immersion. The Grade 8 class at this school was French Immersion. At E1S2, E2S2, and E2S3, two Grade 4 classes took part. At E2S6, three Grade 4 classes took part. T refers to teacher interviews, P

refers to parent interviews, Q refers to student questionnaires, D refers to student drawings, and FG refers to student focus group interviews.

Furthermore, students from six private schools took part in the questionnaire and drawing portions of the study. Information about the private schools is shown in Table 5. As with the school districts, the pseudonyms for the private schools refer to their geographical locations, with ‘E’ referring to private schools in Eastern Ontario and ‘SW’ referring to schools in Southwestern Ontario (e.g., ‘EPr1’ refers to the first private school in Eastern Ontario that participated).

Table 5
Demographic Information and Participation Details for Participating Private Schools

School	Religious/ Secular	Grades offered	Language	Population classification	Grades taking part	Participated in:
EPr1	Secular	JK-12	English	Urban	4, 8	Q, D*
EPr2	Secular	JK-8	Bilingual	Urban	4	Q, D
EPr3	Secular	JK-8	English	Urban	4*, 8	Q, D
EPr4	Secular	JK-6	English	Suburban	4	Q, D
EPr5	Religious	JK-8	English	Urban	8	Q
SWPr1	Secular	JK-12	English	Rural	8	Q, D

Note. At EPr3, two Grade 4 classes participated. In all other schools, only one class per grade took part in the study. Q refers to student questionnaires, whereas D refers to student drawings.

All of the participating private schools had day programs for elementary students, used the Ontario Ministry of Education curriculum, and charged tuition fees (ranging from \$10,000 to more than \$17,000 per year). As with the school districts, the private schools represented a variety of sizes. EPr1 and EPr4 are very small schools with fewer than 75 students in total,

whereas EPr2 is mid-sized, with approximately 150 students. The other three schools (EPr3, EPr5, and SWPr1) have large populations, ranging from approximately 300 to 400 students.

Preparation for Data Collection

This section reports the manner in which the data collection was set up. I first detail this process for public and private school participants, followed by personal contact participants.

Public and Private Schools

The first step was obtaining permission from each school district (public schools) or school (private schools). A letter of invitation and request for permission to conduct my research was sent to the director of each school district (Appendix I) and to the principal of each private school (Appendix J). In four of the five participating school districts, a written or an oral agreement by the director of the school district and/or research director was sufficient. In Eastern 2, an application process had to be undertaken with the school district's research committee. Once permission was granted from the school districts, letters of invitation (Appendix J) were mailed to principals of schools with Grade 4 and/or Grade 8 classes. For the private schools, mailing the letters to the principals was the first step. Enclosed with these letters were letters for the Grade 4 and 8 teachers (Appendix K). If the principal agreed for the school to take part, the enclosed letters were passed on to the teachers. Teachers who wished to participate contacted me to set up the data collection process.

Participating teachers were provided with packages of materials to use with their classes. These packages included information letters/consent forms for parents and students, slips of paper with the questionnaire's website address, and forms/envelopes for the drawings. Students were initially provided with information letters/consent forms to take home to discuss with their parents. The letters and consent forms were addressed to the parents and students, although only

a parent's agreement to participate was legally necessary for the student's participation.

However, I felt it was necessary to focus the materials toward the students, as they would be the ones participating in the study. Thus, the information letters were written in student-friendly language and the consent forms required both a parent's signature and the student's signature.

The consent form included a section where participants indicated, via selecting checkboxes, the portions of the research in which they wanted to participate. If participating in the questionnaire was selected on a signed consent form, the teacher provided the student with a slip of paper with the questionnaire's website address (Appendix L). The letters to the teachers, parents, and students all clearly indicated that the questionnaire was to be completed at home. However, if a student did not have internet access at home, the schools were asked to allow the student to complete the questionnaire at school, preferably outside of school hours.

If participating in the drawing was selected, the teacher provided the student with the drawing form and an envelope. Students at non-local schools were provided with stamped envelopes in which the drawings were mailed directly to me. Students in local schools returned their drawings in sealed envelopes to a large envelope posted in their classroom. Teachers would not see the students' drawings or know who had returned a drawing, thus ensuring the students' privacy. When I picked up the consent forms from local teachers, I also picked up the large envelope that contained the individual envelopes of drawings. Teachers in non-local schools were provided with a stamped envelope in which they mailed me the signed consent forms.

If a parent wished to participate in an interview, he or she would provide an email address and/or telephone number on the consent form. I would then contact the parent individually to set up the interview time and location. Similarly, teachers who wished to participate in interviews would email me to set up a time and location for their interviews.

If a student indicated that he or she wished to participate in a focus group interview, I then arranged with the school administration to set up dates and times for the focus group interviews to take place, as they were conducted on school property.

Personal Contacts

The approach for setting up data collection with my personal contacts was less formal. Due to a shortage of Grade 8 teacher participants for the interviews, I approached two personal contacts who had experience teaching at that level: an extended family member and a friend of a family member. Both of these personal contacts were invited to participate in an interview via email. Once they agreed to participate, we set up an interview date. The third ‘personal contact’ teacher interview participant was a friend of one of my personal contacts, so messages were relayed to her via my personal contact; these two teachers elected to have their interview conducted together.

Since I only had girls volunteer to participate in the Grade 8 focus group interviews, I needed to find a way to include Grade 8 boys in this aspect of the research. Conveniently, one of my father’s violin pupils at the time was a boy in Grade 8 who has a twin sister. I emailed their mother to inquire if her children were interested in participating. Once the children agreed to take part, I asked the mother and the children to invite a few of the children's friends to participate. She contacted the other three focus group participants’ parents via email. Once all of the children and parents had agreed to participate, I sent a scanned, signed copy of the consent form to them via email. The focus group participants then brought their signed consent forms with them to the interview.

Participants: By Data Collection Type

In the following sections, I provide detailed information regarding the participants in each data collection type – the student questionnaire, the student drawings, the student focus group interviews, the parent interviews, and the teacher interviews.

Student Participants: Questionnaire Portion

There were 161 students who participated in the online questionnaire, which was posted on *SurveyMonkey* (See Appendix B). These data were collected between September of 2010 and June of 2011. Five participants' questionnaires were not included in the analysis: Three were removed because the participants were not in Grade 4 or 8, and two were removed because the participants (both Grade 8 boys from public schools) provided inappropriate, nonsensical responses (e.g., writing 'Alaska' for the town/city, patterns in the Likert-scale responses). Thus, the resulting dataset consisted of 156 questionnaires that were used in the analysis.

The questionnaire participants were from 12 schools (with 17 classes taking part) in four school districts (Eastern 1, Eastern 2, Central 1, and Northern 1) and six private schools (with nine classes taking part): Eastern Pr1-Pr5 and Southwestern Pr1. Specifically, 45 participants (28.8%) were from private schools, whereas 111 participants (71.2%) were from public schools. The percentage of private school students participating in the questionnaire is much higher than the percentage of students in Ontario enrolled in private schools, which was 5.6% as of 2006 (Van Pelt, Allison, & Allison, 2007). However, the group of participants was quite balanced, and thus representative of Ontario students, with regard to gender (85 girls and 71 boys, which represents 54.5% and 45.5%, respectively) and grade level (77 Grade 4 students and 79 Grade 8 students, which represents 49.4% and 50.6%, respectively). The participants were also fairly evenly distributed when considering gender and grade level together, as there were 40 Grade 4

girls (25.6% of all participants), 37 Grade 4 boys (23.7%), 45 Grade 8 girls (28.8%), and 34 Grade 8 boys (21.8%) who took part in the questionnaire.

SurveyMonkey provides information regarding the date, time of commencement, and time of completion of each questionnaire. According to these data, 93 participants (59.6%) completed the questionnaire during school hours, whereas 63 participants (40.4%) completed it during the evening or weekend. This finding was surprising in light of the instructions stating that all participation in the research should take place outside of class time. Most questionnaires completed during school hours were presumably done during a period spent in a computer lab, as all the students' questionnaires from one class had similar start/end times and the same date.

Using the time of commencement and time of completion data, I calculated the total time that it took each participant to finish the questionnaire. For the sake of simplicity, I rounded each time to the nearest quarter-minute (e.g., 7:42 would be recorded as 7.75). Ten participants' finishing times were excluded from these calculations – three participants who had completed the questionnaire in multiple sittings and seven participants who had not completed major sections of the questionnaire. Thus, 146 participants' finishing times were used to calculate the average finishing time, which was 24.4 minutes. This time aligned well with my prediction that the questionnaire would take approximately 20 minutes to complete. Boys' and girls' times to complete the questionnaire were very similar, with boys taking 24.8 minutes on average, compared to 24.0 minutes for girls. There were, as expected, substantial differences in the completion times of Grade 4 and Grade 8 students. In general, Grade 4 students took longer to complete the questionnaire than did Grade 8 students (27.8 minutes compared to 21.3 minutes). Presumably, most Grade 4 students read more slowly than Grade 8 students, and Grade 4 students may have needed to ask for help with some of the terminology in the questionnaire,

although I attempted to keep it simple and pilot-tested it with elementary students. Indeed, 35.1% of the Grade 4 participants reported having help (from a parent or someone else, such as a teacher) completing the questionnaire, compared to only 4.3% of the Grade 8 participants.

Student Participants: Drawing Portion

Ninety-six students participated in the drawing portion. The drawing form provided space for the drawing of a mathematician at work on the first page and space for a written explanation of the drawing on the second page (See Appendix C). The drawings were received by letter mail or picked up at the schools between October of 2010 and June of 2011. The participants in the drawing portion were from 10 schools in four school districts (Eastern 1, Eastern 2, Central 1, and Northern 1) and five private schools (Eastern Pr1-Pr4 and Southwestern Pr1). Two drawings were not included in the analysis: One by a student who was in Grade 3, and one that was missing all the demographic information that was necessary for the analysis. Therefore, 94 drawings were used in the analysis. More girls than boys and more Grade 4 students than Grade 8 students took part in the drawing portion. Specifically, 38 (40.4%) of the drawing participants were boys, 55 (58.5%) were girls, and one student (1.1%) did not identify his/her gender. When considering the participants by grade level, 54 (57.4%) were Grade 4 students and 40 (42.6%) were Grade 8 students. The majority of participants (73.4%) came from public schools, compared to 26.6% from private schools. Like the questionnaire participants, this is a much higher percentage of private school students than in the Ontario population as a whole (Van Pelt, Allison, & Allison, 2007). All participants completed the drawing portion, but four students (two Grade 4 girls from private schools and two Grade 8 boys from public schools; 4.3% of the drawings) did not include any written descriptions with their drawings.

Student Participants: Focus Group Interviews

Five focus group interviews were held with Grade 4 and 8 students. The interviews were conducted in March and May 2012, and ranged in length from 0:36:07 to 0:55:47, with a mean duration of 0:47:03. Focus group participants were from the Eastern 2 school district and from Southwestern Ontario (personal contacts). The first four focus group interviews were conducted at E2S6 in March 2012, taking place during nutrition breaks and recess time, in order to minimize the amount of time away from class. The fifth focus group interview (personal contacts, all from the same Grade 8 class) took place in May 2012, after school, at the home of two participants. Table 6 provides information regarding the participants in each focus group.

Table 6
Demographic Information about Focus Group Interview Participants

Focus group	Grade	Location	Number of participants	Number of girls	Number of boys
FG1	4	E2S6	3	1	2
FG2	4	E2S6	4	2	2
FG3	8	E2S6	6	6	0
FG4	4	E2S6	3	3	1
FG5	8	Participants' home	5	3	2

The sizes of the focus groups, three to six participants each, were generally aligned with the optimal size to allow for full participation, five to six children per focus group (Greig, Taylor, & MacKay, 2007). The participants from E2S6 were grouped by the administration of the school, based on the students being in the same class and their perceived ability to get along, whereas the fifth focus group consisted of a family friend, his sister, and their friends.

The four focus group interviews at E2S6 took place in a school meeting room. At the beginning of each interview, participants were provided with a meal. While they were eating, introductions took place, and I read through the student information sheet with the participants (Appendix M). Participants had the chance to ask questions at this point. The participants also completed a student consent form (attached to the student information sheet; Appendix M), on which they were asked to write their chosen pseudonym. Allowing the participants to choose their own pseudonyms allowed them greater autonomy and control over their participation in the research project, plus reinforced the importance of confidentiality. This task engaged the participants in conversation in a nonthreatening, fun manner. The meals also helped to create a casual, comfortable atmosphere for the interviews.

Once the interviews began, the participants were seated around a table, and the videos were projected on a screen at the front of the room. Two video cameras were placed at the front of the room, on either side of the table, to capture the action of the interview and allow for subsequent transcription and analysis. The interviews were also digitally audio-recorded as a back-up method. I did not take any notes during the interviews as I wanted to maintain a conversational tone. After showing each video clip, I asked for a volunteer to summarize what had happened, and then I transitioned into asking the participants questions about what they had just seen. I had prepared interview protocols (Appendix D for Grade 4 students; Appendix E for Grade 8 students) with questions regarding each video, but I tended to follow the flow of the participants' conversation instead. In three of the four focus group interviews at E2S6, I also had time to show the participants 10 sample drawings of mathematicians (Appendix F) completed by students in the earlier portion of the research. No questions were formally prepared for this portion of the interviews; rather, I simply asked the participants to discuss which of the drawings

accurately portrayed mathematicians in their opinions, and then followed up on their comments. After each interview concluded, I made notes about any interactions during the focus group that particularly stood out to me (e.g., group dynamics). I also noted what went well and poorly during the interview, in hopes of making improvements prior to conducting the next interview.

Since the fifth focus group interview took place at a family friend's home, the dynamics and the manner in which the interview was conducted were slightly altered. The participants were provided with snacks rather than a meal, as the interview took place directly after school. The interview took place around a kitchen table, which allowed for a relaxed atmosphere. As I was not able to bring the projector or tripods with me to the interview location, the participants were shown the video clips on my laptop, and the video cameras were propped up on the table using plastic tubs as bases. Otherwise, the pre-interview processes and interview process occurred as with the focus group interviews that took place at E2S6 school.

Parent Participants: Individual/Pair Interviews

Thirteen parents participated in interviews, which nearly met my goal of having 15 participants, and surpassed the point at which Denzin and Lincoln (1994) suggest that data saturation should be able to occur in individual interviews (12 participants). The interviews were conducted between November of 2010 and April of 2011, and ranged in length from 0:40:04 to 1:57:40, with a mean duration of 1:28:06. Participants were recruited from two geographically-convenient school districts, Eastern 1 (seven parents; five interviews) and Eastern 2 (six parents; six interviews). Parents could complete the interview individually or with their partner. Information about the parent interview participants and their children is provided in Table 7.

Table 7
Information Regarding Parent Interview Participants

Interview number	Number of participants	Gender(s) of participants	Child's grade	Child's gender	School district
1	2	Woman, Man	4	Girl	Eastern 1
2	2	Woman, Man	4	Girl	Eastern 1
3	1	Man	4	Girl	Eastern 1
4	1	Woman	4	Girl	Eastern 1
5	1	Woman	4	Boy	Eastern 1
6	1	Man	4	Boy	Eastern 2
7	1	Woman	4	Boy	Eastern 2
8	1	Woman	4	Girl	Eastern 2
9	1	Man	8	Girl	Eastern 2
10	1	Man	8	Boy	Eastern 2
11	1	Man	8	Girl	Eastern 2

Eight interviews were conducted in participants' homes, two at public libraries, and one at a participant's workplace. At the start of each interview, the participant(s) read the information letter and completed the consent form (Appendix N). All interviews were digitally audio-recorded to allow for transcription and analysis. Like the student interviews, I did not take any notes during the parent interviews, as I wished to keep the tone conversational. In some cases, this was accomplished to the point that the interviews felt more like conversations between acquaintances. I was able to seamlessly weave the interview questions into a conversation rather than follow the order in which they were listed on the interview protocol. Additionally, many

participants elected to chat with me about both related and unrelated topics after the interview concluded. After each interview concluded, I made notes of anything non-audible that had occurred in the interview (e.g., facial expressions), as well as notes about my general impressions of the parents. Within a few days, I emailed the parents to thank them for participating. I also provided them with a list of useful and interesting websites about mathematics and mathematicians to share with their children (Appendix O). Most participants responded to this email, thanking me for the information and informing me that they would share the information with their children.

Teacher Participants: Individual/Pair Interviews

Ten teachers participated in interviews, but only nine interviews were held as two teachers were interviewed as a pair; this exactly met my goal of having 10 teacher interview participants. This sample size was close to the data saturation point of 12 individual interview participants (Denzin & Lincoln, 1994). Teacher interviews were conducted between November of 2010 and May of 2011, and ranged in length from 1:05:30 to 2:11:22, with a mean duration of 1:39:51. Teachers were recruited from two geographically-convenient school districts, Eastern 1 and Eastern 2, and a school district close to my hometown, Southwestern 1. Additionally, three teachers who were personal contacts participated in interviews; these participants teach in two school districts (located in Southwestern and Central Ontario) that did not participate in the study. The two personal contacts from Southwestern Ontario elected to be interviewed together, whereas the personal contact from Central Ontario was interviewed individually.

All teacher interview participants only had experience teaching in public schools. Although some of the participants were not currently teaching Grade 4 or 8, they were grouped with the Grade 4 and 8 teachers based on their prior teaching experience or their current

placement. For instance, one participant had mainly taught Grade 8, but was teaching Grade 1/2 at the time of the interview; thus, she was grouped with the Grade 8 teachers. Similarly, teachers who were teaching other Junior grades (i.e., Grades 4 to 6) or Intermediate grades (i.e., Grades 7 to 10) at the time of the interview were grouped with the Grade 4 and Grade 8 teachers, respectively; notably, all these teachers had experience teaching Grade 4 or Grade 8 in past. Henceforth, any teachers who taught Grade 4 at the time of the interview, or have in past, are referred to as ‘Grade 4 teachers’; the same holds true for ‘Grade 8 teachers’. Thus, the participants were five Grade 4 teachers and five Grade 8 teachers.

All but two of the nine teacher interviews took place in school, either in the teacher’s classroom (five interviews) or the staff room (two interviews). This allowed me to observe the set-up of the classroom, and allowed the participant to show me student work or classroom materials if he or she wished. The two interviews conducted with the three personal contacts were conducted at the participants’ homes. As with the parent interviews, each teacher interview began with the participant reading the information letter and completing the consent form (Appendix P). All teacher interviews were digitally audio-recorded to allow for transcription and analysis. No notes were taken during the interviews in order to maintain a conversational tone, and I found that I could easily connect with the teacher participants as a result. I made notes about each participant, as well as made a sketch of the classroom (if possible; one teacher, whose interview was conducted in a staff room, did not show me his classroom), after each interview concluded. The notes about the participants included a description of the participant (age, gender, etc.) and remarks about my initial impressions of the participant. The sketches of the classrooms allowed me to cross-reference any allusions to something in the classroom the teachers made during the interview.

At the conclusion of each interview, I provided the participant with a mathematics resource book. I sent a follow-up email to the teachers (similar to that sent to the parent participants; see Appendix O) a few days after each interview, thanking them for their participation and providing them with a list of websites with mathematics and mathematicians resources for their students to explore. Teachers whose students participated in the study but who did not partake in a teacher interview were also provided with a teacher resource book and a thank-you email with the links to the mathematics and mathematicians resources. The teacher participants' responses to these emails were similar to those of the parent interview participants.

Data Analysis

In the following sections, I discuss how analysis occurred for each data type. The Media section of the questionnaire is discussed first, as it was analyzed separately from the rest of the questionnaire data, in order to find the video clips to use in the focus group interviews. I then describe my analysis of the children's media. This is followed by a discussion of the analysis of the focus group interview data, as it relied on the examples from the children's media. I then return to a discussion of the analysis of the other sections of the questionnaire, as well as the student drawings. Finally, the analysis of the parent and teacher interviews is discussed; since the data were very similar, the analyses took place in nearly identical ways so are discussed together.

Student Questionnaires: Media Section

The media section of the questionnaire asked participants about their frequency of use and 'favourites' for five types of media: television shows, movies, websites, video games, and reading materials. The frequency questions provided multiple-choice ranged options (e.g., '1-3 hours') for the time the participants typically use the media type on weekdays and weekends. For

each media type, I calculated percentages for each time range – for all participants, by gender, and by grade level – noting the modal category and any gender or grade-level differences.

One question in the ‘favourites’ section inquired about the type of reading materials the participants used most often: books, magazines, comics, or other. I provided these options as I thought that they would be the most common types of reading materials Grade 4 and 8 students would use. These questions were analyzed in the same manner as the frequency questions: calculation of percentages and identification of modal categories overall, by gender, and by grade level. The other questions in the favourites section asked the participants to identify their three ‘favourites’ (i.e., most often watched/played for television shows, websites, and video games, and favourites for movies and reading materials) for each media type. Since participants typed in their responses, I needed to code them all by hand. Many responses had misspellings or typos, the vast majority of which I could decipher, either on my own or through internet searches. For the few that I could not decipher regardless of the strategies I tried, I simply left the response as the participant wrote it, placed in quotation marks. There were only three such instances (two reading materials and one website). An additional challenge occurred when participants provided acronyms or short forms for titles. Through internet searches, I was able to decipher all of these instances. Participants would often provide the name of a website without the address. Internet searches allowed me to decipher the names and obtain website addresses (with the one exception mentioned). For all the media examples with which I was not familiar, I conducted an internet search to ensure the example indeed existed and to learn more about it.

Often, participants would provide their responses in a general way, such as ‘*Harry Potter*’ rather than writing the name of one of the books in the *Harry Potter* series. In those cases, the response was coded as ‘[series name] (all/unspecified)’. This code also included

instances where participants had written, for example, ‘all *Harry Potter* books’. I followed this procedure even when the name of the first book/movie/etc. in the series was the same as the general name of the series (e.g., *Transformers*), as there was no way to know if the participant was referring to the first book/movie/etc. or the whole series. In a few instances, participants provided more than three responses. In these cases, I only coded the first response written in each of the three spaces. When participants provided additional information regarding their choices (e.g., ‘short edition’, ‘French version’), it was not included, as the basic media example was the same; the choice was coded with the generic version of the media example. Responses of ‘N/A’ or, for example, ‘I don’t play video games’ were coded as blanks. Generalized responses were coded by being written in quotation marks (e.g., ‘basketball books’, ‘hockey games’).

Once a list of titles was compiled accurately to the best of my ability, I coded each participant’s responses by matching each written response to the appropriate coded title. The coding was completed in a checklist format, with tallies (zeroes or ones, with one meaning the title was selected) for each title listed under each ranked response (i.e., #1, #2, and #3, referring to the participant’s ranking of the choice). Then, the sum of the #1 to #3 responses for each title was calculated, and the sums were ordered from greatest to least. I then reported the top three choices for each media for nine different categories, herein referred to as ‘gender/grade categories’: all participants, Grade 4 students, Grade 8 students, girls, boys, Grade 4 girls, Grade 4 boys, Grade 8 girls, and Grade 8 boys. If there were ties, additional choices were reported.

Further analyses of the media data were undertaken in order to better understand the range of responses. The spread of titles within each media type was analyzed through three measures: 1) Ratio of the number of titles to the number of participants, 2) Percentage of titles selected by only one person, and 3) Percentage of titles selected by 10% or more people. Each of

these three measures was calculated for each of the nine gender/grade categories. The first measure was calculated in order to compare the amount of overlap in the titles. For instance, if each participant had selected three responses that were different from all the other participants' responses, the ratio would be 3:1. The second measure was calculated in order to see how many 'marginal' responses there were, those that were only selected by one person. The third measure was calculated in order to see how many titles were fairly commonly selected amongst participants in a given group, in that they were selected by 10% of the respondents. Although 10% may seem like a low percentage, recall that participants only selected their top three choices for each media type. In the above calculations, blanks were not included. However, blanks were separately analyzed to see if any patterns occurred by media types, by gender, or by grade level.

Children's Media

My initial plan was to view the media that were the top three responses for each media type (i.e., television shows, websites, movies, video games, and reading materials) for each of the nine grade/gender categories, in order to search for representations of mathematics and mathematicians. These representations were used as prompts in the focus group interviews and as a data source on their own, to show how mathematics and mathematicians are depicted. Once I had collected the data, I changed my plan for viewing as it was clear that some of the 'top' choices had very few respondents. In some cases, the third place choice was selected by fewer than 10% of the participants in that category. Thus, if I watched all of the 'top three' responses, many examples would not have been viewed (or at least, not often) by many participants.

I decided that I needed to place a cut-off between the 'top' media examples I would view and those I would not view. I selected a cut-off of 20%, meaning that the chosen media examples in the top three choices that I viewed must have been selected by at least 20% of the participants

in that gender/grade group. I felt this percentage was high enough to suggest that a sufficiently large portion of participants would have viewed the example. If a lower percentage was used, then, arguably, so few participants would have viewed the example that it would not be considered a popular choice for that group; thus, it would not be relevant to view as an example of popular media for that group. Conversely, selecting a higher percentage for the cut-off would mean that many categories would not have any examples reaching the cut-off.

Even with the relatively low 20% cut-off, no movies or reading materials in any of the nine gender/grade categories made the cut-off. However, I still wanted to ensure I analyzed movies and reading materials that the students in the study were watching and reading. I decided to include the top choice in each of the nine categories for movies and reading materials, with the caveat that the top choice had to reach a 10% minimum level. I also followed this procedure in the few gender/grade categories within television shows, websites, and video games in which no examples met the 20% cut-off. Following these guidelines resulted in 10 television shows, three movies (two series), seven websites, six video games, and five books (four series) being selected. Specifically, the top television shows were:

- *The Big Bang Theory*
- *Family Guy*
- *Glee*
- *Hannah Montana*
- *iCarly*
- *Phineas and Ferb*
- *Pretty Little Liars*
- *Spongebob Squarepants*
- *The Suite Life On Deck*
- *Wizards of Waverly Place*

The top movies or movie series were:

- *The Hangover*
- *Harry Potter* (all/unspecified)
- *Star Wars* (all/unspecified)

The top websites were:

- *Club Penguin* (www.clubpenguin.com)
- *Facebook* (www.facebook.com)
- *Family Channel* (www.family.ca)
- *Google* (www.google.com)
- *Miniclip* (www.miniclip.com)
- *Webkinz* (www.webkinz.com)
- *YouTube* (www.youtube.com)

The top video games were:

- *Call of Duty: Black Ops*
- *Call of Duty: Modern Warfare 2*
- *Lego Batman*
- *Mario Kart*
- *NHL 11*
- *Super Mario Bros.*

The top reading materials (all books or book series) were:

- *Diary of a Wimpy Kid* (all/unspecified)
- *Geronimo Stilton* (all/unspecified)
- *Harry Potter* (all/unspecified)
- *The Hunger Games* (all/unspecified)
- *Lockdown*

Television Shows

My purpose for watching the top selections for television shows was twofold. My first priority, due to the time constraints of the data collection, was to select video clips for the student focus group interviews. Secondly, the top television shows were watched and analyzed for their portrayals of mathematics and mathematicians. These were not separate processes: While I was initially watching television shows to select the clips for the focus group interview prompts, I was also conducting analyses of the representations of mathematics and mathematicians therein.

To select the prompts for the focus group interviews, I decided to begin with television shows rather than movies, as the top movie choices did not seem, based on my prior knowledge,

as though they would contain meaningful references to mathematics and/or mathematicians. I began by watching television shows that were top choices of the Grade 4 students, as I already had selected video clips to show the Grade 8 students (*Glee*, *The Big Bang Theory*, and *The Simpsons*; these clips were selected based on my prior knowledge of mathematics-related references, and two of the three television shows – *Glee* and *The Big Bang Theory* – were among the Grade 8 questionnaire participants' top choices), but I did not have any clips selected for the Grade 4 focus groups. I thus planned to watch all episodes in the most recent season of each show when the questionnaire data were collected, the 2010-2011 season. I created a protocol (Appendix Q) to track each show that I watched, wherein I summarized the events of the show and highlighted any mathematics-related references. However, upon watching several episodes of *Hannah Montana* and *Spongebob Squarepants*, two of the top Grade 4 choices, I had found virtually no mathematics-related references at all beyond the most trivial (e.g., numbers written on a sign). None of these examples were suitable as prompts for the focus group interviews.

I then made another change to my media viewing process to make it more focused. I began by reading through the *Wikipedia* descriptions of each episode ever aired for the top television shows up until June of 2011, when the last questionnaire data were collected. I selected *Wikipedia* for the episode descriptions as it provided information about all of the shows, and the information was the most detailed that I could find, even in comparison to the shows' official sites or the sites of the television networks on which the shows are broadcast. Episodes were selected if the description hinted that there might be a reference to, and thus a message about, mathematics or mathematicians (e.g., a school setting, problem solving). These messages could be explicit, such as stereotypes about mathematically proficient people, or implicit, such as messages implied by the mathematics content itself. This method of searching resulted in one

episode each of *Glee* and *Spongebob Squarepants*. Through my searching, I learned that *The Suite Life on Deck* is a spin-off from *The Suite Life of Zack & Cody*. I then read the episode descriptions of *The Suite Life of Zack & Cody*, which resulted in three episodes to view. I found a clip from this show to use in the focus group interviews with the Grade 4 students. I also showed them the clip from *The Simpsons* that I showed the Grade 8 students, as it was age-appropriate.

To find additional mathematics-related references in the top television shows, I did *Google* and *YouTube* searches of the terms '[show name] AND math'. This allowed me to find a few more episodes that featured mathematics-related references: two episodes of *Family Guy* and one episode of *The Suite Life on Deck*. I also found online mathematics games related to some of the shows, a description of a mathematically proficient character on *Phineas and Ferb*, and examples of young actors from the shows being involved in mathematics-related activities (e.g., participating in a math-a-thon, being featured in a mathematics magazine).

I knew from my own viewing that nearly every episode of *The Big Bang Theory* features mathematics in some way, from mathematics jokes to equations on a whiteboard. Similarly, after researching *Phineas and Ferb*, I learned that nearly every episode focuses on inventions, building, and/or science. Therefore, I needed to alter my selection process for these two shows, since there were so many options from which to choose. I decided to limit my viewing to two episodes of each show, with the selections being those that I considered to be particularly mathematics-focused. My first selection for *The Big Bang Theory* was the episode from which the clip was selected for the Grade 8 focus group interviews. The second episode was selected based on its *Wikipedia* description. In contrast, the *Wikipedia* descriptions of the *Phineas and Ferb* episodes did not provide any suggestions of mathematics in particular (rather than science or inventing in general). Additionally, I was only able to find one mathematics-related clip of

Phineas and Ferb on YouTube; thus, this was the first episode selected. Fortunately, my Google search resulted in a link to an extremely detailed *Phineas and Ferb* wiki; I searched this wiki for the term ‘math’, which allowed me to find several references and relevant clips. From these, I selected the one that I felt had the greatest focus on mathematics.

In total, when combining the episodes found through my initial searches with two episodes each of *The Big Bang Theory* and *Phineas and Ferb*, 15 episodes from seven different shows were selected for analysis. Specifically, two episodes of *The Big Bang Theory*, four episodes of *Family Guy*, one episode of *Glee*, two episodes of *Phineas and Ferb*, one episode of *Spongebob Squarepants*, three episodes of *The Suite Life of Zack and Cody*, and one episode of *The Suite Life on Deck* were viewed. During the viewing of each episode, detailed notes were taken in the protocol described above. For the television series from which more than one episode was selected, comparisons were also drawn across the episodes viewed.

Movies

Similar to my revised plan for viewing the top television shows, I narrowed my viewing of the top movie selections to those where, based on the *Wikipedia* descriptions of each movie, I thought there was the possibility of mathematics-related references. There were three selections for movies based on the students’ questionnaire responses, but two of these selections were series. This resulted in 15 different movies: *The Hangover*, eight *Harry Potter* movies, and six *Star Wars* movies. From reading the *Wikipedia* descriptions of each movie, I narrowed my viewing list to *The Hangover*, *Harry Potter and the Philosopher’s Stone*, *Harry Potter and the Prisoner of Azkaban*, and *Harry Potter and the Goblet of Fire*. I also conducted a Google search of the terms ‘[movie title] AND math’, which resulted in one further *Harry Potter* film to view: *Harry Potter and the Order of the Phoenix*. Surprisingly, neither of my searching methods

resulted in any mathematics-specific references in any of the *Star Wars* movies. I viewed these five movies, making notes about any mathematics-related references on a similar protocol (Appendix R) to the one used for viewing television shows. Since four of the five movies were from the same series (*Harry Potter*), I looked for trends within that series.

Websites

Although there were seven websites in the ‘top choices’ list, only four (*Club Penguin*, *Family Channel*, *Miniclip*, and *Webkinz*) were considered for analysis, as *Facebook*, *Google*, and *YouTube* did not provide any specific content to examine. Where available, descriptions of the websites were first read on *Wikipedia*, in order to familiarize myself with the websites. Then, I searched each website for mathematics-related references by both opening various pages and, where possible, doing a search for the term ‘math’. In the event that a mathematics-related reference was a game or interactive activity, where possible (i.e., without having a membership to the site), I would play the game or activity. Like the other data types, I looked for trends in the mathematics-related references within each website and across the four websites examined.

Video Games

My initial plan was to play each of the top video game selections in order to analyze the mathematics-related references therein. However, as my research progressed, I realized that this was not feasible. I have never owned a video game system and I only have minimal experience playing video games as a child at friends’ houses. Since today’s gaming systems and games are far more complicated than the ones I used as a child, it would neither be efficient nor reasonable for me to learn how to operate the systems and controls, as well as how to play the games. I thus decided to ask others who play video games to learn more about each game.

At this point in my study, all data collection with the students was complete, so I had to turn to a convenience sample of my friends, family members, and acquaintances. I created a short online questionnaire (Appendix S), posted on *SurveyMonkey*, wherein I asked the participants for basic demographic information (gender and age via multiple-choice options; post-secondary education and occupation via open-ended questions) and information about their experiences with each of the six 'top' games. For each game, participants were asked how often they had played it (multiple-choice responses of 'never', 'rarely', 'sometimes', and 'often'), what mathematical content they saw within the game (open-ended), and what mathematical skills they needed to play the game (open-ended). At the end of the questionnaire, participants were asked to contact me via email if they were willing to allow me to watch them play any of the games.

The invitation to participate in the questionnaire was sent in August of 2012 to 196 contacts via email and 284 contacts via a Facebook message, resulting in a total of 480 people being contacted. The individuals to whom the message was sent were primarily aged 20 to 35, the ages of most of my friends and acquaintances, most of whom reside in Ontario. These individuals were given two weeks to complete the questionnaire, and they were asked to pass the invitation to participate to anyone they knew who had experience with any of the video games.

Forty-five participants completed the questionnaire: 19 women (43.2%), 25 men (56.8%), and one participant (2.2%) who did not identify his/her gender. Most participants were ages 25-29 (51.1%), followed by ages 30-34 (24.4%), and ages 18-24 (20.0%). No participants under the age of 18 took part, and only one participant from each of the 35-39 (2.2%) and Over 39 (2.2%) age groups took part. The participants provided information about their post-secondary education and current occupations in open-ended questions, and I coded their responses using emergent coding. That is, after reading through the open-ended responses carefully, I came up with an

initial list of codes. Then, I assigned a code to each participant's responses. Codes with few responses were combined into 'other' categories. The participants were generally quite highly educated, with over 90% indicating that they had completed post-secondary education (in a variety of fields). The most commonly reported occupations were those in business fields and graduate studies. The purpose for collecting the data regarding education and occupations was to see if there were any trends in the responses related to the participants' mathematical backgrounds (e.g., a high level of education in mathematics being linked to a higher propensity for seeing mathematics in the games). No such trends were apparent, so the responses to the questions about the video games were analyzed as a whole.

Descriptive statistics were calculated for the multiple-choice questions (frequency of play) about each video game. For the open-ended questions about the mathematics content and the mathematical skills, the participants' responses were first read to provide an overview. Then, a list of codes was compiled based on these responses. The written responses were then coded using the list of codes; in many instances, a response would have multiple codes assigned to it. While some participants explicitly provided a response of 'spatial skills', this code was also applied to responses that suggested such skills (e.g., predicting trajectories of airborne weaponry, timing when to push the controller's buttons in order to jump and avoid an enemy).

I decided that observing two people play each game was sufficient, as it would provide me with different viewpoints of the players, who would have varying skill levels and/or may play the game on different platforms. Reflecting the questionnaire responses, I had many more volunteers who offered to allow me to watch them play *Super Mario Bros.* and *Mario Kart* than I needed, so I had to turn some volunteers away. I simply selected the first two volunteers for each game who lived in a geographically convenient location. I then went to each player's home and

watched her/him play the game, taking notes on a protocol (Appendix T) that allowed me to record information about the player (e.g., gender, experience playing the game) and the game (namely, the mathematical content therein and the mathematical skills needed to play the game).

Four participants allowed me to observe them playing four of the top six games, with the observations all occurring in August of 2012. On average, I spent approximately 40 minutes watching each player or pair of players playing each game. The games observed were *Call of Duty: Black Ops* (once, single player), *Lego Batman* (once, pair), *Mario Kart* (twice, one single player and one pair), and *Super Mario Bros.* (twice, two single players). I also played the two *Mario* games after observing the participants, as they encouraged me to do so. The participant whom I observed playing *Call of Duty: Black Ops* had played *Call of Duty: Modern Warfare 2*, another top game, and he assured me that the mathematical content therein would be similar. Thus, I was not concerned that I did not have volunteers for this game. Unfortunately, I did not have any volunteers for *NHL 11*, the only sports-related game in the top choices.

During the observation sessions, I had the opportunity to ask the players questions about the gaming system, the controls, and their experiences with the game – before, during, and after game play. Using a simple protocol (Appendix T), I took notes on the participants' comments and my impressions of the mathematical content in the games, and drew pictures of the screens during play. These notes were later analyzed for mathematical content, both within and across the games, as well as in comparison to the questionnaire responses. In order to check for accuracy (both of my understandings of the games and of the players' experiences and viewpoints), the volunteers read over my write-ups of the findings and provided feedback.

Reading Materials

My plan for analyzing the top reading materials was very similar to my procedure for television shows and movies: I would only read the top selections where there seemed to be a possibility of mathematics-related references, based on the *Wikipedia* description of each book and my *Google* search of the terms '[book title or book series title] AND math'. Note that all of the top selections were books, rather than comics, magazines, or another type of print media. As with the top television show and movie choices, I limited my analysis to books that had been published by June 2011, the last date by which questionnaires were received.

Similar to the top movie selections, all but one of the five top book selections were series rather than individual books. Thus, there were 73 books to consider: five *Diary of a Wimpy Kid* books, 49 *Geronimo Stilton* books, seven *Harry Potter* books (Note that there were eight *Harry Potter* movies because the last book in the series was split into two movies), three *Hunger Games* books, and *Lockdown* (the only individual book in the top selections). Of these top selections, 13 books were selected for analysis: one *Diary of a Wimpy Kid* book (*The Ugly Truth*), six *Geronimo Stilton* books (*Lost Treasure of the Emerald Eye*, *The Curse of the Cheese Pyramid*, *The Mona Mousa Code*, *Shipwreck on the Pirate Islands*, *A Fabumouse School Adventure*, and *The Quest for Paradise: The Return to the Kingdom of Fantasy*), four *Harry Potter* books (*Harry Potter and the Sorcerer's Stone*, *Harry Potter and the Prisoner of Azkaban*, *Harry Potter and the Goblet of Fire*, and *Harry Potter and the Order of the Phoenix*), and two *Hunger Games* books (*The Hunger Games* and *Catching Fire*). I read each of these 13 books, making notes about any mathematics-related references, both in the books' text and illustrations, on a similar protocol (Appendix U) to the one I used for viewing television shows. I looked for trends within each series, as well as trends across all the top book selections that were analyzed.

Student Focus Group Interviews

The videotapes of the student focus group interviews were reviewed in their entirety, with detailed notes taken during the viewings. These notes included summaries of the various discussions related to each media prompt. Additionally, meaningful portions of the discussions were transcribed verbatim. Once the detailed notes were completed, summary tables were created in order to enable comparisons across the interviews of the key ideas related to each media prompt. Moreover, an ‘Other’ table was created for discussions unrelated to the media prompts, such as descriptions of the participants’ mathematics classes, the participants’ feelings about mathematics, and my impressions of the gendered group dynamics.

Comparisons were primarily made within each grade level; that is, the three Grade 4 focus groups were compared (FG1, FG2, and FG4) and the two Grade 8 focus groups were compared (FG3 and FG5). This choice was made due to the fact that the Grade 4 and Grade 8 students were shown different media prompts. The Grade 4 students were shown a clip from *The Suite Life of Zack and Cody*, whereas the Grade 8 students were shown clips from *Glee* and *The Big Bang Theory*. However, both grade levels were shown a clip from *The Simpsons* and the student drawings. Thus, for these two media prompts, grade-level comparisons were drawn.

Student Questionnaires: Mathematics and Mathematicians Portions

In the following sections, I discuss my analysis of the questionnaire data from the sections about mathematics and mathematicians. My discussions are separated by the type of question (i.e., Likert-Scale, multiple-choice, or open-ended) rather than by section, as similar types of analyses took place based on the type of question as opposed to the topic of the sections. As a reminder, the sections were ordered in the questionnaire as follows: 1) Mathematics (eight Likert-Scale questions), 2) Mathematicians (two multiple-choice questions, four open-ended

questions, and five Likert-Scale questions), 3) Parents (five repeated Likert-Scale questions), and 4) Gender (seven multiple-choice questions).

Likert-Scale Questions

After the initial demographic questions and the questions about the participants' media habits and media favourites, the rest of the student questionnaire featured the questions about mathematics and mathematicians. Five-point Likert-Scale questions (with 'strongly agree', 'agree', 'neither agree nor disagree', 'disagree', and 'strongly disagree' responses) were included in the 'Mathematics' section (eight questions), 'Mathematicians' section (five questions), and 'Parents' section (five questions, repeated for mothers and fathers). Responses to these questions were initially analyzed through descriptive statistics (e.g., means, standard deviations, percentages), in order to understand the overall trends for each question. Within each section, Cronbach's alpha coefficients (α) were calculated using *SPSS Statistics* software in order to determine if the individual questions therein were sufficiently cohesive to warrant creating aggregate variables. All questions were retained for the 'Mathematicians' and 'Parents' sections, while three questions were removed from the 'Mathematics' section. These questions were checked for cohesion, but none existed, so they were analyzed separately.

Once the misaligned questions were removed, I created four aggregate variables, each of which was comprised of five questions: 'Math View' ($\alpha = .64$), 'Mathematician View' ($\alpha = .63$), 'Mom View' ($\alpha = .62$), and 'Dad View' ($\alpha = .73$). While three of the four Cronbach's alpha coefficient values were slightly lower than the recommended minimum value of 0.7 for social science research (Bland & Altman, 1997), they were sufficiently close; additionally, substantially higher values could not be attained by removing other individual questions. Scores for each aggregate variable were calculated by summing the scores from the individual questions.

Summation was selected due to the assumption that the individual items were equally weighted. Each question was coded with a score from 1 to 5, with higher scores indicating more positive/less stereotypical views. Negatively-worded (or stereotypically-worded) questions were reverse coded, such that a higher aggregate score indicated a more positive/less stereotypical view. Thus, possible scores for each aggregate variable ranged from 5 to 25.

Once the aggregate variables were established, initial checks were performed on the data. First, each aggregate variable was examined for normality (i.e., examining skewness and kurtosis). The skewness statistic (Sstat) was calculated by dividing skewness by the standard error of skewness (s_s), and the kurtosis statistic (Kstat) was calculated by dividing kurtosis by the standard error of kurtosis (s_k). Using Brown's (1997) guidelines, each aggregate variable was deemed to be skewed or kurtic if the absolute value of the skewness/kurtosis statistic did not fall within twice the standard error of skewness/kurtosis. Using these calculations, 'Math View', 'Mathematician View', and 'Mom View' were all deemed not to be skewed or kurtic. However, 'Dad View' was both negatively skewed (Sstat = -4.10) and leptokurtic (Kstat = 3.07). Since 'Dad View' was negatively skewed, a reflection and square root transformation was conducted, using the following formula: "NEWX = SQRT(K-X)", as suggested by Tabachnick and Fidell (2007, p. 89) for 'moderate negative skewness'. In this formula, X refers to the variable name, whereas K refers to a constant that is computed by adding one to the largest score (in this case, $K = 25 + 1 = 26$). Using the aforementioned calculations (i.e., guidelines by Brown, 1997), the new variable 'Dad View_RefSqrt' was deemed to neither be skewed or kurtic. Thus, in most discussions of 'Dad View' in the Findings chapter, this transformed variable is used, as it is normally distributed (like the three other aggregate variables). An exception occurs when the

‘Dad View’ and ‘Mom View’ aggregate variables are discussed together: In these instances, the original ‘Dad View’ aggregate variable is used in order to have comparable data.

Before analysis of the data could begin, the aggregate variables were checked for homogeneity of variance, which indicates that “the variability in scores for one continuous variable is roughly the same at all values of another continuous variable” (Tabachnick & Fidell, 2007, p. 85). Homogeneity of variance is a necessary condition before the means of two datasets can be accurately compared, as in ANOVAs. Inspections were completed via calculations in which the square root of the standard deviation of the dependent variable was divided by that of the independent variable; for homogeneity of variance, the resulting value should be less than or equal to four (Tabachnick & Fidell, 2007). For each aggregate variable, these calculations were conducted for two pairs: 1) boys and girls, and 2) Grade 4 and Grade 8 students. The two groups compared for each variable were found to have sufficient similarity in their variances that analysis could proceed.

Then, for each aggregate variable and the three individual questions not included in the ‘Math View’ variable (The above checks were also conducted for the individual tests, and no issues arose), the responses were analyzed using one-way ANOVAs to discern if there were any statistically significant differences (at the $\alpha = .05$ level) between the means of paired groups.

Multiple-Choice Questions

In addition to the five Likert-scale questions about mathematicians, the ‘Mathematician’ section also contained two multiple-choice questions (about meeting a mathematician or seeing one in the media) with ‘yes’, ‘no’, and ‘not sure’ options for responses. These questions were analyzed with descriptive statistics (e.g., percentages).

The ‘Girls, boys, and math’ section was comprised of seven questions that offered ‘boys’, ‘no difference’, and ‘girls’ as response options. The data were analyzed overall with descriptive statistics in order to determine the modal category for each question. Then, Chi-square tests for independence were performed in order to determine if there were statistically significant differences (at the $\alpha = .05$ level) in the ways that a) boys’ and girls’ responses and b) Grade 4 and Grade 8 students’ responses were distributed across the three response categories.

Additional Quantitative Analyses

In order to address Research Question #3 (relationship between students’ views of mathematics and mathematicians and each of parents’ views, teachers’ views, and media representations), the quantitative data from the questionnaire were further analyzed. Namely, to examine the link between a) meeting a mathematician or b) seeing one in the media and the student questionnaire participants’ views of mathematicians, ANOVAs were conducted, using ‘met’ and ‘not’ or ‘seen’ and ‘not’ as the groups that were compared (Note that the ‘no’ and ‘not sure’ responses were compiled into one ‘not’ category). The variables that were considered were the ‘Mathematician View’ aggregate variable and each of the five variables from which this aggregate variable was comprised. Factorial ANOVAs were conducted to check for effects of gender and grade level on meeting a mathematician or seeing one in the media (i.e., four ANOVAs: gender/‘met’, grade/‘met’, gender/‘seen’, and grade/‘seen’ pairings). None of these effects were found to be statistically significant, which resulted in the data from all participants being considered together.

The second type of analysis related to the relationship between the student questionnaire participants’ reported media use and their views of mathematicians. Specifically, the ‘Mathematician View’ aggregate variable and the individual question about mathematicians

being nerdy ('Mathematician Nerdy') were considered in the correlational analysis (using the Spearman correlation coefficient), as they seemed to be the variables that would mostly likely be related to media use. The questionnaire provided ranged multiple-choice options for the students' media use (e.g., 'I don't watch television on weekdays', '3-5 hours'), with separate responses for weekday and weekend use for the 'daily' media types (i.e., television, websites, video games, and reading materials). First, these categorical data were transformed into numeric data, ranging from one (no use) to five (highest use). In the case of movie viewing, there was only one question provided, and this question had four multiple-choice options (different options than those provided for the 'daily' media types, such as 'At least once per month'), so the numeric data subsequently ranged from values of one to four. Then, in order to obtain a '[Media type] Use' variable that summarized the students' use of each of the daily media types, I added the values from weekday and weekend use. Correlational analyses were then conducted for each of the five media types with a) 'Mathematician View' and b) 'Mathematician Nerdy'. Finally, to obtain a global view of the relationship between the student participants' overall media use and their views of mathematicians, I created a new variable 'Media Use', using the equation 'Media Use' = 'TV Use' + 'Video Game Use' + 'Internet Use' + 'Reading Material Use' + $2(5/4)$ 'Movie Use'. The coefficient of $2(5/4)$ for 'Movie Use' was used in order to equally weight the numeric values for this media type with the other media types. Recall that there was only one question about the use of movies compared to two questions about the use of the other media types (hence multiplication by 2) and the movie question only had four response options, whereas the questions about the other media types had five options (hence multiplication by $5/4$). The 'Media Use' variable was also used in a correlational analysis with each of the aforementioned variables. As I will elaborate upon in the Findings chapter, since the relationships found in the correlational

analysis using the data from all participants were not particularly strong, I elected not to conduct additional analyses by gender or grade level.

The portion of Research Question #3 regarding parents' views was also investigated using the questionnaire data. While the research questions focus on the parents' views, the student questionnaire data involves the students' perspective on the parents' views rather than the parents' reported views. Arguably, however, the perception that the students garner of their parents' relationship with mathematics may be more telling than the parents' reported views. Analyses using the Spearman correlation coefficient were undertaken in order to understand any correlations between the students' views and their perceptions of their parents' views. The relationships that were considered were those between the aggregate variables concerning perceptions of parents' views of mathematics and the students' reported views of mathematics (i.e., 'Mom View'/'Dad View' and 'Math View') and between the individual questions concerning perceptions of parental pride if the student became a mathematician and the student's reported interest in becoming a mathematician. Since the relationships found in the correlational analysis using the data from all participants were not overly strong (as I will discuss in the Findings chapter), I elected not to conduct additional analyses by gender or grade level.

Finally, two multiple regression analyses were conducted to see what proportion of the variance in the student questionnaire participants' views of mathematics and mathematicians could be attributed to media use and the students' perceptions of their parents' relationships with mathematics. In the first regression analysis, the aggregate variables 'Mom View', 'Dad View', and 'Media Use' were the predictor variables for the aggregate variable 'Math View', which was the dependent variable. In the second regression analysis, the same three predictor variables were used, but with the aggregate variable 'Mathematician View' as the dependent variable. Due to

the relatively large number of questionnaire participants and the fact that only three predictor variables were used, the R^2 value, rather than the adjusted R^2 value, was appropriate to use, as discussed by Tabachnick and Fidell (2007).

Open-Ended Questions

The 'Mathematician' section also featured four open-ended questions (where the participant met/saw the mathematician; a description of the mathematician; reasons for hiring a mathematician; and tools mathematicians use). The first two open-ended questions followed from the aforementioned multiple-choice questions, so they were analyzed in response to the answers to those questions. I created two spreadsheets – one for the responses related to meeting a mathematician (herein referred to as 'met in real-life') and one for the responses related to seeing a mathematician in the media (herein referred to as 'saw in media') – and removed any participants' data where the responses to the multiple choice questions were 'no' or 'not sure', or where the participant left the question blank. Then, for each resulting dataset, I analyzed the data through emergent coding. I began by reading through the responses to get a sense of the data, and then created codes to capture the common ideas in the data. I only retained categories that had two or more responses. All single responses were grouped together in an 'other' category.

The responses to the question that inquired where the participant met or saw the mathematician (herein referred to as 'where') were coded into different categories, based on whether they were 'met in real-life' or 'saw in media' responses. The 'where' responses for participants who had met a mathematician were coded as 'family', 'teacher', 'other', 'not sure', and 'blank'. If the mathematician was categorized as 'other', then a description was provided (e.g., other – museum worker). Multiple codes were used where multiple examples were provided by a single participant (e.g., 'my teacher and my uncle' was coded as 'teacher' and

‘family’). The responses to the question that asked for a description of the mathematicians (herein referred to as ‘description’) the participants met in real life were coded in a checklist format, with the checklist categories arising from emergent coding, which was conducted in a similar fashion to that described above for the ‘met in real-life’ and ‘saw in the media’ questions. The categories in the checklist were ‘nice’, ‘helpful’, ‘cool’, ‘normal’, ‘intelligent’, ‘good at math’, ‘loves math’, ‘other’, and ‘blank’. Again, any ‘other’ responses were listed with details of the participants’ responses. The ‘where’ and ‘description’ responses from participants who had seen a mathematician in the media were coded in a similar fashion. The codes for ‘where’ for media mathematicians were ‘TV – general’, ‘TV – specific – [name of show/channel/etc.]’, ‘other [with the location specified]’, ‘not sure’, and ‘blank’. The codes for the description of the media mathematicians were ‘intelligent’, ‘good at math’, ‘lab coat’, ‘glasses’, ‘weird’, ‘other – appearance’, ‘other – personality’, ‘other – general’, ‘not sure’, and ‘blank’. The ‘other’ categories for the media mathematicians were divided into the three categories since the responses were so varied; in comparison, the ‘other’ responses for real life mathematicians focused on personality, so they remained in a single category.

In a few cases, the participants’ responses to the ‘met in real life’ or ‘saw in the media’ multiple choice questions were contradicted by their written responses to the ‘where’ question. Namely, one participant (Q34) selected ‘not sure’ for ‘met in real life’ and ‘yes’ for ‘saw in the media’, but then discussed her grandfather in the ‘where’ question. This description included the grandfather’s name, which was also included in one of the mathematician drawings (on an ‘Office of [name]’ sign). This provided me with sufficient evidence that Q34 believes her grandfather is a mathematician. Thus, I changed her ‘met in real life’ response to ‘yes’ (from ‘not sure’). Similarly, Q31 selected ‘no’ for ‘met in real life’, but then discussed her father in the

‘where’ question; thus, the ‘no’ response was changed to a ‘yes’. Finally, Q116, selected ‘no’ for ‘met in real life’ but then referenced a mathematics museum in the ‘where’ question; thus, the ‘no’ response was changed to a ‘yes’. In these three cases, it appeared as though the participants may have clicked on the incorrect button (beside the responses) by accident when responding to the questions. Beyond these three responses that I considered to be inconsistencies, there were two respondents who answered ‘not sure’ for ‘met in real life’, but then discussed people in the ‘where’ question. Namely, Q99 said ‘not sure’, but discussed her teacher, whereas Q150 discussed her father, an electrical engineer. In these cases, there was no evidence to suggest that these participants accidentally selected the wrong button, so I considered these two participants to be legitimately unsure whether these individuals were mathematicians.

The other two open-ended questions in the ‘Mathematician’ section were not directly linked to the aforementioned questions. These final two open-ended questions asked the participants why someone would need to hire a mathematician (herein referred to as ‘hire’), and what tools mathematicians use (herein referred to as ‘tools’). The responses to the ‘hire’ question were analyzed through emergent coding, with a list of codes compiled based on the participants’ responses, after a careful initial reading to understand common ideas in the data. The codes fell under four headings: ‘Fields of study’ (e.g., accounting, construction; 13 codes), ‘Teaching-related’ (e.g., teaching, tutoring; five codes), ‘Other tasks’ (e.g., personal finance, solving problems; six codes), and ‘Other responses’ (‘misunderstood question’, ‘I don’t know’, ‘blank’, and ‘unintelligible response’). Within ‘Other responses’, ‘misunderstood question’ refers to responses that referred to plumbing and medicine, which were examples in the question (e.g., ‘If you break your leg, you need the services of a doctor’), whereas ‘unintelligible’ refers to

responses that I could not understand or responses that did not answer the question. Counts and percentages were calculated for each code, for all participants, by gender, and by grade level.

The responses to the ‘tools’ question were analyzed similarly, with a list of codes compiled based on emergent coding of the participants’ responses. The responses were: computer, calculator, brain, chalkboard, whiteboard, pencils, pens, other writing tools, erasers, paper, graph paper, notebooks/notepads, other stationery supplies, math books/textbooks, geometry sets, protractor, compass, metre stick, ruler, math tools (unspecified), laboratory equipment, mathematical topic/concept, and other. All of the ‘other’ categories, as well as the ‘laboratory equipment’ and ‘mathematical topic/concept’ categories, were also coded with a description of each participant’s response. In addition, ‘I don’t know’ and ‘blank’ were provided as codes. As with the ‘hire’ question, descriptive statistics were calculated for the ‘tools’ question, for all participants and separated by gender and by grade level.

Student Questionnaires: Comments Portions

At the end of the questionnaire, there were two opportunities for the participants to provide comments: One question asked for comments about mathematics or mathematicians, while the other question asked for comments about the questionnaire. The responses to these open-ended questions were analyzed through emergent coding. First, the responses to both ‘comments’ questions were compiled into a single list, since there were a few instances where the comments were written in the incorrect spot. This resulted in 56 questionnaires where the participant made a comment of some sort. Responses indicating that a participant did not have any comments (e.g., ‘nope’) were simply treated as blanks.

After an initial reading of the data, codes were created under each topic (i.e., mathematics/mathematicians and the questionnaire). Namely, three codes were created about the

mathematics/mathematician comments: 1) Questions about mathematicians (Most commonly, ‘What is a mathematician?’ or ‘What does a mathematician do?’), 2) Positive comments about mathematicians, and 3) Positive comments about mathematics. Two codes were created about the questionnaire: 1) Questions about the questionnaire (e.g., ‘What will this be used for?’) and 2) Positive comments about the questionnaire. For both types of ‘comments’ responses, an ‘Other’ code was also an option, for the few responses that did not align with the categories discussed above. Once the responses were coded, totals were calculated for each code.

Student Drawings

The student drawings and their associated written explanations were analyzed several ways. Throughout this section, I provide two sample drawings (Figure 2 and Figure 3) and use these examples to highlight the manner in which the analyses took place for all drawings.



Figure 2. Mathematician drawing by D4, Grade 4 girl.

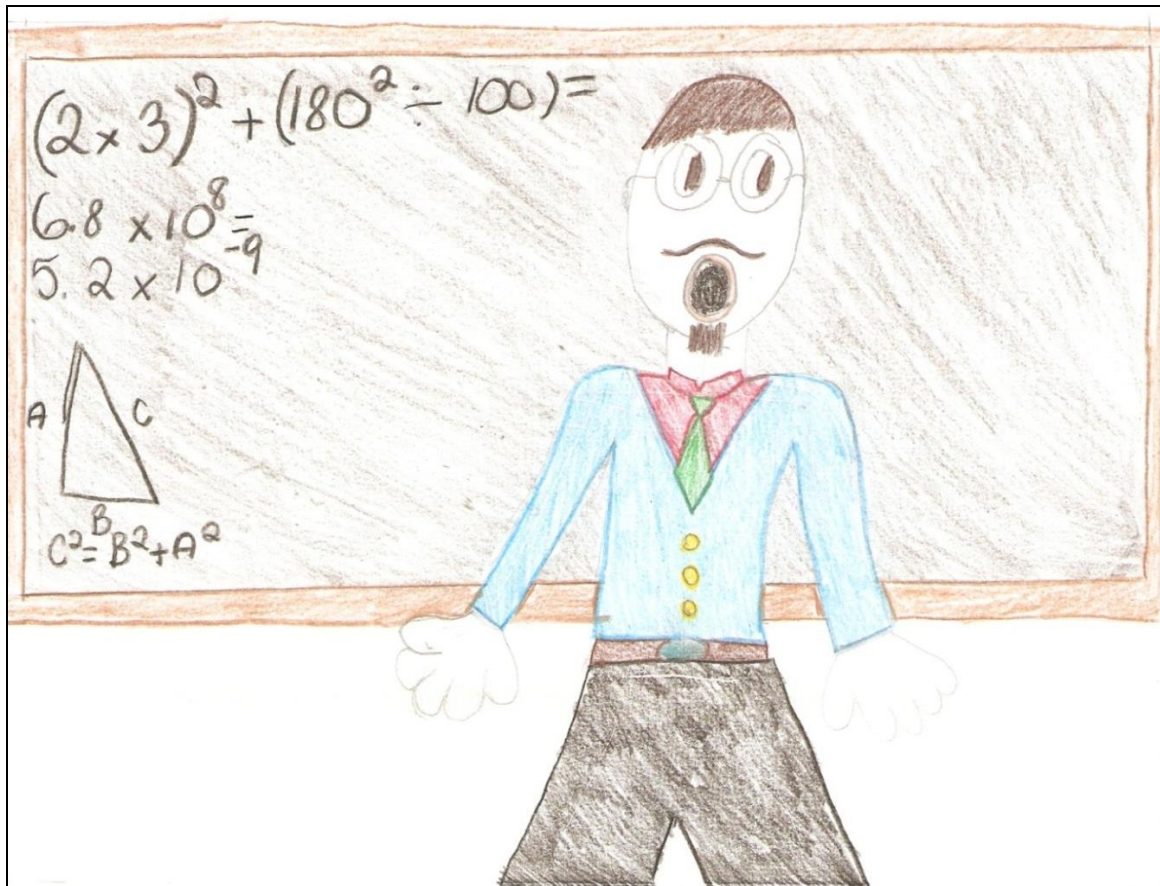


Figure 3. Mathematician drawing by D28, Grade 8 girl.

First, in order to have a record of my overall impression of each drawing, I wrote holistic descriptions – simply a brief paragraph that described the mathematician, what he/she was doing, and anything/anyone else in the drawing. For the drawing by D4, the holistic description stated:

This drawing shows a woman mathematician in a lab coat, saying 'Ah Ha' while holding a pointer up in the air. The chalkboard shows two large numbers multiplied together (with a nonsensical answer), and there is a table with a calculator and textbook on it.

For the drawing by D28, the holistic description stated: “This drawing shows a man teacher (wearing glasses and professional clothing) at a chalkboard, which has BEDMAS, scientific notation, and Pythagorean Theorem questions (without answers) on it.”

My second method of analysis was at a very fine, detailed level, where I created a checklist with more than 100 descriptors that I used to analyze the drawings. The list was created by first looking through all the drawings in order to establish broad categories that I wanted to code, and then establishing the codes therein. Specifically, the checklist was divided into 12 broad categories. The first category focused on gender information – the gender of the participant, his/her teacher, and the mathematician; and whether there was a match of the gender of the participant with either the gender of the teacher or the mathematician. These data allowed for gender-based comparisons of the mathematician drawings (i.e., if there were differences between boys' and girls' drawings) and examinations of any gendered trends relating to the participants' own genders, their teachers' genders, and the genders of the mathematicians in the drawings. The remaining 11 categories solely focused on the mathematician in the drawing:

- Physical characteristics, which were divided into:
 - Hair colour (e.g., brown, black)
 - Hair style (e.g., mainstream, Einstein-esque)
 - Clothing (e.g., casual clothing, lab coat)
 - Facial hair (coded for male or gender-unclear mathematicians only; e.g., beard, goatee)
 - Build (e.g., slim to average, overweight)
 - Other physical characteristics (e.g., eyeglasses, braces)
- Expression (e.g., smiling, frowning)
- Position (e.g., at board – teaching, sitting at desk/table – on computer)
- Setting (e.g., classroom, laboratory)
- Items in the drawing with mathematician (e.g., chalkboard, computer)

- Students in the drawing with mathematician (e.g., number, age)
- Mathematical content (e.g., two-digit computations, Pythagorean Theorem)
- Location of mathematical content (e.g., speech bubble, chalkboard)
- Comments (e.g., location of the comment, comment directly quoted)
- Specific (real-life) people (e.g., Einstein, their teacher)
- Character category (e.g., elementary teacher, textbook writer)

This final list was altered from my initial list. As I was coding, I realized that some of my initial categories were not feasible to use in my coding, so they were either removed or altered. For example, I initially had an ‘age’ category, but I found it nearly impossible to discern the age of the vast majority of the mathematicians in the drawings, so that category was removed. Another change to the coding scheme related to the setting. I had initially coded any drawing with a chalkboard or whiteboard as a classroom, but then I realized that this was not a definitive feature of a classroom, as many offices and some homes also feature chalkboards or whiteboards. Thus, the setting was only coded as a classroom if students were drawn or if it was clear from the written description. Indeed, the written description was often consulted to clarify aspects of the drawing, such as the mathematician’s gender. As such, I present the written descriptions for the drawings by D4 and D28 next (Figure 4 and Figure 5), prior to Table 8, which demonstrates the coding for each drawing.

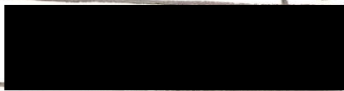
My Drawing of a Mathematician
is suppose to represent a very
smart mathematician creating
a new number. special feature
are the black board and calculator
and the Math text book on the table
by 

Figure 4. Written description that accompanied D4's mathematician drawing.

-A math teacher is teaching the kids
about BEDMAS, Scientific Notation, and
Pytherom therom.

Figure 5. Written description that accompanied D28's mathematician drawing.

Once the coding was completed for each drawing, frequency counts and percentages were calculated for each aspect of the coding scheme (for all participants, by gender, and by grade level).

Table 8 shows the coding that occurred for the drawings completed by D4 and D28.

Table 8
Coding of Two Sample Drawings, Completed by Participants D4 and D28

Category	Codes for D4's drawing	Codes for D28's drawing
Physical Characteristics:		
1. Hair colour	1. Blonde	1. Brown
2. Hair style	2. Mainstream	2. Mainstream
3. Clothing	3. Lab coat	3. Professional clothing
4. Facial hair	4. N/A	4. Goatee
5. Build	5. Slim to average	5. Slim to average
6. Other physical characteristics	6. Glasses	6. Glasses
Expression	Talking, 'a-ha' expression	Talking
Position	At chalkboard – doing mathematics	At chalkboard – teaching mathematics
Setting	Unclear	Classroom
Items in the drawing with the mathematician	Desk, calculator, mathematics textbook, chalkboard, chalk	Chalkboard
Students in the drawing with mathematician	N/A	N/A
Mathematical content	3+ digit calculation (multiplication)	BEDMAS, scientific notation, Pythagorean Theorem, exponents, shape (right triangle)
Location of mathematical content	Chalkboard	Chalkboard
Comments	"Ah Ha", speech bubble	N/A
Specific (real life) people	N/A	N/A
Character category	Inventor	Teacher

Notably, the mathematician in the drawing by D4 was not coded as wearing either 'casual' or 'professional' clothing; due to the long lab coat, it was not possible to categorize the other clothing that was showing. There were no clues as to whether the mathematician was in an office, classroom, or other location, so the setting was coded as 'unclear'. Information about the

items in the drawing, namely the book with ‘math’ written on it, was drawn from the written description; otherwise, there was no way to know what kind of book the ‘math’ book was. Similarly, the ‘setting’ and ‘character category’ for the drawing by D28 were only ascertained through the written description, which confirmed that the mathematician was indeed a teacher. Additionally, without the explicit statement about BEDMAS, that equation may have simply been coded as ‘exponents’ and ‘one-digit and three-digit calculation’.

My third method of analysis was thematic sorting of the drawings. Using both the drawings and the associated written descriptions, my supervisor and I sorted the drawings by the ‘character category’ of the mathematician, most of which were associated with professions. The sorting occurred as follows: The drawings were placed in a stack, and then we looked at the top drawing, discussed what category it might fit into, and then placed it into that pile. When the drawing alone was not a clear indication of the category, we then consulted the written explanation to see if it provided any direction. In the event that we disagreed, we discussed our differing opinions until we came to a consensus. At the end of the sorting, we checked through the drawings in each category to ensure we still agreed that they were appropriately placed. Then, I created a spreadsheet that listed the demographic information for each participant under the category under which their drawing was placed; this allowed me to quickly check if there were any trends within any individual schools/classes (None were apparent). I also calculated frequencies and percentages for each category – in total, by gender, and by grade level – in order to look at overall thematic trends, gendered trends, and grade level trends.

The final categorization, after combining some of the smaller, similar categories, was:

- 1) Teacher, 2) Professional mathematician, 3) Inventor, 4) Student, 5) Historical figure,
- 6) Textbook writer, 7) Wacky character, and 8) Generic person.

The ‘Teacher’ category was comprised of drawings of elementary and high school teachers, as well as college and university professors. In terms of the sample drawings, the drawing by D2 was placed into the ‘inventor’ category and the drawing by D28 was placed into the ‘teacher’ category. The ‘Professional mathematician’ category was comprised of drawings in which the mathematicians were shown doing mathematics (as opposed to, for instance, teaching mathematics). Although this term is not ideal, as it may suggest that the other types of mathematicians are not ‘professionals’, it was the closest term to the idea we were trying to convey. The ‘Historical figure’ category was comprised of drawings of Einstein and Archimedes, while the ‘Wacky character’ category was comprised of drawings of two highly stereotypical ‘nerds’, a colourful, clown-like character, and a wizard. Finally, the ‘Generic person’ category was comprised of drawings where the person in the drawing was not in any way indicated to be involved in mathematics. We attempted to further sort the two largest categories, ‘Teacher’ and ‘Professional mathematician’, into sub-categories, but we found there was not sufficient information in the drawings or associated write-ups to do so. Furthermore, since the thematic sorting occurred after the detailed coding via the checklist, we found that there was sufficient overlap to not warrant any further thematic sorting.

As a final step, the write-ups provided with the drawings were analyzed. In the first three methods of analysis, the write-ups were often consulted for clarification, and some of the information from the write-ups was included in the coding of the drawings. There was, however, other information that did not pertain directly to the drawings’ contents, so this information was coded separately. After reading through all the write-ups, I created a brief checklist with which I

coded the drawings. The checklist was comprised of two sections: 1) Personality traits of the mathematician (e.g., smart, nerdy) and 2) Comments from the participant about mathematics and mathematicians (e.g., participant's feelings about mathematics, comments about gender and mathematics). Similar to the checklist for the drawings, I coded the write-ups and then calculated frequencies and percentages overall, by gender, and by grade level. For the sample drawings, the write-up by D4 was coded only for 'smart'. The rest of the write-up was already coded in the checklist analysis and the character categories, with 'creating a new number' leading to a conclusion of 'inventor'. No codes were selected for the write-up by D28, as it mainly consisted of a description of the mathematics content and information that confirmed the 'teacher' character category.

Parent and Teacher Interviews

The parent and teacher interviews were analyzed similarly, so their analysis is discussed together. The interviews were all transcribed verbatim, including pauses and non-speech sounds (e.g., laughter), from the digital audio recordings. This resulted in 433 single-spaced pages of data from the 11 parent interviews (13 participants), and 412 single-spaced pages of data from the nine teacher interviews (10 participants). Analysis began with the creation of a list of coding categories. Most of the coding categories arose from specific questions or sections of the interview protocol (e.g., student experiences, views of mathematicians), whereas a few coding categories emerged from the data, related to topics beyond those included in the interview protocol (e.g., comments about gender and mathematics). The interviews were then coded using these categories in the qualitative data analysis program *Atlas.ti*. Namely, relevant quotations related to each code were extracted for each participant. Then, these resulting files were further analyzed, with key ideas drawn out and margin notes made on the resulting files.

The coding categories and associated data were grouped under four overarching categories: 1) Participant profile, 2) Messages consumed, 3) Views of mathematics and mathematicians, and 4) Messages produced. Beyond the profiles of the participants, the remaining overarching categories were selected in alignment with my conceptual framework. That is, the data were organized with regard to the parent and teacher participants' roles as producers and consumers of messages about mathematics and mathematicians, and their current views about these topics. Comparisons were drawn across the participants in order to determine trends within each participant pool (i.e., teachers, parents) for each of the overarching categories.

Cross-Data Analysis

While conducting the analysis for each data type separately, I noticed several broad themes that emerged that encompassed multiple data types. I began by compiling a list of these broad themes: 1) Views of mathematics, 2) Views of mathematicians and/or mathematically proficient people, 3) Views of school mathematics, and 4) Views of mathematics and gender. Then, I re-examined the findings in order to ascertain sub-themes that fit under each broad theme. While writing up these findings, I realized that some sub-themes were better suited to other broad themes than the ones to which I had initially assigned them. Some sub-themes were combined due to their similarities. The same four broad themes were maintained, but the initial sub-theme categories were altered during the cross-data analysis and write-up of these cross-data findings.

Concluding Remarks

The methodology of the study, from conception to analysis, was underpinned by both my feminist, social constructivist epistemological stance and my producer/consumer conceptual framework. These influences can be seen in the ways in which I conceptualized my participants

(particularly the child participants), the considerations of gender, the types of data collected, and ways in which the data were analyzed. Since the study's purpose was to understand elementary students' views of mathematics and mathematicians, and the potential influence of parents' views, teachers' views, and popular media representations on students' views, a multi-method framework was warranted in order to allow me to gather a variety of perspectives from multiple data sources on this complex issue. Students' views were ascertained via questionnaires, drawings of mathematicians, and focus group interviews, while parents' and teachers' views were ascertained through interviews. Media representations were ascertained via an analysis of children's media. The results of the analyses are discussed in the following chapters.

CHAPTER 5: FINDINGS

This chapter focuses on a discussion of the findings for each of the data types separately (i.e., student questionnaires, drawings, and focus group interviews; parent interviews; teacher interviews; and children's media). Addressing the findings for each data source in detail in this chapter will allow me to discuss cross-data findings and address the research questions in the next two chapters. Specifically, this chapter begins by addressing the findings related to the first two types of data that involved the students: questionnaires and drawings. Within my discussion of the findings for each student data type, I address the findings overall, as well as any gender and grade-level trends (in order to later address the research questions, which involve investigating the students' views overall, as well as any gender and grade-level differences). The findings from the analysis of the children's media are reported next, as the choices of media arose from the responses to the student questionnaire. The discussion of the findings from the student focus group interviews follow, as they were dependent upon the children's media (i.e., the media prompts for the focus group interviews arose from the analysis of the children's media). The chapter concludes by addressing findings from the two data collection types with adults: interviews with Grade 4 and 8 teachers, and with Grade 4 and 8 parents. These data types were placed together in order to permit comparisons.

Student Questionnaires

There were 156 Grade 4 and 8 students who completed the questionnaire, which was comprised of two major sections: 1) 'Media': Questions about the participants' media habits and 2) 'Mathematics and Mathematicians': Questions about the participants' views of and experiences with mathematics and mathematicians. Below, I discuss my findings from the

analysis of the questionnaire data in the order in which the questions appeared, separated by the various subsections of the questionnaire. The discussion of the questionnaire findings concludes by addressing analyses that involved multiple subsections (i.e., analyses that addressed Research Question #3). Findings are first presented for all participants, followed by a discussion of gender and grade-level trends. The notation Q# refers to the participant number for the questionnaires (e.g., Q3 refers to the third questionnaire participant).

Media Section

The ‘Media’ section of the questionnaire provided information about the participants’ experiences with media – both in terms of frequency of use and specific media examples used – for five media types (i.e., reading materials, television shows, websites, video games, and movies). These data helped me to understand the students’ patterns of media use, which consequently impacted any claims I could draw from my findings about the representations of mathematics and mathematicians in the media. For each media type, participants indicated their viewing frequency, plus indicated their three ‘favourite’ titles (i.e., for television shows, websites, and video games, the ones they viewed/used most frequently, and for reading materials and movies, their favourites). The list of the top choices for each media source is provided in the Methodology chapter, and the analysis of the mathematics-related references in the ‘top choices’ is provided later in this chapter. Below, I first discuss the findings related to the ‘frequency’ questions and then I discuss the spread of the responses to the ‘favourites’ questions.

Frequency of Media Use

For reading materials, television shows, websites, and video games (herein referred to as ‘daily media types’), the same response options were provided for the frequency questions – multiple choice ranged options (e.g., ‘1-3 hours’), with separate questions for weekday and

weekend use. Since movies are typically not viewed on a daily basis, only one ‘frequency’ question was provided, with different ranges (e.g., ‘at least once per week’) for response options.

When all participants were considered, the most common response for the daily media types was to use each of the media types for a few hours or not at all each day. Table 9 shows the modal categories for weekday and weekend media use for each media type.

Table 9
Modal Categories for Weekday and Weekend Media Use for Daily Media Types

	Media type			
	Reading materials	Television shows	Websites	Video games
Weekdays	‘Less than one hour’	‘1-3 hours’	‘Less than one hour’	‘I don’t play video games on school days’
Weekends	‘Less than one hour’	‘1-3 hours’	‘1-3 hours’	‘Less than one hour’

As shown in Table 9, the participants generally did not report being heavy daily media users. The maximum number of hours of media use could sum to five hours on weekdays and eight hours on weekend days, both of which are much lower than the average number of hours (10:45) of daily media use reported in a large-scale U.S. study of 8- to 18-year-olds (Rideout, Foehr, & Roberts, 2010). However, similar to this study and reports by many researchers (e.g., Lemish, 2007; Marshall, 2004), television was the most frequently used media type. In contrast to the relatively infrequent use of the daily media types, the modal response for watching movies was ‘at least once per week’, indicating that many participants are frequent movie watchers.

When considering the data by the gender of the participants, one is struck by the fact that the modal categories for girls’ and boys’ media use were the same for nearly all media types. When gender differences existed, boys were always found to be the heavier media users. For weekend internet use and weekend video game use, two of the three categories for which gender

differences existed, the modal category for boys was ‘1-3 hours’, compared to ‘Less than one hour’ for girls. The most marked gender difference existed for weekday video game use, with modal categories of ‘1-3 hours’ for boys and ‘I don’t play video games on weekdays’ for girls.

When considering the data by the grade level of the participants, the findings again were marked by more similarities than differences: Five of the nine categories had the same modal categories for Grade 4 and Grade 8 students, and the differences tended to be small. When grade-level differences occurred, they tended to favour Grade 8 students as heavier media users. In weekday television viewing and weekday and weekend internet use, the modal category for the Grade 4 students was ‘Less than one hour’, compared to ‘1-3 hours’ for Grade 8 students. The only category in which the modal category for Grade 4 students was greater was weekend video game use, with ‘Less than one hour’ as the modal category, compared to ‘I don’t play video games on the weekend’ as the modal category for Grade 8 students.

To summarize, the questionnaire participants did not report being heavy media users. Television was the most frequently used daily media type, followed by the internet, findings that align with prior research (e.g., Rideout, Foehr, & Roberts, 2010). Video games and reading materials were the least frequently used daily media types, whereas the most frequent option for movie viewing (‘at least once per week’) was the modal category. Arguably, the more frequently a media type and the messages therein are viewed, the more influence it may have on the viewer. In terms of gender and grade-level comparisons, the findings were characterized more by similarities than differences. When differences occurred, they tended to favour boys and Grade 8 students as heavier media users, which again is a finding that aligns with prior research (e.g., Rideout, Foehr, & Roberts, 2010). However, these differences tended to be small – typically a difference of one modal category. These findings suggest that, while media play an important,

time-consuming role in the participants' lives, they tend to use media less than the 'average' young person. Thus, the messages about mathematics and mathematicians in the children's media must be considered in light of the less-than-average exposure of the participants.

Spread of the 'Media Favourites' Responses

As detailed in the Methodology chapter, 10 television shows, three movies (or movie series), seven websites, six video games, and five books (or book series) met the requirements for being a 'top media selection'. I undertook a series of analyses to better understand the trends within the responses to the 'media favourites' questions, which are reported below.

With regard to blank responses for the 'media favourites' questions, clear patterns emerged by media type: A low number of blanks for television shows and movies (26 and 22, respectively), a moderate number for reading materials and websites (50 and 62, respectively), and a high number for video games (101). These patterns are reflective of the participants' media use, with television and movies being the most frequently-used media types. For all media types, Grade 8 students were more likely than Grade 4 students to leave the question blank (although Grade 8 students use media more frequently), while gender differences only existed for reading materials (more blanks from boys) and video games (approximately 80% of the blanks from girls). These figures align with prior research (e.g., Rideout, Foehr, & Roberts, 2010) that shows that boys tend to read less than girls, whereas girls tend to play video games less than boys.

The spread of the 'media favourites' responses was examined by comparing the ratio of the number of titles to the number of participants, and by calculating the percentage of titles only selected by one person. These analyses indicated that there is the greatest variety in participants' responses with regard to movies and reading materials, followed by video games and television shows, and finally websites. However, regardless of the media type, a sizeable majority of the

titles were only selected by one person, which indicates a great variety in the media students are viewing and using. This finding is consistent across all participant categories. The great spread of responses was corroborated by an examination of the percentage of titles selected by 10% or more participants in any gender/grade category (i.e., all participants, boys, girls, Grade 4 students, Grade 8 students, Grade 4 boys, Grade 4 girls, Grade 8 boys, and Grade 8 girls). As expected, the media types with the greatest spread of titles (i.e., movies and reading materials) had the lowest percentages of titles selected by 10% or more participants.

The analyses of the spread of the ‘media favourites’ indicate a lack of similarity in the participants’ responses. In prior generations (i.e., those before the advent of widespread internet and cable television usage), a much smaller range of media options was available, which led to more consistency in the messages to which viewers were exposed. In contrast, the questionnaire participants, who are part of a generation with a plethora of available media options, reported few similarities in the media they view and use. These findings are consistent with the economic theory of the Long Tail, posited by Chris Anderson, which states that:

Our culture and economy are increasingly shifting away from a focus on a relatively small number of hits (mainstream products and markets) at the head of the demand curve, and moving toward a huge number of niches in the tail. (2008, p. 52)

Accordingly, the ‘top media choices’ provided by the questionnaire participants show a great deal of variety, with few titles that indicate a common interest. Therefore, any findings with regard to messages about mathematics and mathematicians shown in the ‘top media choices’ (i.e., the ones that were selected for analysis) must be couched in an understanding that a majority of students may not have been exposed to these media examples – or at least, not on a frequent basis. Certainly, the participants have exposure to media examples beyond the three

titles per media type they provided on the questionnaire; however, given their reported lack of media use, their exposure presumably is primarily to these ‘top three’ responses.

Mathematics and Mathematicians Section

The ‘Mathematics and Mathematicians’ section was the main focus of the questionnaire, and it was accordingly comprised of a greater number, variety, and depth of questions than the ‘Media’ section. The ‘Mathematics and Mathematicians’ section contained four subsections: 1) ‘Mathematics’: Views of mathematics (particularly school mathematics), 2) ‘Mathematicians’: Views of and interactions with mathematicians, 3) ‘Parents’: Views of and interactions with their parents and mathematics, and 4) ‘Gender’: Views of mathematics and gender. While most questions in this section were closed (Likert-scale or multiple-choice), there were several open-ended questions in the ‘Mathematicians’ subsection. Findings from each subsection are discussed below – first, addressing the dataset as a whole, and then reporting gender and grade-level trends. Note that the term ‘gender/grade group’ used when discussing the remainder of the questionnaire refers to four groups: boys, girls, Grade 4 students, and Grade 8 students (as compared to the nine ‘gender/grade categories’ used for the ‘Media’ section).

Questions about Mathematics

The ‘Mathematics’ subsection of the questionnaire consisted of eight 5-point (i.e., ‘strongly agree’ to ‘strongly disagree’ responses) Likert-scale questions that probed the participants’ views of mathematics – particularly within a school setting. The questions, in order, were as follows: 1) I enjoy my math class. 2) I don’t do very well in math. 3) In my math class, I usually work alone. 4) Math makes me feel uncomfortable and nervous. 5) I don’t know when I will ever use the math I learn in school. 6) I have fun working on math problems. 7) Math is a subject you either ‘get’ or don’t ‘get’. 8) Being good at math makes you popular.

Upon testing for internal consistency in the questions in the ‘Mathematics’ subsection, questions #3, #7, and #8 were not included in the aggregate variable ‘Math View’. Once these three variables were removed, a reasonable level of cohesion was obtained ($\alpha = .64$). The three questions that were not included were analyzed separately. The ‘Math View’ aggregate variable involved the summation of the scores (ranked 1 to 5, with 5 indicating the most positive/least stereotypical view) on the remaining five individual questions (i.e., #1, #2, #4, #5, and #6). Therefore, the possible aggregate scores ranged from 5 to 25.

When considering the dataset as a whole, the ‘Math View’ score was relatively high ($M = 18.82$, $SD = 3.67$). Within the questions that comprised this aggregate variable, the most positive views were shown for Question #4 ($M = 4.14$, $SD = 1.06$), indicating that mathematics does not make the participants feel uncomfortable and nervous, while the least positive views were shown for Question #6 ($M = 3.54$, $SD = 1.22$), which relates to having fun working on mathematics problems. However, this mean value still falls within the ‘agree’ response, indicating a non-stereotypical overall view – Thus, the students tend to enjoy doing mathematics problems. In terms of the three questions not included in the aggregate variables, all three mean responses fell into the ‘disagree’ category. This indicates that the students are more likely to work alone in their math classes ($M = 2.41$, $SD = 1.05$), believe that understanding mathematics falls into a dichotomy (‘get’ or not) ($M = 2.53$, $SD = 1.21$), and do not believe that being good at mathematics makes one popular ($M = 2.03$, $SD = 1.11$). When examining each question separately, the most negative views were associated with the link between popularity and mathematics and the most positive views were associated with confidence and mathematics.

There were no statistically significant gender differences at the $p < .05$ level on the aggregate variable ‘Math View’: $F(1,152) = 0.77$, $p = .38$. Statistically significant gender

differences only occurred on one of the eight individual questions. Namely, boys ($M = 2.26$, $SD = 1.13$) were more likely than girls ($M = 2.76$, $SD = 1.23$) to hold a dichotomous view of mathematics as a subject that you ‘get’ or don’t ‘get’ [$F(1, 150) = 6.70$, $p = .01$].

In contrast, there were statistically significant grade-level differences at the $p < .05$ level on the aggregate variable ‘Math View’ [$F(1, 152) = 17.60$, $p < .001$]. This indicates that Grade 4 students ($M = 19.10$, $SD = 4.04$) had an overall more positive view toward mathematics than did Grade 8 students ($M = 18.58$, $SD = 3.34$). When the eight individual questions were considered separately, statistically significant grade-level differences occurred on three questions, two of which were part of the aggregate variable: #1, #3, and #6. Specifically, Grade 4 students ($M = 3.97$, $SD = 0.95$) were more likely than Grade 8 students ($M = 3.45$, $SD = 1.11$) to report enjoying their mathematics classes [$F(1, 152) = 9.88$, $p = .002$]. Additionally, Grade 4 students ($M = 4.21$, $SD = 0.90$) were more likely than Grade 8 students ($M = 2.88$, $SD = 1.13$) to report having fun working on mathematics problems [$F(1, 152) = 64.86$, $p < .001$]. Conversely, Grade 8 students ($M = 2.83$, $SD = 1.06$) were more likely than Grade 4 students ($M = 1.97$, $SD = 0.85$) to report working alone in their mathematics classes [$F(1, 152) = 30.71$, $p < .001$].

Overall, the participants reported holding fairly positive and non-stereotyped views toward mathematics, particularly in a school setting. The only three questions for which there was an overall negative, stereotyped view were those regarding working alone in mathematics class, a dichotomous view of understanding mathematics, and the link between mathematics and popularity. There were no gender differences found on the aggregate ‘Math View’ variable and only one question for which there was a statistically significant gender difference. In contrast, there was an overall grade-level difference on the aggregate variable and three individual questions, with Grade 4 students reporting more positive views than Grade 8 students.

Questions about Mathematicians

The ‘Mathematicians’ subsection was comprised of several open-ended questions. These questions investigated the participants’ exposure to and impressions of ‘real-life’ and media mathematicians, as well as more general views about mathematicians, their work, and their tools. This subsection began with two multiple choice questions that inquired whether the participant had met a mathematician in ‘real life’ and/or seen one in the media (with ‘yes’, ‘no’, and ‘not sure’ response options). If the participant responded yes to either question, he/she was then asked to indicate in the next two open-ended questions where he/she met and/or saw the mathematician, and what the mathematician was like. Two open-ended questions followed that were posed to all participants, inquiring why someone would need to hire a mathematician and what tools mathematicians use. The ‘Mathematicians’ subsection concluded with five Likert-scale questions about the participant’s views about mathematicians.

Data regarding the participants’ experiences with real life and media mathematicians are shown in Table 10.

Table 10
Percentages of Participants who reported Having Exposure to Mathematicians, by Group

	All participants	Boys	Girls	Grade 4 students	Grade 8 students
Met a mathematician in real life	22.7%	27.5%	18.5%	22.4%	23.0%
Saw a mathematician in the media	34.5%	42.6%	27.5%	30.1%	38.7%

Within each group, the proportion of participants who reported seeing a mathematician in the media was always substantially higher than the proportion of participants who reported meeting a mathematician. Between-group differences were more pronounced for comparisons by gender

than by grade level. While the higher proportion of boys who reported seeing a mathematician in the media could be explained by their tendency of being frequent media users (i.e., the more media one views, the greater the likelihood of seeing a mathematician), no parallel explanation exists for the gender difference in meeting a mathematician. Although similar proportions of Grade 4 and Grade 8 students reported meeting a mathematician, a larger proportion of Grade 8 students reported seeing a mathematician in the media, which might be explained by their more frequent media use. Notably, approximately one-third of the participants in each group reported that they were ‘not sure’ if they had met a mathematician or seen one in the media, which reflects a lack of understanding of who mathematicians are and what they do. In fact, two participants responded ‘not sure’ to this question, but then provided responses to the ‘where’ question: Q99 referenced her teacher, while Q150 referenced her father, an electrical engineer who does computer coding. These two instances appear indicative of these participants’ lack of understanding of who a mathematician is.

With regard to meeting a mathematician in real life, the most common responses were that the mathematician was a teacher ($n = 13$; 38.2%) or a family member ($n = 8$; 23.5%). Other responses included museum employees and a mathematician who visited the participant’s school. When describing these mathematicians, the participants were generally very positive: The three most common descriptors were ‘nice’ ($n = 11$; 32.4%), ‘normal’ ($n = 9$; 26.5%), and ‘intelligent’ ($n = 7$; 20.6%). Notably, two participants who described the mathematician they had met as ‘normal’ commented on the way mathematicians’ brains work, which may be suggestive of claims of a biological basis for mathematics talent. For instance, Q123 (Grade 8 boy) noted “You can’t tell them [mathematicians] from anyone else unless you work with them on a problem because their brian [*sic*] works in many diffrent [*sic*] ways”. Other descriptions of

mathematicians the participants had met included ‘good at math’, ‘helpful’, ‘cool’, and ‘loves math’. Only one participant commented on a physical characteristic (‘tall’). No gender or grade-level trends were evident for the data regarding ‘real life’ mathematicians.

With regard to seeing a mathematician in the media, nine participants reported seeing a mathematician on television (generally), while an additional eight students described a specific television show/channel (e.g., Discovery Channel, a documentary about Einstein, *The Big Bang Theory*). By far, the most common descriptor provided about the media mathematicians was ‘intelligent’ ($n = 11$; 21.6%), followed by ‘good at math’ ($n = 5$; 9.8%). Other common responses were two physical characteristics – lab coat ($n = 5$; 9.8%) and glasses ($n = 2$; 3.9%) – and the descriptor ‘weird’ ($n = 3$; 5.9%). Six additional students reported on other physical characteristics (e.g., frizzy hair, beard). No gender or grade-level trends were evident in the data about media mathematicians. Other than the common view of ‘real life’ and media mathematicians as being intelligent, few similarities existed between the participants’ perceptions of these two groups of mathematicians. The participants who had met a mathematician were most likely to describe them in terms of (positive) personality traits, whereas the participants who had seen mathematicians in the media were more likely to discuss (stereotypical) physical traits. Notably, nearly every participant who reported meeting a mathematician provided a description, whereas nearly half of the participants who reported seeing a mathematician in the media left the ‘description’ question blank ($n = 18$; 35.3%) or provided a ‘not sure’ ($n = 10$; 19.6%) response. The large proportion of non-responses may suggest that media mathematicians do not leave the same impact as real life mathematicians.

The responses to the question about reasons for hiring a mathematician suggested a lack of understanding of what mathematicians do, as nearly one-third of the participants (45 of 156;

28.9%) provided a ‘non-response’, such as leaving the question blank or writing ‘I don’t know’. These ‘non-responses’ were fairly evenly distributed between boys and girls, and between Grade 4 and Grade 8 students. Of the remaining 111 responses (representing 71.1% of the questionnaire participants), the most common responses were ‘to help with math’ (generally) ($n = 36$; 32.4%), ‘to teach’ ($n = 29$; 26.1%), ‘to help with personal finance’ (e.g., taxes) ($n = 16$; 14.4%), and ‘to tutor’ ($n = 15$; 13.5%). These responses clearly indicate a common perception of mathematicians being educators. The participants also suggested several fields of study in which mathematicians could be helpful, with the three most common fields being space programs ($n = 10$; 9.0%), computing/programming ($n = 8$; 7.2%), and engineering ($n = 8$; 7.2%). Some students provided more than one response to this question, so the percentages sum to more than 100 percent. For every gender/grade group, the two most common responses were identical (‘to help with math’ and ‘to teach’), indicating consistency in the participants’ views.

In contrast to the question about hiring a mathematician, the participants appeared to have a much better idea about the kinds of tools mathematicians use. Only 23 participants (14.7%) provided a ‘non-response’ (e.g., blank, ‘I don’t know’) to this question; no gender or grade-level differences were evident in the patterns of the ‘non-responses’. Of the remaining 133 responses (representing 85.3% of the questionnaire participants), the three most common responses were calculators ($n = 75$; 56.4%), pencils ($n = 65$; 48.9%), and the brain ($n = 42$; 31.6%). Other commonly reported responses were rulers ($n = 39$; 29.3%), protractors ($n = 33$; 24.8%), paper ($n = 32$; 24.1%), and computers ($n = 25$; 16.0%). As with the prior question, multiple responses were permitted for the ‘tools’ question; hence, the percentages sum to more than 100 percent. Again, the participants’ responses were characterized by similarities across the gender/grade groups: The most common two responses in each group were pencils and calculators, with each

of these tools listed by at least one-third of the responding participants. These tools may have been listed since they are commonly used in the participants' mathematics classes.

Encouragingly, 'the brain' was the third or fourth most commonly listed tool overall and in each gender/grade group, indicating that the participants recognize the importance of thinking.

The 'Mathematicians' subsection concluded with five 5-point Likert-scale questions. In order, the questions were (with their abbreviations listed in parentheses): 1) Mathematicians usually work alone ('Alone'). 2) I would like to become a mathematician when I grow up ('Become'). 3) I would like to marry a mathematician when I grow up ('Marry'). 4) Mathematicians seem like nerdy people ('Nerdy'). 5) A mathematician's work looks like fun to me ('Fun Work'). As with the 'Mathematics' subsection, an aggregate variable ('Mathematician View') for this subsection was created by summing the scores of each individual question. Since all of the questions were retained ($\alpha = .63$) and each question was scored from 1 to 5 (with 5 representing the least stereotypical/most positive views), the maximum aggregate score was 25.

Overall, the participants tended to have a far less positive view of mathematicians than they do (school) mathematics. For the 'Mathematician View' aggregate variable, the mean value was only 13.45 ($SD = 3.42$). All but one of the questions had mean values that aligned with the 'disagree' response option. Specifically, the most positive views (which, in this case, indicated the least stereotypical views) were seen for Question #4, 'Nerdy', with the participants generally agreeing that mathematicians do not seem nerdy ($M = 3.42$, $SD = 1.21$). In contrast, the most negative views were seen for Question #2: Participants reported that they are not interested in becoming mathematicians ($M = 2.17$, $SD = 1.08$).

No statistically significant gender differences at the $p < .05$ level were found on the 'Mathematicians View' aggregate variable [$F(1, 144) = 0.83$, $p = .36$]. However, a statistically

significant gender difference occurred on Question #3, 'Marry' [$F(1, 146) = 5.70, p = .02$]. Specifically, the girls' mean score was 2.60 ($SD = 1.00$), while the boys' mean score was 2.21 ($SD = 1.00$). Notably, both of these mean scores fall into the 'disagree' category (which indicates that the participants generally do not want to marry mathematicians), although boys' views are more negative, on average.

A statistically significant grade-level difference occurred on the 'Mathematician View' aggregate variable [$F(1, 144) = 26.98, p < .001$]. Namely, Grade 4 students ($M = 14.92, SD = 3.24$) were shown to have more positive views overall than Grade 8 students ($M = 12.11, SD = 3.07$). Statistically significant grade-level differences were also seen on Questions #2 ('Become'), #4 ('Nerdy'), and #5 ('Fun Work'). Specifically, Grade 4 students ($M = 2.56, SD = 1.07$) were more likely than Grade 8 students ($M = 1.78, SD = 0.94$) to want to become mathematicians. Grade 4 students ($M = 3.92, SD = 1.13$) were also more likely than Grade 8 students ($M = 2.92, SD = 1.08$) to see mathematicians as not being nerdy. Additionally, Grade 4 students ($M = 3.32, SD = 1.15$) were more likely than Grade 8 students ($M = 2.31, SD = 1.06$) to view a mathematician's work as being fun.

Generally speaking, the Likert-scale questions indicated that the participants do not have an overly positive view of mathematicians. Although there were no statistically significant gender differences overall in the participants' views, grade-level differences were found, with Grade 4 students' views being more positive than those of Grade 8 students.

Questions about Parents

The 'Parent' subsection was comprised of five Likert-scale questions about the participant's mother and the participant's father (five questions each; identically worded for each parent). In order, these questions (with abbreviations in parentheses) were: 1) My [parent] helps

me with my math homework ('Homework'). 2) My [parent] thinks math is an important subject to study ('Important'). 3) My [parent] hates to do math ('Hates'). 4) My [parent] is good at math ('Good'). 5) My [parent] would be proud if I became a mathematician when I grow up ('Proud'). All five questions were retained for each parent, resulting in two aggregate variables: 'Mom View' ($\alpha = .62$) and 'Dad View' ($\alpha = .73$). Again, the questions' individual scores (1 to 5, with 5 indicating the most positive view) were added to obtain the aggregate variables, resulting in a maximum value of 25. Recall that 'Dad View' refers to the aggregate variable that was transformed (to meet conditions of normality), whereas 'Mom View' was not transformed (as conditions of normality were already met). However, in order to have comparable data, the original 'Dad View' variable is used when making comparisons to the 'Mom View' variable.

When examining the dataset as a whole, the participants tend to have quite positive views of their parents and mathematics. With regard to the aggregate variables, fathers ($M = 19.53$, $SD = 3.61$) were viewed more positively than mothers ($M = 18.84$, $SD = 3.31$). However, the patterns of the highest to lowest scoring individual questions were identical for mothers and fathers, with the most positive views being shown for Question #2 (about the importance of studying mathematics) and the most negative views being shown for Question #1 (about receiving help with mathematics homework); however, all individual questions for both parents had mean values that fell into the two categories that aligned with the most positive views.

As with the previous aggregate variables, no statistically significant gender differences at the $p < .05$ level were found on the 'Mom View' [$F(1, 145) = 0.61$, $p = .44$] or 'Dad View' [$F(1, 141) = 0.70$, $p = .40$] aggregate variables. Additionally, no statistically significant gender differences were found on any of the individual questions about either parent.

In contrast, statistically significant grade-level differences at the $p < .05$ level were found on both the ‘Mom View’ [$F(1, 145) = 42.43, p < .001$] and ‘Dad View’ [$F(1, 141) = 5.83, p = .02$] aggregate variables, which indicates that Grade 4 students having more positive views than Grade 8 students with regard to both their mothers and fathers, with respect to mathematics. Specifically, the mean ‘Mom View’ score for Grade 4 students was 20.42 ($SD = 2.86$), compared to a mean score of 17.28 for Grade 8 students ($SD = 2.99$), while the ‘Dad View’ score for the Grade 4 students was 20.25 ($SD = 3.29$), compared to a mean score of 18.82 ($SD = 3.79$) for the Grade 8 students. Statistically significant grade-level differences were shown for every individual question about mothers and all but Question #1 (homework) about fathers. For every question, Grade 4 students viewed their parents more positively than did the Grade 8 students.

Overall, the participants viewed their parents as having positive relationships with mathematics, although fathers’ relationships with mathematics were viewed more favourably than were mothers’ relationships with mathematics. As with all the other aggregate variables examined, there were no statistically significant gender differences on either the ‘Mom View’ or ‘Dad View’ aggregate variable. Again, like the other aggregate variables, there were statistically significant grade-level differences on both the ‘Mom View’ and ‘Dad View’ aggregate variables and all but one of the individual questions. Once more, Grade 4 students were shown to have more positive views than Grade 8 students.

Questions about Gender

The seven questions about the participants’ views of mathematics and gender provided ‘boys’, ‘no difference’, and ‘girls’ as multiple-choice response options. Most questions were worded in the form ‘Who is more likely to...?’. The questions are shown in Table 11, which

reports the spread of responses overall (i.e., for all participants), as well as the number of responses and abbreviations for each question.

Table 11
Spread of Responses for ‘Gender’ Questions

Question	Abbreviation	Number of Respondents	Gender Category Selected		
			Boys	ND	Girls
1) Who IMLT* say math is their favourite subject?	Favourite Subject	$n = 147$	12.2%	63.3%	24.5%
2) Who IMLT distract other students from their math work?	Distract	$n = 146$	67.1%	19.9%	13.0%
3) Who IMLT be good at math?	Good at Math	$n = 147$	8.8%	66.7%	24.5%
4) Who do math teachers spend more time with?	Teacher Time	$n = 145$	28.3%	60.7%	11.0%
5) Who IMLT tease girls if they are good at math?	Tease Girls	$n = 146$	53.4%	29.5%	17.1%
6) Who IMLT tease boys if they are good at math?	Tease Boys	$n = 145$	36.6%	33.1%	30.3%
7) Whose parents would be more upset if they do not do well in math?	Parents Upset	$n = 146$	15.1%	69.9%	15.1%

Note. ‘IMLT’ stands for ‘is more likely to’. ‘ND’ stands for ‘No Difference’

As shown in Table 11, four of the seven questions (#1, #3, #4, and #7) have modal categories of ‘no difference’, indicating that the participants generally see no gender differences in terms of mathematics as a favourite subject, being good at mathematics, spending time with mathematics teachers, and parental concern over poor mathematics grades. In contrast, the participants tended to think that boys were more likely to distract other students from mathematics work and to tease both girls and boys who are good at mathematics. Notably, the modal categories contained more

than 60% of the responses for all but the two questions about teasing strong mathematics students. The responses were almost evenly distributed across the three categories for teasing boys who are good at mathematics, while just over half of the participants reported that boys would tease girls who are good at mathematics. This is pattern of responses may be more indicative of gendered interactions generally, rather than with regard to mathematics specifically.

Chi-square tests were performed in order to determine if there were statistically significant differences in the distribution of responses by a) gender and b) grade level. Table 12 provides the chi-square and significance values resulting from each comparison.

Table 12
Results of Chi-Square Tests for Each Question (Gender and Grade-Level Comparisons)

Question	Gender Comparison		Grade-Level Comparison	
	Chi-square	Significance	Chi-square	Significance
1) Favourite Subject	$\chi^2 = 1.58$	$p = .45$	$\chi^2 = 7.88$	$p = .02^*$
2) Distract Others	$\chi^2 = 1.60$	$p = .45$	$\chi^2 = 1.28$	$p = .53$
3) Good at Math	$\chi^2 = 10.28$	$p = .006^*$	$\chi^2 = 6.70$	$p = .04^*$
4) Teacher Time	$\chi^2 = 7.75$	$p = .02^*$	$\chi^2 = 1.04$	$p = .60$
5) Tease Girls	$\chi^2 = 0.30$	$p = .86$	$\chi^2 = 3.91$	$p = .14$
6) Tease Boys	$\chi^2 = 0.41$	$p = .82$	$\chi^2 = 6.46$	$p = .04^*$
7) Parents Upset	$\chi^2 = 0.95$	$p = .62$	$\chi^2 = 1.98$	$p = .37$

* $p < .05$

As indicated in Table 12, statistically significant gender differences were found for #3 (Good at Math) and #4 (Teacher Time), while statistically significant grade-level differences were found

for #1 (Favourite Subject), #3 (Good at Math), and #6 (Tease Boys). Table 13 presents the trends for questions with statistically significant differences in the gendered distribution of responses.

Table 13
Spread of Responses for Questions with Statistically Significant Differences by Gender in Response Distribution

Question	Participant group	Gender category selected		
		Boys	No difference	Girls
3) Good at Math	Boys	16.7%	65.2%	18.2%
	Girls	2.5%	67.9%	29.6%
4) Teacher Time	Boys	21.2%	60.6%	18.2%
	Girls	34.2%	60.8%	5.1%

For both questions, nearly equal proportions of boys and girls selected ‘no difference’. With regard to #3 (Good at math), a far higher percentage of boys than girls reported that boys are better at mathematics, while the reverse was true with regard to perceptions of girls being better at mathematics. Notably, boys who held a gendered stance (i.e., selecting either ‘boys’ or ‘girls’) were nearly evenly divided between ‘boys’ and ‘girls’, where nearly all the girls who held a gendered stance selected girls as being better than boys at mathematics. The girls’ patterns of responses, with nearly one-third of girls selecting ‘girls’, are indicative of an in-group bias. Nearly identical patterns occurred for #4 (teacher time); although the gendered patterns of responses appears reversed, recall that this is essentially a negatively worded question (i.e., taking up the teacher’s time is seen negatively). Again, the boys’ gendered responses were split between ‘boys’ and ‘girls’, while the girls’ gendered responses strongly leaned toward ‘boys’, indicating that girls think boys take up more of the teacher’s time. This pattern of responses is again indicative of an in-group bias for girls, but not for boys.

Similarly, Table 14 provides the spread of responses for the questions for which there was a statically significant difference in the distribution of grade-level responses.

Table 14
Spread of Responses for Questions with Statistically Significant Differences by Grade Level in Response Distribution

Question	Participant group	Gender category selected		
		Boys	No difference	Girls
1) Favourite subject	Grade 4	8.1%	74.3%	17.6%
	Grade 8	16.4%	52.1%	31.5%
3) Good at math	Grade 4	14.9%	62.2%	23.0%
	Grade 8	2.7%	71.2%	26.0%
6) Tease boys	Grade 4	27.8%	33.3%	38.9%
	Grade 8	45.2%	32.9%	21.9%

As demonstrated in Table 14, the spread of responses was quite varied for #3 (Favourite subject), with a far higher proportion of Grade 4 students than Grade 8 students selecting ‘no difference’. However, the pattern of the gendered responses was similar at both grade levels: Approximately twice as many students selected ‘girls’ as ‘boys’, indicating that girls are more likely than boys to be perceived as selecting mathematics as their favourite subject. In contrast to #3 (Favourite subject), #4 (Good at math) had a higher proportion of Grade 8 than Grade 4 students selecting ‘no difference’. At both grade levels, ‘girls’ was selected more than ‘boys’, indicating a more positive view of girls’ mathematics abilities. Notably, nearly all of the gendered responses from Grade 8 students were ‘girls’, while the gendered responses split in approximately a 2:3 ratio of boys to girls for the Grade 4 students. Finally, #6 (Tease boys) was the only question for which nearly equal proportions of Grade 4 and 8 students selected ‘no difference’. The pattern of

responses was reversed between Grade 4 and 8 students in terms of gendered responses, with Grade 4 students being more likely to select ‘girls’, while Grade 8 students were more likely to select ‘boys’. As before, it is possible that this pattern of gendered teasing would apply in a general sense at these two grade levels, not specifically for mathematics.

Overall, the responses to the ‘Gender and Mathematics’ questions were encouraging as the modal responses for most questions (and for all questions not focused on social interactions) was ‘no difference’. The questions for which the modal category was ‘boys’ seemed to be more related to general gendered interactions than those specifically related to mathematics. For a few questions, gender and grade-level differences emerged in the distribution of responses. Girls tended to demonstrate an in-group bias, whereas the same bias was not shown for boys. Although there were differences in the grade-level patterns of responses, both Grade 4 and 8 students tended to view girls more positively with regard to liking and being good at mathematics. Notably, the proportion of students who selected non-gendered responses (i.e., ‘no difference’) differed substantially between Grade 4 and 8 students for these two questions.

Analyses Involving Multiple Subsections: Mathematician Interactions and Mathematician Views

The impact of the participants’ interactions with mathematicians, either in ‘real life’ or in the media, was investigated by comparing the responses of the ‘met’/‘saw’ sub-groups of participants to the general questions about their views of mathematicians (via ANOVAs). When considering the dataset as a whole, there were no statistically significant differences at the $p < .05$ level in the ‘Mathematician View’ aggregate variable scores between participants who reported that they had met a mathematician in real life (‘met’) and those who reported that they had not met a mathematician in real life (‘not’). When examining the five questions that comprised the ‘Mathematician View’ aggregate variable separately, the only question for which

there was a statistically significant difference was becoming a mathematician [$F(1,144) = 7.06, p = .009$]. Namely, participants who had met a mathematician ($M = 2.63, SD = 1.40$) were more likely to want to become a mathematician than those participants who had not met a mathematician ($M = 2.06, SD = 0.94$). With regard to the impact of seeing a mathematician in the media, there were no statistically significant differences between the scores of participants who reported seeing a mathematician in the media and those who reported that they had not seen a mathematician in the media on either the ‘Mathematician View’ aggregate variable or the individual questions about mathematicians. Thus, it appears that seeing a mathematician in the media does not have the same impact as meeting a mathematician, particularly with regard to students’ interest in becoming mathematicians.

Analyses Involving Multiple Subsections: Media Use and Mathematician Views

The relationship between students’ media use generally (as opposed to media use that involved viewing mathematicians) and their views of mathematicians (specifically, the aggregate variable ‘Mathematician View’ and the ‘Mathematician Nerdy’ individual question) was explored through correlational analyses. The strength of the relationships between each pair of variables that is reported aligns with Cohen’s (1988) scale: small ($r = .10$ to $.29$), medium ($r = .30$ to $.49$), or large ($r = .50$ to 1.0).

When considering each media type separately, statistically significant correlations were found for 5 of the 11 pairs examined (i.e., two pairs for each of ‘Television Use’, ‘Internet Use’, ‘Video Game Use’, ‘Reading Material Use’, and ‘Media Use’ and one pair for ‘Movie Use’). The details of these statistically significant correlational relationships are shown in Table 15.

Table 15
Correlational Relationships involving Media Use and Views of Mathematicians

Pairing	<i>r</i> value	Strength	Direction
‘Television Use’/‘Mathematician View’	-.16*	small	negative
‘Television Use’/‘Mathematician Nerdy’	-.19*	small	negative
‘Internet Use’/‘Mathematician View’	-.35**	medium	negative
‘Internet Use’/‘Mathematician Nerdy’	-.31**	medium	negative
‘Video Game Use’/‘Mathematician Nerdy’	-.20*	small	negative
‘Media Use’/ ‘Mathematician View’	-.20*	small	negative
‘Media Use’/ ‘Mathematician Nerdy’	-.23*	small	negative

* = significant at the $p = .05$ level

** = significant at the $p = .01$ level

Notably, all pairings for which a statistically significant correlational relationship was found have a negative relationship, indicating that increased media use is correlated with more negative/stereotyped views of mathematicians. Indeed, all of the pairings examined, other than those involving reading materials, had a negative correlation. Although the strength of the relationships between the variables that had a statistically significant correlation was small or medium, these findings still indicate that media use is related to students’ views of mathematicians.

Interestingly, the strongest relationship was shown for internet use, as media type in which no stereotypes were found during the media analysis. However, recall, as discussed in the Methodology chapter, that three of the top choices were *Google*, *Facebook*, and *YouTube*, websites that could not be analyzed for mathematics-related references due to their vast, unspecific content. Students are quite possibly being exposed to stereotypical ideas about mathematics and mathematicians on these websites. Another explanation may relate to heavy

media use in general, as opposed to specific exposure to ideas about mathematics and mathematicians: Heavy media use (with the exception of print media, for which the relationship is reversed) by children is linked to lower levels of parental education (Roberts & Foehr, 2004). Therefore, such views could be indicative of more complicated relationship involving heavy media users' home environments and parental support.

Analyses Involving Multiple Subsections: Parent Views and Mathematics/Mathematician Views

The relationship between the students' perceptions of their parents' views ('Mom View' and 'Dad View' aggregate variables and the questions from which the aggregate variables are comprised) and the students' views ('Math View' and 'Mathematician View' and the questions from which these aggregate variables are comprised) was explored through correlational analyses. As with the above correlational analyses, the reported strength of the relationships between each pair of variables discussed below aligns with Cohen's (1988) scale: small ($r = .10$ to $.29$), medium ($r = .30$ to $.49$), or large ($r = .50$ to 1.0).

When considering the dataset as a whole, no statistically significant correlation was shown between 'Mom View' and 'Math View'. In contrast, the relationship between 'Dad View' and 'Math View' was medium strength and statistically significant ($r = .31, p < .01$). This indicates that a higher score on 'Math View' is associated with a higher score on 'Dad View'.

The other topic investigated via correlational analysis was the relationship between students' interest in becoming mathematicians ('become') and their perceptions of how proud their parents would be if they became mathematicians ('Mom proud' and 'Dad proud'); Note that 'become' is a question on the 'Mathematician View' scale whereas the 'Mom proud' and 'Dad proud' questions are part of the 'Mom View' and 'Dad View' scales, respectively. A medium-strength, positive correlation was found between 'become' and 'Mom proud' ($r = .34, p < .01$),

as well as between ‘become’ and ‘Dad proud’ ($r = .40, p < .01$). These findings indicate that students’ interest in becoming mathematicians is correlated with the perceptions of their parents’ pride in this career (i.e., a higher ‘become’ score is linked to a higher ‘Mom proud’ and a higher ‘Dad proud’ score).

Analyses Involving Multiple Subsections: Parent Views/Media Use and Mathematics/Mathematician Views

Multiple regression analyses were conducted to understand the relationship between the student questionnaire participants’ views of mathematics and mathematicians and the combination of several predictor variables. The multiple regression model for ‘Math View’ used the ‘Mom View’, ‘Dad View’, and ‘Media Use’ aggregate variables as predictors. The analysis resulted in an R^2 value of .112 ($p = .001$), which indicates that that 11.2% of the variance in the ‘Math View’ variable can be explained by the three predictor variables. This relationship was found to be statistically significant [$F(3, 137) = 5.748, p = .001$]. An examination of the three predictor variables separately showed that only the ‘Dad View’ variable was a statistically significant predictor for the ‘Math View’ variable ($\beta = .239, p < .001$). The multiple regression model for ‘Mathematician View’ used the same three aggregate variables as predictors, which resulted in an R^2 value of .156 ($p < .001$). This indicates that 15.6% of the variance in the ‘Mathematician View’ variable can be explained by the three predictor variables. This relationship was found to be statistically significant [$F(3, 137) = 8.448, p < .001$]. When considering the three predictor variables separately, both the ‘Mom View’ ($\beta = .273, p = .001$) and ‘Dad View’ ($\beta = .186, p = .021$) variables were found to be significant predictors for the ‘Math View’ variable. Overall, both regression models show that parental views and media use are predictors of students’ views of mathematics and mathematicians.

While the R^2 values for both multiple regression analyses may be relatively low, recall that parents and media are only two of the many sources of information about mathematics and mathematicians to which young people are exposed. For example, particularly with regard to ‘Math View’, teachers arguably play a substantial role in the production of messages, as is evidenced by other data in this study. Additionally, there are many other actors that were not examined in this study, such as peers, that produce messages about mathematics and mathematicians to the young participants.

Additional Comments

Approximately one-third of the participants (56 of 156; 35.9%) provided comments at the conclusion of the questionnaire – either about mathematics and/or mathematicians, or about the questionnaire itself. Specifically, eight participants asked a question about mathematicians (Most commonly, ‘What is a mathematician?’ or ‘What does a mathematician do?’), indicating a lack of understanding of the occupation. There were also several positive comments: Eight regarding mathematicians and 10 regarding mathematics. For instance, Q109 (Grade 4 girl) wrote “They [mathematicians] look like fun and cool people wheter [sic] they are boys or girls”, while Q151 (Grade 8 girl) wrote, “Mth [sic] is fun!!” Most responses about the questionnaire were positive comments, with only a few questions: 13 positive comments compared to four questions. Eleven of the responses were coded as ‘other’; these responses included negative comments about mathematics ($n = 2$), comments about liking other subject areas ($n = 2$), and comments about being happy to get out of class to complete the questionnaire ($n = 2$).

Summary of Findings: Student Questionnaires

Outside of the ‘Media’ section of the questionnaire, which was predominately used to guide the media analysis, the questionnaire focused on the student participants’ views of and

experiences with mathematics and mathematicians. The findings indicated that, overall, the participants have a positive relationship with school mathematics and their views of themselves as mathematics learners. The participants also reported that their parents have a positive relationship with mathematics, although fathers were viewed more positively (i.e., viewed as being better at mathematics and liking it more) than mothers. For both aggregate variables about their parents and mathematics, no gender differences were found in the participants' views, although Grade 4 students consistently reported more positive views than Grade 8 students. Additionally, the participants tended to view mathematics as a gender-neutral domain, which is an encouraging finding. However, some indications of in-group bias were found for girls with regard to a few questions about gender and mathematics.

As expected, the participants reported having less exposure to 'real-life' mathematicians than media mathematicians; for both types of mathematicians, less than one-third of the participants reported any exposure. Notably, exposure to real-life mathematicians tended to lead to more positive views that focused on personality traits, whereas exposure to media mathematicians tended to lead to more stereotyped views, focused on appearance; intelligence was the only common trait discussed by participants with exposure to either type of mathematicians. Overall, a lack of understanding of what a mathematician does was reported by a large proportion of the participants. Most commonly, mathematicians were linked to teaching if a role was discussed. Generally, the participants' views were more negative about mathematicians, particularly in terms of their own interest in the career, than they were about mathematics. While boys reported more exposure to both real-life and media mathematicians, no gender differences were found in boys' and girls' views. In contrast, Grade 8 students reported more exposure than Grade 4 students to media mathematicians (but equal exposure to real-life

mathematicians), and Grade 8 students tended to have more negative views. Thus, given the lack of real-life exposure to mathematicians, it appears that the media representations are playing a significant role in affecting students' views – often in negative, stereotyped ways.

Student Drawings

The student participants' drawings of mathematicians were analyzed via holistic descriptions, checklist-based analysis, and thematic sorting, while the write-ups were coded. I discuss my findings, drawn from the various analyses, with respect to the dataset as a whole ($n = 94$), as well as gender- and grade-related trends. In this section, the notation D# refers to the participant number for the drawings (e.g., D3 refers to the third participant to submit a drawing).

Findings: All Participants

The drawings by the student participants demonstrate both some encouraging themes and some enduring stereotypes. To begin, the drawings of mathematicians were fairly gender-balanced: 43 drawings (45.7%) depicted a woman, 46 drawings (48.9%) depicted a man, and five drawings (5.3%) depicted an individual whose gender could not be discerned. This gender balance is encouraging, as it suggests that the participants do not adhere to the stereotype of mathematicians being men. However, analysis by the gender of the participant, as discussed later, highlights gendered trends.

A second encouraging finding relates to the appearance of the mathematicians drawn: Nearly all were very mainstream-looking, with only four exceptions (two 'nerds', one wizard, and one colourful character). A few participants commented in their write-ups that mathematicians look just like everyone else: "Most people seen [sic] to think they look nerdy or are a geek, but they are normal people" (D72, Grade 8 girl). The mathematicians tended to be drawn with slim to average builds and mainstream hairstyles, wearing mainstream clothing.

Approximately two-thirds of the mathematicians who were drawn with discernible clothing were wearing casual clothing, such as jeans and a t-shirt, compared to one-third of the mathematicians who were drawn wearing professional clothing, such as a suit or a skirt and blouse.

Nevertheless, a few stereotypical aspects were present in the mathematicians' appearances. Nine of the mathematicians (9.6%) had Einstein-esque hair and 17 (18.1%) were wearing lab coats. The common presence of lab coats in the drawings may suggest a perceived link between mathematicians and scientists. Of the 79 mathematicians who were drawn wearing pants, eight (10.1%) were drawn with pants that were too short. Notably, more than a third of the mathematicians ($n = 32$; 34.0%) were drawn wearing glasses. This may relate to the notion of 'looking smart', as glasses are commonly used as an indicator of intelligence in popular media representations (Conaway, 2007). Studies have found that this trope is highly embedded in our cultural consciousness from a young age: In a study that involved children being asked to draw a 'very clever' person, glasses were one of the most common indicators drawn, as well as indicators of being good at mathematics (Sandow, 1997). In addition to the inclusion of glasses as an indicator of intelligence, some write-ups included comments regarding intelligence: Seven participants (7.4%) indicated that their mathematicians were generally intelligent, compared to three participants (3.2%) who discussed being good at mathematics specifically and three participants (3.2%) who discussed being highly educated.

More than half ($n = 51$; 54.3%) of the mathematicians were drawn with smiles on their faces. Contrary to the conclusions drawn by some prior studies (e.g., Rock & Shaw, 2000), I do not feel that the presence of a smile on the mathematician's face in a drawing indicates that the participant enjoys doing mathematics. Rather, smiles are more likely suggestive of the mathematician's happiness while doing mathematics, which seven participants (7.4%) indicated

in their write-ups, or a smile could simply be the default expression children draw on the face of any person (La Voy et al., 2001; Note that these findings are culture-specific, related to the degree to which emotion is publically displayed in a culture).

The most common position for the mathematician was standing at a chalkboard or whiteboard (herein referred to as a ‘chalkboard’ for the sake of brevity), either teaching ($n = 25$; 26.6%) or doing math ($n = 18$; 19.1%). In contrast, far fewer mathematicians were shown sitting at a desk, either doing mathematics on paper ($n = 14$; 14.9%) or at a computer ($n = 4$; 4.3%). Notably, mathematicians were much more likely to be shown working at a chalkboard or on paper than using technology. This pattern may be reflective of the manner in which the participants do mathematics in their own classrooms – or at least, what they think it means to ‘do mathematics’.

The aspects of the drawings beyond the mathematician (i.e., the location of the mathematician and the items in the drawing) were also analyzed. Other than a classroom, which was depicted in 26 of the drawings (27.7%), it was generally difficult to discern the location of the mathematician. For instance, if the mathematician was simply shown standing by a chalkboard, the location was not assumed to be a classroom, as many offices and some homes also contain chalkboards. More than a third of the drawings ($n = 34$; 36.2%) fell into this ‘unclear location’ category, and an additional 28 drawings (29.8%) did not contain any background at all. When examining the items in the drawings, chalkboards were the most common item shown ($n = 57$; 60.6%). Low-tech items, such as pens/pencils ($n = 26$; 27.7%) and papers ($n = 20$; 21.3%) were also quite common. Although very few mathematicians ($n = 4$; 4.3%) were shown using a computer, 14 drawings (14.9%) contained a computer, while 19

(20.2%) contained a calculator. Pointers featured in quite a few ($n = 11$; 11.7%) drawings as well; this is related to the high number of drawings of teachers, which will be discussed later.

The mathematics content shown in the drawings varied substantially. Recall that each type of mathematical content was coded separately; therefore, due to the presence of multiple types of mathematics in some drawings, the percentages will sum to more than 100 percent. Twenty drawings (21.3%) did not show any written mathematics (numeric, pictorial, graphical, etc.) at all, and a further 16 drawings (17.0%) simply featured ‘squiggles’ (i.e., no numerals, letters, or symbols). Seven drawings (7.2%) strictly showed symbols (e.g., multiplication sign) without any numbers, and five drawings (5.3%) contained nonsensical mathematics-looking writing. Overwhelmingly, the mathematics that was shown was arithmetic, namely questions involving the four basic operations with whole numbers. This focus on arithmetic may be related to the common misconceptions that equate mathematics with arithmetic, and mathematical genius to the ability to rapidly do calculations involving large numbers in one’s head (Paulos, 1988). Most of the arithmetic questions shown in the drawings were far below the grade level of the participants, particularly those in Grade 8. Twenty-two (23.4%) drawings included one-digit calculations (mostly addition and multiplication), 18 (19.1%) included two-digit calculations (mostly division), and 16 (17.0%) included calculations with three or more digits. Another common feature of the drawings was the famous ‘ $E = mc^2$ ’ equation (which relates to Einstein’s theory of special relativity), shown in nine drawings (9.6%). Since this equation is not part of the elementary curriculum, the participants presumably were exposed to it in popular culture references. There were a few references to geometric concepts, particularly the Pythagorean Theorem by Grade 8 participants ($n = 8$; 8.5%), but other mathematics topics, such as patterning, statistics, and probability were absent. The lack of variety in the mathematics content depicted in

the drawings is surprising, since Ontario students are exposed to a wide variety of mathematical topics in the provincial mathematics curriculum, including data management, algebra, geometry, and measurement (Ontario Ministry of Education, 2005). Consistent with the discussions above, the most common location for the written mathematics was a chalkboard ($n = 47$; 50.0%).

Combining information provided in the drawings and the write-ups allowed for the mathematicians to be identified by ‘character categories’, broad classifications that usually related to an occupation. Overwhelmingly, the drawings fell into two categories: professional mathematicians ($n = 38$; 40.4%) and teachers ($n = 26$; 26.7%). ‘Professional mathematicians’ included drawings of a mathematician working on equations at a chalkboard (without any students present) or working at a desk. Mathematicians were identified as teachers due to the presence of students in the drawings ($n = 11$; 42.3%) and/or through the write-up. All the other character categories, such as textbook writers and inventors, contained fewer than 10 drawings.

Twenty mathematicians (21.3%) were identified as being ‘real’ people, as opposed to generic mathematicians. Seven (35%) were historical figures – six drawings of Einstein and one of Archimedes. As noted earlier, Einstein’s impact was also seen through mathematicians drawn with Einstein-like hair and the inclusion of the ‘ $E = mc^2$ ’ equation. In terms of people the participants would have met, five mathematicians (5.3%) were the participants’ teachers and four mathematicians (4.3%) were the participants’ family members (two grandfathers, one father, and one mother). Four participants (4.3%) drew pictures of themselves, either at present or in the future, as mathematicians. One concerning issue came from the written description accompanying a Grade 8 girl’s drawing (D72) of herself as a mathematician, wherein she minimized her own mathematical abilities. Initially, she had written, “I chose myself because I enjoy math class and I am good at the subject” – but then she added in “I think”, resulting in “I

think I am good at the subject”. This tendency to minimize one’s mathematical talents (and intelligence in general) has been particularly shown for adolescent girls (e.g., Damarin, 2000).

Notably, the only time other people were drawn with the mathematician was when the mathematician was depicted as a teacher and the other people were students. No drawing, for instance, showed a mathematician collaborating with a colleague while working. While this possibly could be attributed to the wording of the task (‘Draw a picture of a mathematician at work’, not ‘Draw a picture of mathematicians at work’), it may also be indicative of perceptions of mathematicians’ work – alone, pouring over a page or chalkboard full of complicated-looking equations.

Overall, the mathematicians drawn tended to be shown in a fairly positive light in two key ways: They were mostly mainstream-looking (as opposed to ‘nerdy’-looking) and they were a balance of women and men (as opposed to mostly men). A few stereotypes, such as wearing glasses and a lab coat, were shown in some drawings. Overwhelmingly, the mathematics shown in the drawings was simple arithmetic – whole-number addition, subtraction, multiplication, and division – which suggests a narrow view of mathematics. Participants tended to view mathematicians in two roles – ‘professional mathematician’ and teacher – with very little occupational diversity shown. Similar to the narrow conception of mathematics shown in the drawings, the narrow range of conceptions of mathematicians’ work is certainly worrisome. If mathematics and mathematicians are seen in such a narrow manner, presumably, only a narrow subset of individuals will be interested in the field and/or feel that they fit into such an identity.

Gendered Trends

As discussed, gender balance in the drawings was the case for the entire dataset. However, when the data were examined in more detail, clear gendered patterns emerged. For the

discussions of gendered trends, only 93 of the drawings were used in the analysis, as one participant (D24) did not indicate her/his gender. The drawings used in the gendered analyses were comprised of 55 drawings by girls (59.1%) and 38 drawings by boys (40.9%).

Examining the drawings by the gender of the participant highlights a clear trend: Participants tend to draw mathematicians the same gender as themselves. Namely, 37 of the 55 girls (67.3%) drew women mathematicians, whereas 27 of the 38 boys (71.1%) drew men mathematicians. While this trend aligns with prior research about children's drawings of people in general (e.g., Chen & Kanter, 1996; Houston & Terwilliger, 1995), it stands in contrast to prior research involving children's drawings of mathematicians, in which the majority of both boys and girls drew men as mathematicians (e.g., Picker & Berry, 2000, 2001). When further investigating these gender-matched drawings, another gendered trend emerges: More than twice the proportion of the drawings of woman mathematicians by girls compared to the drawings of man mathematicians by boys depicts the mathematician as a teacher. Specifically, 14 of the 37 drawings (37.8%) of woman mathematicians by girls depict a teacher, compared to only 5 of the 27 drawings (18.5%) of man mathematicians by boys. Interestingly, all 14 of these girls have a woman teacher, and five specifically indicated that the mathematician in the drawing was 'her teacher'. Four girls drew a man teacher as the mathematician, and half of these girls have a man teacher; yet, no man teacher drawn was identified as a girl's own teacher. In comparison, only one of the five boys who drew a man teacher as the mathematician has a man teacher; no boy indicated that his drawing, either of a man or woman teacher, was 'his teacher' specifically.

Delving further into the importance of the teacher's gender, it appears that having a man teacher was a significant factor in a participant's choice of the gender of the mathematician, with eight of the nine participants (88.9%) whose teacher is a man drawing a man as their

mathematician. The same impact did not hold true for the majority of participants (84 of 93; 90.3%) who have a woman as their teacher: Only half of these participants (42 of 84) drew a woman as their mathematician. Plausibly, having a man as an elementary teacher made a particular impact on these participants, since it is unlikely that they have had a man teacher before, given that elementary school teachers are predominately women.

When the 26 drawings of teachers were examined separately, clear gendered trends were again evident: The majority of the drawings of teachers are drawings of women. In particular, 16 drawings (61.5%) were of a woman teacher, nine drawings (34.6%) were of a man teacher, and one drawing was of a teacher of unidentified gender (3.8%). Notably, these proportions are not in alignment with the proportions of man and woman teachers the participants have: 84 of the 93 participants (90.3%) have a woman teacher, which is a much higher proportion than the proportion of woman teachers drawn. Nearly all drawings of woman teachers (14 of 16; 87.5%) were completed by girls, compared to just over half the drawings of man teachers (5 of 9; 55.6%) being completed by boys. Overall, a higher proportion of girls (32.7%) than boys (21.1%) view mathematicians as teachers (of any gender). However, when examining the other prevalent ‘character category’, professional mathematicians, the reverse is true: A higher proportion of boys than girls (50.0% vs. 34.5%) view a mathematician as a ‘professional mathematician’. Notably, nearly equal proportions of girls drew mathematicians as teachers or professional mathematicians (32.7% vs. 34.5%), whereas more than twice the proportion of boys drew mathematicians as professional mathematicians compared to teachers (50.0% vs. 21.1%).

In terms of the mathematician's appearance, similarities were shown in girls’ and boys’ drawings in terms of the mathematicians’ build (slim to average) and facial expression (smiling), as well as stereotyped traits like Einstein-esque hair, glasses, and pants that are too short. Boys

and girls were both more likely to draw a mathematician in casual clothing than professional clothing, but the proportions of mathematicians in each type of clothing differed substantially between the girls' and boys' drawings. The ratio of casual to professional clothing was approximately 8:1 in the boys' drawings and 3:2 in the girls' drawings. A far greater proportion of girls' drawings than boys' drawings (25.5% vs. 7.9%) featured a mathematician wearing a lab coat. Interestingly, one participant commented in her write-up that, when comparing 'ordinary teachers' and mathematicians, "the only difference is the lab coat" (D94, Grade 8 girl).

Gender differences were also evident in terms of the mathematician's position. Girls were more likely than boys (32.7% vs. 18.4%) to draw the mathematician teaching at a chalkboard, whereas boys were more likely than girls (21.1% vs. 10.9%) to draw the mathematician doing paperwork at a desk. This presumably is linked to girls' increased likelihood of drawing teachers, compared to boys' increased likelihood of drawing 'professional mathematicians'. Similarly, girls were more likely than boys (36.4% vs. 15.8%) to draw the mathematician in a classroom. In terms of tools in the drawings, girls were more likely than boys (18.2% vs. 10.5%) to include computers, whereas boys were more likely than girls (26.3% vs. 16.4%) to include calculators.

The mathematics content was very similar in the girls' and boys' drawings. The most common type of mathematics shown was simple whole-number arithmetic, which was provided by similar proportions of boys and girls. Similarities were also shown in the proportions of boys and girls who included the Pythagorean Theorem and the equation ' $E = mc^2$ ', as well as the proportions of participants who solely provided mathematics symbols (without numerals or letters) or squiggles. However, greater proportions of boys than girls included no written mathematics (26.3% vs. 16.4%) or nonsensical mathematics-looking writing (10.5% vs. 1.8%).

Most of the write-ups provided with the drawings were simply descriptions. However, three write-ups included gender-related comments. These comments were all by girls, one in Grade 4 (D87) and two in Grade 8 (D74 and D94), who have woman teachers and who drew woman mathematicians. Their comments all related to the notion that both men and women can be mathematicians; that is, gender is not perceived as a key factor in being a mathematician. Interestingly, the comments from the two Grade 8 participants came at the notion of gender equality in mathematics from different angles. While one participant (D74) stated that “The mathematician is a woman because not all mathematicians are men”, the other (D94) stated, “I don’t believe that all mathematicians are female. I drew a female mathematician because I heard that the mathematician conducting this survey [*sic*] was a girl.”

In sum, although the dataset of drawings by all participants appeared to be fairly balanced in terms of the genders of the mathematicians, a closer examination of the data highlighted several gendered trends. Namely, participants tend to draw mathematicians the same gender as themselves. Furthermore, a higher proportion of girls than boys see mathematicians as being teachers, whereas a higher proportion of boys than girls see mathematicians as being ‘professional mathematicians’. The drawings of teachers were mostly women, but in a lower proportion than the participants’ actual teachers. The teacher’s gender appears to have an impact on the gender of the mathematician drawn only when the teacher is a man. In terms of the mathematician’s appearance, boys’ and girls’ drawings tended to be similar in most aspects. The mathematics shown in the drawings was very similar in boys’ and girls’ drawings, although a greater proportion of boys tended to not include any written mathematics. Few participants provided gender-related comments with their drawings, but these participants (all girls) all made comments associated with gender equality in mathematics.

Grade Level Trends

For the analyses by grade level, all 94 of the drawings could be used, as each participant indicated his or her grade level. Specifically, 54 drawings (57.4%) by Grade 4 students and 40 drawings (42.5%) by Grade 8 students were used in these analyses.

With regard to the gender of the mathematicians, the proportions of men and women were reversed between the drawings by Grade 4 and Grade 8 students. Of the drawings by Grade 4 students, 55.6% were women and 39.6% were men, compared to 32.5% women and 60.0% men for drawings by Grade 8 students (These numbers do not sum to 100 percent due to a few ‘gender unclear’ mathematicians). These percentages do not appear to be influenced by the gender of the students’ teachers, as the vast majority of participants (89.4%) have teachers who are women, and the students taught by men are fairly evenly divided between Grade 4 (four participants) and Grade 8 (six participants).

In terms of appearance, the mathematicians drawn by Grade 4 and Grade 8 students were similar with regard to having slim to average builds, dressing in mainstream clothing, and having smiles on their faces. However, the ratio of casual to professional clothing was approximately 3:1 for mathematicians drawn by Grade 4 students, compared to 2:1 for mathematicians drawn by Grade 8 students. Higher percentages of Grade 8 students than Grade 4 students drew mathematicians wearing lab coats (25.0% vs. 13.0%) and glasses (57.5% vs. 16.7%).

While Grade 4 and Grade 8 students were both most likely to draw the mathematician standing at a chalkboard, either teaching or doing math, grade level differences occurred when examining mathematicians working at desks. Specifically, Grade 4 students were far more likely to draw mathematicians working at desks, with 10 (18.5%) of the drawings showing a mathematician doing paperwork and four drawings (7.4%) showing a mathematician working at a computer. In comparison, only four (10.0%) of the Grade 8 students’ drawings showed a

mathematician doing paperwork and no drawings at all showed a mathematician working at a computer. Grade 4 students were also more likely to include technological tools: Twelve (22.2%) drawings included a computer, while eight (14.8%) included a calculator. In contrast, very few drawings by Grade 8 students included any technological tools: Only two drawings (5.0%) contained a computer and two (5.0%) contained a calculator.

In terms of the mathematics shown, higher proportions of the Grade 8 drawings than the Grade 4 drawings showed simple one-digit whole-number calculations (30.0% vs. 14.8%), whereas higher proportions of the Grade 4 drawings featured such calculations with numbers with two or more digits. This is particularly noteworthy since single-digit calculations are far below the level of Grade 8 mathematics content. Understandably, the Pythagorean Theorem was only present in drawings by Grade 8 students, as Grade 4 students have not yet been exposed to it in the curriculum. Importantly, the drawings did not include other formulas (e.g., area, volume) to which Grade 8 students would have been exposed, suggesting that the Pythagorean Theorem was particularly impactful – potentially since it is likely the first ‘named’ theorem/formula that these students have learned. One drawing (by D64) features an upset-looking man in front of a chalkboard that displays the Pythagorean Theorem (mislabelled as the ‘Pylagorean Theorem’, but with the equation written in its conventional form, $a^2 + b^2 = c^2$). The mathematician points at the ‘ c^2 ’ portion of the equation, under which is written the admonishment ‘NOT H^2 ’. Although this participant’s teacher is a woman and therefore the drawing is not of her specifically, the write-up hints at this participant’s experiences in class: “Hes [*sic*] upset because nobody gets the Pythagorean therum [*sic*]”. Although Grade 4 students also have no curricular experience with exponents, nearly equal proportions of Grade 4 and 8 students included the equation ‘ $E = mc^2$ ’, and the exponent was always written correctly, which again hints at its common occurrence in

popular culture. Similar proportions of Grade 4 and 8 students either included no mathematics or non-mathematical writing (e.g., squiggles). A higher proportion of Grade 8 students (75.8%) than the Grade 4 students (53.7%) showed the mathematics written on a chalkboard.

By far, the most common ‘character categories’ for both grade levels were professional mathematicians, followed by teachers. In the drawings by Grade 4 students, a far higher proportion were ‘professional mathematicians’ ($n = 25$; 46.3%) compared to teachers ($n = 14$; 25.9%), whereas the proportions were nearly equal in the drawings by Grade 8 students ($n = 13$ and $n = 12$; 32.5% and 30.0%, respectively). Taken another way, a higher proportion of Grade 4 students than Grade 8 students view mathematicians as ‘professional mathematicians’, whereas similar proportions of Grade 4 and 8 students view mathematicians as teachers.

Many similarities existed between Grade 4 and Grade 8 students’ views of mathematicians, particularly with regard to appearance. One area of difference was with respect to stereotypical accessories, glasses and lab coats, which were more prevalent in the Grade 8 students’ drawings. Conversely, mathematical tools, such as computers and calculators, were more prevalent in Grade 4 students’ drawings. Grade 4 students were more likely than Grade 8 students to draw woman mathematicians and ‘professional mathematicians’. The mathematics content shown in the drawings tended to be similar, and was most commonly simple arithmetic.

Summary of Findings: Student Drawings

The student drawings probed the participants’ views of mathematicians, which were encouraging in many respects. Overall, the mathematicians in the drawings were fairly gender-balanced and ‘mainstream’ looking; both of these findings stand in contrast to stereotypes about gender and mathematics, and about ‘math geeks’. However, other stereotypes were depicted in the drawings, such as an association with intelligence (e.g., through ‘markers’ like glasses) and

the tendency to equate mathematics with arithmetic. Additionally, the participants' drawings indicated narrow views about the types of occupations a mathematician could hold, with 'professional mathematician' and 'teacher' being overwhelmingly the most common responses. Very few drawings depicted the participants themselves as mathematicians, and no drawings featured the mathematician working collaboratively with a colleague.

When examining the findings by the gender and grade level of the participants, gendered trends emerge: Namely, girls were more likely to draw women mathematicians, while boys were more likely to draw men mathematicians. Similarly, Grade 4 students were more likely to draw women mathematicians, while Grade 8 students were more likely to draw men mathematicians.

Table 16
Gender of Mathematician Drawn, by Participant Group

Gender of mathematician	All participants (<i>n</i> = 93)*	Gender		Grade	
		Girls (<i>n</i> = 55)	Boys (<i>n</i> = 38)	Grade 4 (<i>n</i> = 53)	Grade 8 (<i>n</i> = 40)
Woman	46 (49.5%)	37 (67.3%)	6 (15.8%)	30 (55.6%)	13 (32.5%)
Man	42 (46.2%)	18 (32.7%)	27 (71.1%)	21 (40.7%)	24 (60.0%)
Unclear	5 (5.4%)	0 (0.0%)	5 (13.2%)	2 (3.7%)	3 (7.5%)

Note. Only 93 drawings were used for this table because one participant did not identify his/her gender. Percentages apply to each column (i.e., each participant group).

Additionally, gender- and grade-level trends are highlighted when considering the two most common professions depicted in the drawings. Namely, girls are equally likely to depict 'professional mathematicians' or teachers, whereas boys are more than twice as likely to depict 'professional mathematicians' than teachers. Similarly, Grade 4 students were nearly twice as

likely to draw ‘professional mathematicians’ than teachers, while Grade 8 students drew these professions in nearly equal proportions.

Table 17
Professional Mathematician and Teacher Drawings, by Participant Group

	All participants <i>n</i> = 93	Gender		Grade	
		Girls (<i>n</i> = 55)	Boys (<i>n</i> = 38)	Grade 4 (<i>n</i> = 53)	Grade 8 (<i>n</i> = 40)
Professional mathematician	38 (40.9%)	19 (34.5%)	19 (50.0%)	25 (47.2%)	13 (32.5%)
Teacher	26 (28.0%)	18 (32.7%)	8 (21.1%)	14 (26.4%)	12 (30.0%)

Note. Percentages apply to each column (i.e., each participant pool).

Finally, Grade 8 students were more likely than Grade 4 students to draw mathematicians with stereotypical appearances (e.g., glasses, lab coats), while Grade 4 students were more likely than Grade 8 students to draw mathematicians using mathematical tools in their work. In contrast, other than lab coats (which girls drew more often than did boys), no gender differences were apparent with regard to the mathematicians’ appearances.

Children’s Media

As described in detail in the Methodology chapter, my selection of children’s media to view and analyze was based on the participants’ responses to the ‘Media’ section of the online questionnaire. Through my selection process, five books (or book series), three movies (or movie series), 10 television shows, seven websites, and six video games were initially selected. Then, online descriptions of each media title were read and online searches conducted to narrow the list of titles that were analyzed. Each selected title was viewed and analyzed in order to garner an

understanding of the messages about mathematics and mathematicians to which the participants may be exposed. The results of these analyses are discussed below, separated by media type.

Reading Materials

All of the top reading materials were books, which is unsurprising since books were by far the most commonly reported type of reading material that the questionnaire participants read most often ‘for fun’. Specifically, 73.8% of the questionnaire participants reported that they read books most often for fun, compared to less than 15% for any of the other reading material types (e.g., comic books, magazines). Four of the five top book titles were series: *Diary of a Wimpy Kid*, *Geronimo Stilton*, *Harry Potter*, and *Hunger Games*. The fifth book title was *Lockdown*, which is part of the *Escape from Furnace* series by Alexander Gordon Smith. Table 18 provides information regarding the books from each series that were published by June 2011 and the number of books selected for analysis.

Table 18
Books Published and Selected for Analysis

Title of book/series	Number of books published by June 2011	Number of books selected for analysis
<i>Diary of a Wimpy Kid</i>	5	1
<i>Geronimo Stilton</i>	49	6
<i>Harry Potter</i>	7	4
<i>Hunger Games</i>	3	2
<i>Lockdown</i>	1	0
Total	65	13

Based on the descriptions of each book, 13 of the 65 books (20%) published by June 2011 appeared to have mathematics-related references. These 13 books represent all four of the series; however, I did not see any indication of mathematics-related references in *Lockdown*. I discuss my detailed findings below by series, including explanations of why each book was selected. I conclude by drawing comparisons across all the books examined.

Diary of a Wimpy Kid

The *Diary of a Wimpy Kid (DWK)* series, by American cartoonist and author Jeff Kinney, follows Greg Heffley, the wimpy kid, through his everyday adventures. The books are written in a diary format, with handwritten-looking font and several drawings included. The *DWK* books are ranked at a Grade 3 (ages 8-9) interest level and a Grade 5 to 6 (ages 10-12) reading level (Scholastic, 2012). This series was among the top choices for all participants (#1), as well as for Grade 4 students (#1), boys (#1), Grade 4 girls (#3), and Grade 4 boys (#1).

I selected *Diary of a Wimpy Kid: The Ugly Truth* (Kinney, 2010), the fifth book in the series, due to the reference to Greg's father helping him with his homework (although it does not mention a specific subject). There were three mathematics-related references in this book: 1) An image of two pages of a (fictional) mathematics textbook, 2) A discussion of Greg's father helping him with mathematics homework, and 3) A discussion of standardized testing at school.

The image of the textbook pages was difficult to analyze, since much of the mathematical content was covered by graffiti and was thus illegible. The mathematics that was visible either lacked enough information for students to be able to solve the problems or provided answers (for multiple-choice questions) that were all incorrect. The topics and level of difficulty of the mathematics problems were extremely varied and thus did not seem logically ordered. While a reader likely would not notice these details (as the textbook pages basically had the surface

appearance of a ‘real’ mathematics textbook), I found it problematic that the author would not have bothered to check these details.

I found the other two mathematics-related references in this book to be quite real-world applicable and timely in today’s often-politicized educational climate. When Greg’s father attempts to help him with his mathematics homework, they struggle:

I guess the way they teach math these days is totally different from the way they taught it when Dad was a kid, so he gets frustrated with the new rules and starts trying to teach me the way HE learned it. (p. 64)

An associated drawing shows Greg’s father discussing how to add several numbers and ‘carry the four’, and Greg asking, “What does ‘carry’ mean?”, while pulling out his hair. This example mirrors the current reality of many parents when they attempt to help their children with mathematics homework, as was discussed in the parent and teacher interviews in this study and found in other publications (e.g., Mistretta, 2013). In today’s educational climate, mathematics is often taught in a manner that focuses on student understanding of mathematical concepts, rather than memorization of formulas and algorithms (Boaler, 2008). In comparison, in the parents’ generations, mathematics was often taught in a very rule-based, algorithmic manner. Thus, as depicted in this *DWK* example, children and parents often struggle when working at mathematics homework together, due to their different experiences with the subject.

The final mathematics-related reference in the book discussed upcoming standardized tests at Greg’s school. Some key, politicized arguments related to standardized testing are highlighted through Greg’s diary entry, such as pressure on students and consequences for teachers and students. Greg notes that “there’s a lot of pressure on us kids, which kind of stinks” (p. 66), and fondly recalls how math class was much more fun in Kindergarten, when cookies

were used to illustrate the concepts. Greg also mentions that he “heard that the teachers won’t get their bonuses unless we get good scores” (p. 66) and that his teacher told the class that if they didn’t do well on the test, “we’ll lose our budget and music class will turn into detention, or something like that” (p. 67). These two examples highlight Greg’s (slightly muddled) awareness of how both the students and the teacher could be negatively impacted by the students’ poor standardized test scores. These are very real possibilities in a high-stakes testing environment, such as that of the United States, where the *DWK* books are set. When students are aware of the high stakes, a variety of problems can result, from stress-related illnesses to decreased enjoyment of mathematics class (Fleege, Charlesworth, Burts, & Hart, 1992; Jones et al., 1999).

While the examples in *Diary of a Wimpy Kid: The Ugly Truth* highlighted current issues in mathematics teaching and learning, they were a very small portion of the book, and were not explored in much depth. There is minimal mathematical content in this book, and several problems were noted with the mathematical content (e.g., errors, lack of information). The lack of mathematical accuracy may suggest a lack of importance placed on mathematics (relative to the rest of the storyline), or perhaps a lack of understanding of mathematics, by the author.

Geronimo Stilton

The *Geronimo Stilton (GS)* book series, by Italian author Elisabetta Dami, follows the adventures of Geronimo Stilton, a mouse who is a newspaper editor, journalist, and author. By June 2011, 45 regular series books and four special edition books were published. The *GS* books are ranked at Grade 3 to 4 (ages 8-10) interest level and a Grade 3 (ages 8-9) reading level (Scholastic, 2012). This series was among the top choices for Grade 4 students (#2), girls (#3), and Grade 4 girls (#1). Of the 49 *GS* books published by June 2011, I deemed six worthy of investigating further. Table 19 provides details about each book that was selected.

Table 19
Description of Selected Geronimo Stilton Books

Title	Date published	Book number	Reason selected	Possible topics
<i>Lost Treasure of the Emerald Eye</i>	2004	1	Treasure hunt	map reading, problem-solving
<i>The Curse of the Cheese Pyramid</i>	2004	2	Economizing	economics, budgeting
<i>The Mona Mousa Code</i>	2005	15	Solving puzzles	problem-solving
<i>Shipwreck on the Pirate Islands</i>	2005	18	Treasure hunt	map reading, problem-solving
<i>A Fabumouse School Adventure</i>	2009	38	School visit	math class
<i>The Kingdom of Fantasy</i>	2009	S.E. 3*	Treasure hunt	map reading, problem-solving

Note. S.E. refers to Special Edition.

Nearly all of the mathematics-related references in these *GS* books were mathematics content rather than messages about mathematics; indeed, only a few messages could be discerned, and these were rather implicit. The mathematical content was often simply a reference to numbers, such as the time of day, dates, numbers of items in a list, or measurements in a recipe. Besides these incidental examples, several other in-depth examples were included, such as detailed examples involving shapes and measuring devices. In *The Mona Mousa Code*, Geronimo and his cousin, Trap, discuss sharing profits from publishing a book. Trap begins by suggesting that they share the profits “equally: 70 percent for me and 30 percent for you” (p. 9), to which Geronimo replies, “You call that equal?” (p. 10). Trap next suggests a 60/40 split, but before Geronimo can respond, his sister, Thea, suggests that they share the profits evenly, three

ways: “One-third for me and one-third for each of you” (p. 11). In terms of content, this example includes division, ratios, percentages, and fractions. Implicitly, the reader may receive the message that understanding mathematics helps to ensure fairness when sharing with others.

Mapping and time were two other mathematical concepts that were explored in depth. Unfortunately, many of these examples featured substantial inaccuracies, and these inaccuracies often occurred in very simple examples. For instance, in *The Curse of the Cheese Pyramids*, six o’clock is discussed in text and a picture of a clock face with the hands pointing at 6 and 12 (in Roman numerals) is shown. The clock correctly shows the Roman numerals for 3, 6, 9, and 12, but there is only one dash between each Roman numeral, where there should be two. The examples involving maps, which occur frequently in the books since Geronimo is often going on adventures, were even more problematic. Nearly every example of a map either is lacking vital information (e.g., indication of direction) or features nonsensical details (e.g., scales with unequal-sized increments). As with the mathematical inaccuracies in the *DWK* book, I question why the *GS* author or illustrator wouldn’t have paid more attention to these details – and how none of the adults involved with the books caught the mistakes. If such errors are noticed by the young readers, they could become confused about their own understanding of the concepts and/or perhaps develop the idea that accuracy is not important in mathematics.

The only example that portrayed a more explicit message about mathematics was found in *Lost Treasure of the Emerald Eye*. Geronimo’s sister, Thea, discusses with their cousin, Trap, the way that she determined their position on an island:

“First I determined our position, using the astrolabe. Then I checked it with a triangulation... and worked out the logarithm...” “ASTROLAMP? STRANGULATION?”

CONGARHYTHM?” snorted Trap. “Do you mind speaking English? I hate it when you use such big words!” (p. 78)

While most of the steps Thea listed could be reasonable, no explanation is given for any of the ‘big words’, or how one would complete such a task. This likely leaves the young reader feeling as confused as Trap, who simply made up ‘big words’ in response to those provided by Thea. This example serves to make mathematical calculations seem mystifying to the young readers.

The six *Geronimo Stilton* books examined included several examples of mathematical content, but virtually no messages about mathematics. Although the examples were often incidental, they covered a wide range of mathematical concepts. These examples link to positive implicit messages, as the readers see that Geronimo and his friends encounter mathematics frequently in the ‘real world’, and understand that mathematics includes many different topics. Unfortunately, there were mathematical errors in quite a few of the more detailed examples. There were extremely few examples that provided more explicit messages about mathematics, and these messages were mixed. On a positive note, a woman (Thea, Geronimo’s sister) was depicted as being strong in mathematics and using mathematics to solve problems.

Harry Potter

The *Harry Potter* series, by British author J. K. Rowling, consists of seven novels that were published from 1997 to 2007. The series follows Harry Potter, a boy wizard, as he grows up and faces numerous challenges, both in the magical world and the world of Muggles (i.e., non-magical people). The books focus on Harry’s friendship with Ron and Hermione, two classmates at the Hogwarts School of Witchcraft and Wizardry, and his ongoing struggle against Voldemort, a dark wizard. The *Harry Potter* books are all ranked with an interest level of Grade 4 (ages 9-10), but the reading level increases from Grade 5 to Grade 7 (ages 10-13) as the series progresses

(Scholastic, 2012). Regardless of this relatively low ‘interest level’ ranking, the series is hugely popular with adult readers as well (Barber, 2011). The *Harry Potter* series was among the top choices for all participants (#2), as well as for Grade 4 students (#3), Grade 8 students (#3), girls (#1), boys (#3), Grade 4 boys (#3), and Grade 8 girls (#2). Indeed, this series was featured in the top choices for the greatest number of gender/grade categories. From my initial searches, I determined that four of the seven *Harry Potter* books may have mathematics-related references. In Table 20, I provide details about each selected book, as well as the reason for its selection.

Table 20
Description of Selected Harry Potter Books

Title	Date published	Book number	Reason selected
<i>Harry Potter and the Philosopher’s Stone*</i>	1997	1	Chess game, logic puzzle
<i>Harry Potter and the Prisoner of Azkaban</i>	1999	3	Time travel, Arithmancy class
<i>Harry Potter and the Goblet of Fire</i>	2000	4	Hedge maze
<i>Harry Potter and the Order of the Phoenix</i>	2003	5	Arithmancy class

Note. This book is known as *Harry Potter and the Sorcerer’s Stone* in the United States. The Canadian publishers of the book maintained the original British title, *Harry Potter and the Philosopher’s Stone*, so I use that title in my discussions of the book and movie.

While many of the mathematics-related references in the *Harry Potter* books were strictly mathematics content, the *Harry Potter* books also featured explicit messages about mathematics and mathematically proficient people. All of the *Harry Potter* books examined included several instances of incidental mathematics content, such as times of day, dates, numbers of items, relative sizes (e.g., twice as tall), and measurements. Mathematical content was also seen in more detailed examples that involved wizard money (e.g., relationships of coin values); Quidditch, a wizard sport (e.g., scores); and Platform 9 and 3/4, the magical platform that Harry uses to board

the train to Hogwarts (e.g., mixed numbers, number line concepts). Another example of mathematics content relates to ‘house points’. Students at Hogwarts are sorted into four ‘houses’, which are essentially teams relating to their dormitories. When students are punished, their houses lose points, and when students do positive things, their houses gain points. Discussions of house points cover concepts of multiplication (e.g., 50 points lost for each of three people means 150 points lost), ordering (ranking the houses by point totals), and integers (e.g., losing five points and then being awarded 10 points, resulting in a net gain of five points).

Several of the examples that drove my selection of these specific *Harry Potter* books turned out to be rather lacking in terms of mathematical content and/or messages. For instance, the chess example in *Harry Potter and the Philosopher’s Stone* and the time travel example in *Harry Potter and the Prisoner of Azkaban* both contained virtually no mathematics content. *Harry Potter and the Goblet of Fire* was examined for its inclusion of a hedge maze during a wizard tournament, but no image of the maze was provided, and almost no mathematically-relevant discussion was provided about the maze, other than a few basic instances of cardinal (e.g., north, east) and relative (e.g., left, down) directions.

While the example of the logic puzzle in *Harry Potter and the Philosopher’s Stone* was only slightly richer mathematically than the aforementioned examples, it was quite rich in terms of messages about mathematically proficient people. A puzzle was provided that Hermione had to solve in order to figure out which of seven possible bottles contained a potion that she and Harry needed. Unfortunately, no image was provided, so a reader could not solve the puzzle alongside Hermione, due to the lack of information about the bottles’ positions, shapes, and sizes. Furthermore, no explanation was provided about how Hermione solved the puzzle:

‘This isn’t magic – it’s logic – a puzzle... Everything we need is here on this paper...’

[said Hermione] ... Hermione read the paper several times. Then she walked up and down the line of bottles, muttering to herself and pointing at them. At last, she clapped her hands. ‘Got it,’ she said. (p. 207)

This description of Hermione solving the logic puzzle falls into stereotypical ideas about solving mathematical problems, especially by geniuses (as Hermione is often depicted) – muttering to themselves and then shouting, ‘Eureka!’ (or a similar phrase) as the answer just ‘comes’ to them. While Hermione states that there is a mathematical basis to her solution (‘It’s logic’), no details are provided, so her solution probably seems like magic to Harry. Such depictions further serve to make mathematics seem mystifying, a subject only understood by a select few.

Another topic in the *Harry Potter* books that provided rich messages about mathematics and mathematically proficient people was Arithmancy class, which is defined on the *Harry Potter Lexicon* website as “a branch of magic that is concerned with the magical properties of numbers” (Worley, 2007). Arithmancy is mentioned in *Harry Potter and the Prisoner of Azkaban* as one of Hermione’s classes, but at no time is it described in detail. The reader is left to presume it has to do with numbers from the similarity to the word ‘arithmetic’, as well as references to the teacher’s name, Professor Vector, and ‘Arithmancy charts’. Harry is not taking Arithmancy, and he questions Hermione’s interest in the subject area: “‘Arithmancy looks terrible,’ said Harry, picking up a very complicated-looking number chart. ‘Oh, no, it’s wonderful!’ said Hermione earnestly. ‘It’s my favourite subject!’” (p. 185). Their discussion ends because of an interruption, so no further information about Hermione’s love of the subject is given. Harry’s comment relates to stereotypical notions of mathematics – that it looks complicated, and thus, must be terrible.

Arithmancy is briefly referred to in *Harry Potter and the Goblet of Fire* and *Harry Potter and the Order of the Phoenix*. In the former, Hermione claims that Arithmancy is a worthwhile and ‘sensible’ subject to study. Like the example in *Harry Potter and the Prisoner of Azkaban*, Arithmancy is extolled in *Harry Potter and the Order of the Phoenix* for its difficulty:

‘Only four exams left,’ said Parvati Patil [a classmate] wearily as they headed back to Gryffindor common room. ‘Only!’ said Hermione snappishly. ‘I’ve got Arithmancy and it’s probably the toughest subject there is!’ Nobody was foolish enough to snap back, so she was unable to vent her spleen on any of them. (p. 632, emphasis in original)

Later, Hermione shares with Harry and Ron that she thinks she has done ‘all right’ in Arithmancy, a difficult subject that many students do not even attempt.

Similar to the *Geronimo Stilton* books, the *Harry Potter* books provided many incidental examples of mathematical content. However, the range of mathematical concepts in the *Harry Potter* books tended to be narrower (mostly number sense and measurement) and, on a positive note, no mathematical errors were found. While readers can appreciate that the *Harry Potter* characters encounter mathematics in their everyday lives, it is generally not a focus, and often is limited in difficulty and range. In contrast, the examples involving mathematics messages were much richer, involving common stereotypes about mathematics being a difficult subject that can only be understood and enjoyed by highly intelligent people. However, the depiction of a girl being mathematically proficient is a positive challenge to the notion of mathematics as a male domain.

Hunger Games

The *Hunger Games* trilogy, by American author Suzanne Collins, consists of three novels: *The Hunger Games* (2008), *Catching Fire* (2009), and *Mockingjay* (2010). The trilogy

occurs in a post-apocalyptic nation, Panem, which is divided into 12 districts, and is controlled by the Capitol, a totalitarian regime. Each year, the Capitol holds the Hunger Games, in which one boy and one girl, ages 12 to 18, from each district are selected, through a random drawing of names, to participate. The Hunger Games are televised, with the participants (called ‘tributes’) fighting and killing each other until one victor remains, whose district is rewarded. The trilogy focuses on Katniss Everdeen, who, in the first book, at 16 years old, volunteers as tribute for her district when her 12-year-old sister, Prim, is selected. She and a childhood friend, Peeta, through a twist of the games, end up as co-victors. The second book follows the 75th anniversary edition of the Hunger Games, wherein former Hunger Games victors, including Katniss and Peeta, take part in a special version of the event. The final book focuses on the uprising of the districts.

The *Hunger Games* series is similar to the *Harry Potter* series insofar as it is a young adult book series with many adult readers (Armitstead, 2012). Due to its more violent and disturbing content (i.e., children killing children in a ‘game’), the *Hunger Games* series is ranked at a higher interest level than the *Harry Potter* series – Grade 6 (ages 11-12), compared to Grade 4 (ages 9-10), with the reading level ranked as Grade 5 (ages 10-11) (Scholastic, 2012).

Interestingly, the format of the books is mathematical: Due to the author’s background as a playwright, each book is divided into three sections, or acts, of nine chapters, resulting in each book being 27 chapters long. This series was among the top choices for all participants (#3), as well as for Grade 8 students (#1), girls (#2), boys (#3), Grade 8 girls (#1), and Grade 8 boys (#2).

I analyzed *The Hunger Games* (2008) due to its discussion of the lottery system to select the tributes. The second book, *Catching Fire* (2009), was also selected due to the lottery system, as well as the arena in which the Hunger Games occurred being shaped like a clock. As with the

Geronimo Stilton and *Harry Potter* books, these two *Hunger Games* books featured several instances of incidental mathematical content (e.g., times of day, measurements, rankings, scores).

The description of the selection process in *The Hunger Games* is very thorough, addressing the mathematical concept of probability. Every Panem citizen aged 12 to 18 has his or her name entered into the draw each year, with the number of entries increasing with age (i.e., one entry for 12-year-olds, two entries for 13-year-olds, and so on). The entries are cumulative, so that by the time a person is 15 years old, for instance, he or she would have 10 entries ($1 + 2 + 3 + 4$). In that sense, the draw could be considered mathematically fair, with an increased chance of being selected with increased age. However, in another sense, the selection process is unfair, since it preys on the poor and hungry, like Katniss and her family:

You can opt to add your name more times in exchange for tesserae. Each tessera is worth a meager year's supply of grain and oil for one person. You may do this for each of your family members as well. (p. 13)

Since Katniss needs the tesserae for her family, the probability of her name being selected is higher than her wealthier, same-aged peers. Furthermore, certain districts are wealthier, due to their natural resources; this provides their tributes with better preparation and thus results in uneven game play. Notably, the signature phrase of the *Hunger Games*, “May the odds be *ever* in your favour” (p. 19, emphasis in original), relates to the probabilistic nature of the event.

Katniss and her friend, Gale, whose family is also poor, are well aware of the unfair nature of the selection process, and demonstrate a solid understanding of probability through their discussions. When talking about a same-aged peer from a wealthy family (who therefore does not need the tesserae), Katniss notes that “the chance of her name being drawn is very slim... not impossible, but slim” (p. 13), whereas she and Gale know that they have a much

higher probability of being selected as they both needed to take the tesserae, thus increasing the number of times their names would be in the draw. When Katniss' 12-year-old sister, Prim, was selected as tribute initially, Katniss could not believe it, due to the low odds:

This can't be happening. Prim was one slip of paper in thousands! Her chances of being chosen so remote that I'd not even bothered to worry about her. Hadn't I done everything? Taken the tesserae, refused to let her do the same? One slip. One slip in thousands. The odds had been entirely in her favor. But it hadn't mattered. (p. 21)

This quotation highlights how Katniss had purposely kept her sister's chance of being selected low, by not allowing her to take the tesserae, and demonstrates Katniss' understanding of probability. Later in the book, Katniss reasons that she will likely not have to be the one to kill Peeta, the other tribute from her district, during the Hunger Games: Since there are 24 tributes in total, her odds should be low. However, due to the extremely improbable event of her sister being selected as tribute initially occurring earlier, Katniss ponders whether her initial inclination was reasonable, since "the odds have not been very dependable as of late" (p. 33). Thus, she realizes that such an event can indeed occur, even if the chances are almost nonexistent.

In *Catching Fire*, a special version of the Hunger Games is held to celebrate its 75th anniversary, with tributes selected from the existing pool of victors (two victors chosen from each district). While a detailed discussion of the selection process is not provided, references are again made to its unfair nature: Since the wealthier districts have more victors, victors from the poor districts are disadvantaged, as they have a higher probability of being selected. *Catching Fire* was also selected due to the inclusion of a clock-shaped arena in which the Hunger Games occur. The tributes do not initially realize that the arena is shaped in this way, but Katniss eventually pieces it together. She begins by noticing that "the force field has trapped us in a

circle. A dome, really... Very exact. Very symmetrical” (p. 287). This is one of the only instances in either book where any geometric shapes or properties are noted. Once Katniss notices a bell tolling 12 times, she begins pondering whether it relates to the 12 districts, but then realizes that she has been seeing patterns in the game environment. Since the Capitol controls all aspects of the game, the changes of weather and predators are able to occur in unnatural intervals, with a circle divided into 12 equal sectors. While this example was selected due to the clock reference, it actually relates more to patterning and geometry, in terms of Katniss’ uncovering this secret. Readers see that, without being able to recognize patterns and make predictions, Katniss would not have been successful in the Hunger Games.

An additional detailed mathematical example in *Catching Fire* relates to basic operations, particularly division. During the Hunger Games, wealthy sponsors can provide the tributes with gifts that will help them win, such as food, water, and medical supplies. In a few instances, Katniss and her allies (five people in total) receive rolls, 24 in each delivery. The first time the rolls are received, the allies take three each, and decide that “whoever is still alive at breakfast can take a vote on the rest” (p. 349). The reader has to follow the calculations when, after receiving another shipment of 24 rolls, Katniss notes that “That gives us thirty-three in all. We each take five, leaving eight in reserve. No one says it, but eight will divide up perfectly after the next death” (p. 355). The reader needs to understand that there would be four allies left after one dies, leaving them two rolls each. After receiving a third shipment of 24 rolls, Katniss notes that there are “Thirty-two rolls then. So we each take five, leaving seven, which will never divide evenly. It’s bread for only one” (p. 366). Again, the reader needs to follow the calculations, plus additionally realize that seven is a prime number, which thus only divides evenly into one group.

As expected, the two *Hunger Games* books examined provided a rich exploration of probability concepts. These books also provided fairly detailed discussions of a few other mathematical concepts, as well as several incidental examples of mathematical content. Similar to the *Harry Potter* books, the incidental examples in the *Hunger Games* books contained no errors and had a narrow focus (generally number sense and measurement). The *Hunger Games* books did not contain any explicit examples regarding stereotypes about or issues in mathematics. However, more so than the other series examined, the examples in the *Hunger Games* series show how important – indeed, life-saving – knowledge of mathematics can be, particularly in the extreme situations Katniss faces. Katniss is consistently portrayed in a positive manner, as a strong young woman whose understanding of mathematics is vital to her survival.

Summary of the Mathematics-Related References in the Reading Materials Examined

The 13 books that were examined were all from series – *Diary of a Wimpy Kid*, *Geronimo Stilton*, *Harry Potter*, and *Hunger Games* – and all included at least some mathematics-related references. Most of these examples were mathematics content, rather than messages about mathematics or mathematically proficient people. Much of the mathematics content was accurate, but when errors did occur, they were nearly always in the illustrations. The mathematics content typically covered a wide variety of topics and was featured, at least incidentally, in the characters' lives on a regular basis. Through the characters' experiences, readers may receive implicit messages about the breadth of topics that comprise mathematics, as well as the applicability and importance of mathematics in everyday life. The instances that involve detailed discussions of mathematics concepts may help students to gain further understandings of the topics, and they may retain the understandings better as they were learned in the context of a story in which they were engaged (Lake, 2009).

Disappointingly, few examples in the books dealt with more explicit ideas about mathematics and mathematically proficient people; instead, mathematics tended to be treated as a benign topic. Discussions of current mathematics education issues, such as standardized testing, only occurred in the *Diary of a Wimpy Kid* book. When issues about mathematics were raised, stereotypes and misconceptions were typically featured, such as the stereotypes about mathematical ability present in the *Harry Potter* books. In examples in both the *Harry Potter* and *Geronimo Stilton* books, mathematics is portrayed as being a difficult and confusing subject area. In contrast, while the messages about mathematics and mathematically proficient people in the *Hunger Games* books are perhaps less explicit, they are quite positive, as they depict Katniss as a strong young woman whose survival and success depend on her mathematical capabilities. Through these examples, mathematics is portrayed as a useful life skill, and Katniss is portrayed as a mathematically proficient young woman. Indeed, the depiction of mathematically proficient girls and women (i.e., Thea in the *Geronimo Stilton* books, Hermione in the *Harry Potter* books, and Katniss in the *Hunger Games* books) stands in contrast to the stereotype of ‘mathematics as a male domain’. Therefore, while exposure to these books may help students to realize that mathematics is applicable outside of school, their thinking about issues and stereotypes related to mathematics likely would not be challenged, other than with regard to gender stereotypes.

Movies

Three movies (or movie series) were selected as the ‘top’ choices of the questionnaire participants: *The Hangover*, the *Harry Potter* series (eight movies), and the *Star Wars* series (six movies). My examination of the description of *The Hangover* indicated mathematics-related references (card counting), whereas the descriptions of all the *Star Wars* movies did not. The selection of which *Harry Potter* movies to view was done differently because the *Harry Potter*

series was also a top choice for reading materials, which were analyzed before movies. I decided to watch the same movies as the four books I had analyzed earlier, in order to be able to make comparisons: *Harry Potter and the Philosopher's Stone*, *Harry Potter and the Prisoner of Azkaban*, *Harry Potter and the Goblet of Fire*, and *Harry Potter and the Order of the Phoenix*. Since movies and books of the same titles often differ, I also checked the other movies for mathematics-related references, but I did not find anything that warranted further examination. In total, five movies were analyzed – *The Hangover* and four *Harry Potter* movies. Before I watched each *Harry Potter* movie, I consulted my notes regarding the mathematics-related references in the related book to guide my viewing of the movie and enable comparisons. Below, I discuss my findings for each movie, as well as across the four *Harry Potter* movies.

The Hangover

The Hangover (2009) begins with three friends, Phil, Alan, and Stu, awaking on the morning after a bachelor party, where they find the groom-to-be, Doug, missing and a series of unexplained outcomes. The plot focuses on the men retracing their steps in order to try to figure out what happened and to locate Doug. *The Hangover* was among the top choices for all participants (#2), as well as for Grade 8 students (#1), girls (#2), boys (#2), Grade 8 girls (#2), and Grade 8 boys (#1).

This movie was selected due to its inclusion of card-counting. While retracing their steps, the friends are threatened by gangsters who claim they owe them \$80,000. To earn the money, the friends decide to play blackjack, as Alan knows how to card-count. When making his pitch for card-counting, Alan argues to his friends that it is a “foolproof system”. Doug challenges him, stating that, “You gotta be super smart to count cards”, to which Alan responds, “Maybe you should tell that to Rain Man, because he practically bankrupted a casino, and he was a

retard.” On top of the derogatory remark about Rain Man, a character from the similarly-named movie who has autism and is extremely proficient at mental calculations, this example highlights stereotypes (held by Doug) about mathematics-related skills used in card-counting being only available to those who are extremely intelligent.

While Alan is playing blackjack, he is shown muttering to himself as well as shutting his eyes in order to, presumably, focus on card-counting. In these scenes, various equations swirl around his head – appearing as though they are floating in mid-air. While a few of the equations relate to card-counting (e.g., combinations of numbers that sum to 21), many appear to have no relevance whatsoever, but simply look ‘difficult’, such as integrals and infinite sums. In the end, Alan’s use of card-counting is highly successful, as he earns more than the \$80,000 needed.

The card-counting examples in *The Hangover* tend to perpetuate the stereotype of mathematics being only available to a ‘select few’ individuals who are highly intelligent. The inclusion of difficult-looking equations serves to make mathematics look mystifying and complicated, and one character, Doug, explicitly states that being ‘super smart’ is required for card-counting, a highly mathematical activity.

Harry Potter

The *Harry Potter* movie series is based on the *Harry Potter* book series by J.K. Rowling. Since the books generally increased in length as the series progressed, the last book was split into two movies. The *Harry Potter* series was among the top movie choices for all participants (#1), as well as for Grade 4 students (#1), Grade 8 students (#2), girls (#1), boys (#3), Grade 4 girls (#1), Grade 4 boys (#2), and Grade 8 girls (#1).

Harry Potter and the Philosopher’s Stone, the first film in the series, was released in 2001, four years after the book was published. The book was selected due to its inclusion of a

chess game and a logic puzzle. Similar to the book, the examples of wizard chess in the movie were brief and did not provide any mathematically-rich information about the game. The second example, the logic puzzle, was not included in the movie at all, which was surprising considering it was a fairly lengthy, detailed example in the book. Many of the other more detailed examples of mathematics content in the book, such as the explanation of wizard money, were not included, and there were fewer incidental examples of mathematics in the movie. Even when an example was featured in both the book and the movie, the mathematics was almost always simplified in the movie. While one can expect changes and omissions when books are converted to movies, I was surprised at how much of the mathematical content was omitted from the movie version of *Harry Potter and the Philosopher's Stone*, especially some of the longer examples. The book is rather short, at just over 200 pages, whereas the movie is rather long, at approximately two and a half hours, so it seems reasonable that the mathematical content could have been included. I also found it surprising that when a mathematically-relevant scene from the book was included in the movie, the mathematical content was typically simplified, when it was simple initially.

Similarly, in the three other movies viewed, *Harry Potter and the Prisoner of Azkaban* (2004), *Harry Potter and the Goblet of Fire* (2005), and *Harry Potter and the Order of the Phoenix* (2007), the number of instances of incidental mathematics is far fewer than in the books and some concepts, such as those regarding money and fractions, are not present in these films at all. One important mathematics-related reference from the books was Arithmancy class, which was present in *Harry Potter and the Prisoner of Azkaban* and *Harry Potter and the Order of the Phoenix*; however, Arithmancy was not mentioned in these or the other two movies viewed.

Harry Potter and the Prisoner of Azkaban was also selected due to the inclusion of time travel by Hermione, using a time-turner necklace. In the movie, as with the book, this was poorly

explained, with little understanding of how the time-turner worked. The hedge maze in *Harry Potter and the Goblet of Fire* was a surface-level example in the book, with only brief references made to a spell involving Cardinal directions. In the movie, this spell does not occur, and the maze is only seen from ground level, so no further details can be discerned.

Overall, the *Harry Potter* movies provided far fewer examples of mathematical content than did the related books. As a result, viewers of the movies are exposed to mathematics in a much narrower fashion (predominately simple number sense and time concepts). Even when a similar, longer example was provided, the mathematical content was simplified. Thus, the viewers of the movies could presume that mathematics plays a very small role in the lives of the *Harry Potter* characters. The movies did not include the Arithmancy class, which provided the basis for discussions regarding intelligence and mathematical skills in the books. Although there were a few references generally to Hermione's intelligence, rule-following behaviours, and 'know-it-all' demeanor, these were fewer in number than in the books, and did not relate to mathematics specifically. Thus, with the removal of references to the Arithmancy class, the mathematics-related references in the movies were all content-related, rather than providing views or stereotypes about the subject area or those who do mathematics.

Television Shows

Ten television shows were initially considered: *The Big Bang Theory*, *Family Guy*, *Glee*, *Hannah Montana*, *iCarly*, *Phineas and Ferb*, *Pretty Little Liars*, *Spongebob Squarepants*, and *The Suite Life on Deck*. While conducting my initial searches, I learned that *The Suite Life of Zack and Cody* is the precursor to *The Suite Life on Deck*, so I included that show as well, which resulted in 11 television shows being considered initially. Table 21 summarizes the number of episodes that aired for each show by June 2011 and the number of episodes selected for analysis.

Table 21
Television Show Episodes Aired and Selected for Analysis

Title of television show	Number of episodes aired by June 2011	Number of episodes selected for analysis
<i>The Big Bang Theory</i>	87	2
<i>Family Guy</i>	165	4
<i>Glee</i>	44	1
<i>Hannah Montana</i>	98	0
<i>iCarly</i>	83	0
<i>Phineas and Ferb</i>	125	2
<i>Pretty Little Liars</i>	25	0
<i>Spongebob Squarepants</i>	293	1
<i>The Suite Life of Zack and Cody</i>	87	3
<i>The Suite Life on Deck</i>	71	1
<i>Wizards of Waverly Place</i>	93	0
Totals	1171	14

The Big Bang Theory has a great deal of mathematical and scientific content in nearly every episode, while *Phineas and Ferb* involves inventions, building, and a mathematically proficient character named Baljeet. Therefore, these two series are not included in the following calculation, as they would skew the results. There were 959 episodes aired of the other nine television shows by June 2011, and only 10 of these episodes were deemed to potentially contain mathematics-related references. This represents a mere 1.0% of the episodes, indicating a paucity

of mathematical examples in these television shows. Below, I discuss my detailed findings by series, and then conclude by drawing comparisons across all the television shows.

The Big Bang Theory

The Big Bang Theory was first broadcast in 2007 and was in its fourth season when the questionnaire data were collected. This half-hour sitcom focuses on the lives of four friends (Sheldon, Leonard, Raj, and Howard), all of whom are scientists (three physicists and an engineer, respectively). These men are depicted as stereotypical ‘geeks’ – socially awkward, not appealing to most women, and interested in ‘uncool’ activities, such as reading comic books and watching science fiction movies (on a level that is depicted as obsessive). The series is targeted at a teenage and adult audience, due to its sometimes mature content (e.g., sexual content). *The Big Bang Theory* was among the top choices for Grade 8 students (#2) and Grade 8 boys (#2).

Although nearly all episodes of *The Big Bang Theory* involve mathematics and/or science in some way (e.g., equations on a whiteboard), for pragmatic reasons, I limited my viewing to two episodes that appeared as though they would contain the greatest amount of mathematics-related references: *The Alien Parasite Hypothesis* (Season 4, Episode 10, 2010) and *The Bus Pants Utilization* (Season 4, Episode 12, 2011). The former was selected as I was already aware that it featured a discussion about the ‘best number’, while the latter was selected because the storyline focuses on the creation of a smartphone app to solve differential equations.

The discussion about the ‘best number’ in *The Alien Parasite Hypothesis* is dominated by an argument put forth by Sheldon, arguably the most socially awkward of the characters, that 73 is the ‘best number’ (based on a variety of mathematical properties). When Sheldon proposes the topic of discussion while having dinner with Raj, Leonard, and Howard, none of the other men is interested, but Sheldon persists with his argument while the others ignore him. At the end of

Sheldon's argument, Leonard turns to Howard and says, "Remember when you were wondering why the girls didn't want to have dinner with us tonight?" to which Howard replies, "Yeah, I get it". This discussion implies that discussing numbers in a social setting, even with physicists and an engineer, is not a topic of interest, particularly not for women.

The rest of the episode did not contain any mathematics-related references, but there were two other pertinent examples. In the first example, Bernadette, a microbiologist who is Howard's girlfriend, tells her friends, Penny and Amy, that she is much smarter than Howard. She shares that, in order to be both sexually and intellectually stimulated, she listens to NPR (National Public Radio, a U.S. radio station that broadcasts news and cultural programming) after she has sex with Howard. Bernadette does not make Howard aware of her views or practices, arguing that "It's important to protect his manhood". Bernadette's argument is underpinned by the stereotypical notion that a man should be dominant in a (heterosexual) relationship in terms of such factors as intellect and income. Indeed, later in the series when Bernadette is hired at a high-paying laboratory job, references are made to her superior income, compared to Howard's income as an engineer (and his resulting feelings of emasculation). The second relevant example occurred during a discussion between Howard and Raj about hypothetical superheroes. Leonard, arguably the most socially adept of the four men, listens and becomes annoyed by the other two men's trivial (but heated) discussion. He bemoans, "Twelve years after high school, and I'm still at the nerd table". Even though Leonard also is interested in superheroes, his comment suggests that his friends' discussions have crossed some imaginary line into being even too nerdy for him.

The creation of a smartphone app that recognizes and solves handwritten differential equations is the focus of *The Bus Pants Utilization*. The episode shows the four men struggling as they design and test the app. Multiple times in the episode, the camera flashes on whiteboards

that contain differential equations. After pausing the video of the show, I was able to confirm that the equations all appear to be written using standard conventions and all appear solvable. References are also made in this episode to legitimate mathematical equations and types of analysis (e.g., Fourier analysis, spherical Hankel function). Notably, *The Big Bang Theory* has employed a particle physicist from UCLA (University of California, Los Angeles) to ensure that the mathematical and scientific content on the show is accurate (Heyman, 2008).

Beyond the mathematical content, the discussions in this episode allude to the differences between the ‘nerdy’ interests of the men on the show, and their attractive restaurant server/actor neighbour and friend, Penny, who is very socially adept. Sheldon is concerned that Penny will steal the idea for the app, to which she responds, “Whatever your secret is, I’m sure it’s boring, so I’m not interested”. Leonard earnestly counters, “It’s not boring at all! You see, in higher order mathematics, there are certain sets of equations that – ”. At this point, he is interrupted by Penny saying, “Bored”. A similar exchange occurs later in the show, when Sheldon attempts to explain to Penny what an algorithm is. As with the earlier ‘best number’ discussion, Penny is distanced from anything to do with mathematics. These exchanges could be indicative of two themes: the distancing of a woman from mathematics and/or the distancing of a ‘cool’ person from mathematics. Certainly, these exchanges do not place mathematics in a favourable light. Additionally, when the men are discussing the target market for their app, Howard suggests that there would only be “70 or 80 guys” who would buy it. Again, mathematics is depicted not only as a male domain, but a subject (at least at this level of mathematics) that interests few people.

The two episodes of *The Big Bang Theory* that were examined provided several stereotypical representations of mathematics and mathematically proficient people. Mathematics was depicted as a boring subject, not of interest to women or ‘cool’ people. Additionally, the

four men (all scientists) were depicted as highly stereotypical nerds. Although a woman is depicted as an intelligent scientist in one of the episodes examined, she conforms to stereotypical notions of hegemonic male superiority. From my viewing of every episode of the show, I can confirm that the themes addressed in the two episodes examined are typical of the show's content. The show has been criticized for the depiction of scientists as stereotypical nerds. However, these criticisms have been challenged by one of the show's creators, Bill Prady, and one of the actors, Mayim Bialik, who plays a socially awkward neuroscientist. They both argue that they know scientists like the characters in real life, and that the characters are depicted in such ways that their quirks are seen as endearing, rather than pathological (Bialik, 2013; Heyman, 2008).

Family Guy

Family Guy was first broadcast in 1999, and was in its ninth season when the questionnaire data were collected. The half-hour animated comedy focuses on the everyday adventures of a dysfunctional American family, the Griffins: a father, Peter; a mother, Lois; two teenage children, Chris and Meg; a baby, Stewie; and a dog, Brian. The series is targeted at a teenage and adult audience, due to its mature content (e.g., violence, sexual content). *Family Guy* was among the top choices for Grade 8 students (#3) and Grade 8 boys (#1).

Four episodes of *Family Guy* were selected for analysis, all of which were found during YouTube searches, rather than from any indications from the episode descriptions. The four episodes were *Mr. Griffin Goes to Washington* (Season 3, Episode 3, 2001), *When You Wish Upon a Weinstein* (Season 3, Episode 22, 2003), *Hell Comes to Quahog* (Season 5, Episode 3, 2006), and *Foreign Affairs* (Season 9, Episode 17, 2011). Although most of these episodes are

several years old, there is still a fairly high likelihood that they would have been seen by the participants since *Family Guy* re-runs are frequently broadcast on several television stations.

The main storyline of the show often cuts away to brief clips about related topics. In *Mr. Griffin Goes to Washington*, Peter tries to persuade Lois that their children should be allowed to skip school to attend a baseball game, with Peter claiming, “There’s nothing these kids learn in school they can’t learn on the street”. The scene cuts away to two men on the street, where one man asks the other where their friend, Louie, is. The second man answers, “Well, you tell me. Louie left his house at 2:15 and had to travel a distance 6.2 miles traveling at a rate of five miles an hour. When will Louie get here?” The first man responds that it “depends if he stops to see his ho”. The second man explains, “That’s what we call a variable”. This scenario parodies the common format of a travel-oriented word problem. While the problem is not solved, it would be possible to do so since all the necessary information is provided. The example of a ‘variable’, while meant to be amusing, is relatively accurate – something that varies and alters an outcome.

The example in *When You Wish Upon a Weinstein* involves Chris asking Peter for help with his math homework, explaining that his teacher insists that he needs to learn mathematics, or he “won’t be able to function in the real world”. The main scene then cuts away to Chris asking for directions at a gas station. The attendant tells him:

Now, what you gotta do is go down the road past the old Johnston place, and you’re gonna find two roads: one parallel [holds fingers parallel] and one perpendicular [holds fingers perpendicular]. Now, keep going until you come to a highway that bisects it at a 45 degree angle. Solve for x .

The scene pans to Chris lying in the fetal position on the ground, sucking his thumb and rocking back and forth. The focus then returns to the main storyline, where Peter says, “Math! [laughter]

Math, my dear boy, is nothing more than the lesbian sister of biology”. In the cut-away scene, the only accurate mathematics is the representation of parallel and perpendicular lines; the rest of the directions are nonsensical and simply sound ‘mathematical’. Chris’s reaction, although exaggerated, parallels the ‘shutting down’ reactions of students who are highly math-anxious (Tobias, 1993). The ‘lesbian sister’ portion of Peter’s comment may be alluding to the presumed masculine nature of doing mathematics, as homosexual women are often stereotyped as being more masculine than heterosexual women. The scene is interrupted directly after Peter’s comment, so no further explanation is given.

In *Hell Comes to Quahog*, Meg is working as Peter’s supervisor at a big box store. When she admonishes him to take the job seriously, Peter replies, “Meg, I promise I’ll do better on this job than I did on the SATs”, which leads to a flashback. Peter is sitting in a mathematics classroom with his classmates, taking the SATs (Scholastic Aptitude¹⁰ Test, a standardized test used in the United States for college admission). The other students pull out their calculators and start working on the test questions, while Peter reaches under his desk and pulls out an Asian boy, sets him on the desk, and says, “Come on – Do math!” while poking him with a pencil. This example highlights the stereotype of Asian people being superior at mathematics, with this boy being paralleled to a calculator. In *Family Guy*, racial stereotypes are often presented, as well as negative, stereotyped portrayals of a number of groups in a shocking, over-the-top manner. The show’s creator, Seth McFarlane, often describes the show as an ‘equal opportunity offender’ (BoxOffice Staff, 2012). Although this could lead one to dismiss this racial stereotype as simply another offensive portrayal of a group by *Family Guy*, it does not minimize its effect, as it perpetuates the notion that Asian people are superior at mathematics.

Foreign Affairs focuses on Peter home-schooling Meg and Chris. Peter hires teachers for mathematics (because he's "no good at it") and driver's education. The teachers are a Black man and an Asian man, and Peter starts discussing driver's education with the Black man, who informs him that he's the mathematics tutor. Peter finds it hard to believe, so he asks the Asian man, "And that means you're the...?", to which the Asian man, in an unimpressed sounding voice, says, "The driver's ed instructor, yes". Peter seems incredulous, replying "Well, I'll be a son of a gun! [Laughter] Alright! Time to learn math from a Black guy, I guess". This example not only reiterates the stereotype from *Hell Comes to Quahog* (2006) about Asian people being good at mathematics, but also stereotypes another racialized group, Black people, as not being good at mathematics. Additionally, the stereotype of Asian people being bad drivers is highlighted when Peter presumes the non-Asian man is the driver's education instructor.

There were a few other mathematics-related references in the four episodes examined. Two of these examples were very brief and would likely not be noticed by viewers: A bar graph is briefly shown in *Mr. Griffin Goes to Washington* and a circular thermometer is briefly shown in *Hell Comes to Quahog*. A second, more detailed example occurs in *Mr. Griffin Goes to Washington* when the U.S. Congress decides to fine a cigarette company for marketing to children. One congressman, Frank, proclaims that they will fine the company "infinity billion dollars". A second congressman replies, "That's the spirit, Frank, but I think a real number might be more effective" and suggests a fine of 100 million dollars. This response is completely mathematically accurate, as infinity is not a real number (either in the strict mathematical sense or the colloquial sense); rather, it is a mathematical concept. Thus, only a real number would be appropriate for a fine, as one could never pay an infinite dollar amount.

In summary, the main mathematics-related references explored in *Family Guy* tended to focus on racial stereotypes about those who are strong in mathematics or use standard-sounding mathematics questions in the ‘real world’ in a parody, with relatively little mathematical content. The additional mathematics-related references found did not focus on stereotypes, and generally were mathematically accurate. Notably, all the characters involved in these examples were men.

Glee

Glee was first broadcast in 2009, and was in its third season when the questionnaire data were collected. The hour-long live-action series is a musical drama-comedy about students in a high school glee club and their coach/teacher, Mr. Schuester. The series is targeted at a teenage audience, due to the setting of the series, as well as the inclusion of more mature topics such as sex and drinking; however, *Glee* also has a large adult following (Guthrie, 2011). *Glee* was among the top choices for Grade 8 students (#1), girls (#2), and Grade 8 girls (#1).

One episode of *Glee*, *A Night of Neglect* (Season 2, Episode 17, 2011), was selected due to the mention of an Academic Decathlon team in the episode’s description. While the short clip of the Academic Decathlon did not feature any mathematics questions, stereotypes about intelligent people (as ‘nerds’ and/or Asian people) were upheld for most of the team members. Mathematical content was featured during a discussion about fundraising. The equation “ $5,000 \times .25 = 20,000$ ” was written on the board, and Mr. Schuester explained to the students that they needed to raise \$5,000 to pay for their trip to the glee club national championships, by selling saltwater taffy at 25 cents per piece. While pointing to each number on the board, he stated, “To make 5,000 dollars, at 25 cents apiece, we need to sell 20,000 pieces of taffy”. While this statement is true, the equation is not correct: It should be “ $20,000 \times 0.25 = 5,000$ ”, indicating that 20,000 pieces of taffy at (i.e., multiplied by) 25 cents per piece would total \$5,000. Interestingly,

when the Academic Decathlon team (all glee club members) mentions that they need \$250 for their trip to the finals, Mr. Schuester makes the adjustments to the (incorrect) equation correctly, changing 5,000 to 5,250 and 20,000 to 21,000. I found it surprising and disappointing that a relatively simple equation would be written incorrectly, especially when it is such a focus of the clip – The episode begins with the camera panning across the equation, and then Mr. Schuester refers to it multiple times. Among the many actors, directors, and other *Glee* employees, someone should have noticed this mistake. This clip was used as a prompt in the student focus group interviews as an example of a mathematical error in the popular media.

Phineas and Ferb

Phineas and Ferb was first broadcast in 2007 and was in its third and fourth seasons when the questionnaire data were collected. This animated half-hour show follows the lives of stepbrothers Phineas and Ferb, who come up with various schemes and inventions in each show. One of their friends, Baljeet, loves to do mathematics and is portrayed as very mathematically proficient. *Phineas and Ferb* was among the top choices only for Grade 4 boys (#3).

Like *The Big Bang Theory*, there were many episodes of *Phineas and Ferb* that contained mathematics-related references, so I selected two episodes that appeared to have the most mathematics content. Namely, *The Baljeatles* (Season 2, Episode 12a, 2009) was selected due to a discussion of Baljeet's feelings and mathematics, while *We Call It Maze* (Season 2, Episode 35a, 2010) was selected due to a mathematics problem (involving guessing the number of jellybeans in a jar). Both of these episodes were found on *YouTube*.

The Baljeatles focuses on Baljeet's enrolment in a summer course called 'Summer Rocks', which he thought was a geology course. To his dismay, it is a course that involves playing rock music, at which Baljeet is struggling. He is terribly upset that he might get an F in

the course (so much so that he cannot even say the letter), so Phineas and Ferb offer to help. When Baljeet explains that he has read every book ever written on rock music, Phineas tries to get Baljeet to realize that rock music is a way to express himself. Phineas asks Baljeet a series of questions about what he does when he is feeling various emotions (e.g., sadness, happiness). Baljeet answers, “Math!” to each question, causing Phineas to ask, “So every feeling you have makes you want to do math?”. Baljeet responds, “I do not know if it is so much cause and effect. I do a lot of math! The feelings come and go.” This exchange hints at the ‘obsessed mathematician’ trope, as Baljeet is depicted as constantly doing mathematics, regardless of how he is feeling. The episode concludes with Baljeet learning that the course is not graded at all, which makes him very upset: “I do not believe this! I wasted all this time in a class without grades!?” He and his friends then break into a song entitled ‘Gimme a grade’, which includes Baljeet singing the following lyrics: “I like my rules, baby, etched in stone, ‘cause you know I am going to stick to them!” and “This isn't a request. I demand there be a test today!” Through this song, Baljeet is again depicted in a stereotypical manner: a rule-follower who is focused on grades. The former may refer to following ‘rules’ in school to get good grades (i.e., ‘doing school’, as elaborated in the same-titled book by Pope, 2001) or following mathematical rules, which may suggest a focus on formulas and algorithms. Moreover, this episode suggests that Baljeet has school smarts (i.e., He would have done well in geology), but not practical life skills (like playing music), particularly those that involve an emotional connection.

Baljeet’s focus on being tested (and thus receiving good grades) is again referenced in *We Call It Maze*. Phineas and Ferb build an elaborate life-sized maze in their backyard and are discussing testing it out. At this point, Baljeet arrives out of nowhere, asking excitedly, “Did somebody say test!?” Baljeet joins the boys and a few other children as they explore the maze,

which contains various puzzles and tasks (e.g., target shooting, chess) that must be completed before they can proceed. At one point, the children must guess how many jellybeans are in a cylindrical jar. Baljeet states that he is really good at solving such problems, and he and Phineas begin discussing the problem:

PHINEAS: So the base of the jar is pi times radius squared.

BALJEET: You are measuring the radius in centimetres, right?

PHINEAS: No, inches. That way the inch fractions work with pi as 22 over 7.

BALJEET: You do not use 3.14 for pi?

At this point, another boy, Buford, becomes frustrated with their discussion, eats all the jellybeans, and says, “Zero!” The door opens to allow them to continue in the maze, and an upset Baljeet says, “Okay, technically that is correct, but you did not show your work”. In this exchange, Baljeet’s rule-following tendencies again become apparent, as he was upset about Buford’s ‘trick’ of eating the jellybeans, even though it allowed them to proceed. In terms of the mathematics content, the correct formula is given for the circular base of the jar. Additionally, the values used for approximations of pi (22/7 and 3.14) are both fairly close, with the former, as discussed, being a useful approximation when using inches as the unit of measurement.

Although I do not have the same familiarity with *Phineas and Ferb* that I have with *The Big Bang Theory*, I was able to garner a solid understanding of the show and the characters from an extremely detailed *Phineas and Ferb* wiki (<http://phineasandferb.wikia.com/>) that I found during my searches. A search for the term ‘math’ on the wiki resulted in several links. After reading the episode descriptions, it became clear that Baljeet is consistently depicted as a ‘math geek’ who is highly focused on doing mathematics and getting good grades. He is referred to as a ‘nerd’ by some of the other characters. In a Christmas DVD (*A Very Perry Christmas*, 2010), the

‘math geek’ description of Baljeet is apparent in his letter to Santa Claus, which reads “First and foremost, I want to thank you for the *Math Games for Nerds* books which have kept me company on many a lonely night”. Not only is mathematics depicted as a nerdy hobby, but Baljeet is depicted as being lonely.

Spongebob Squarepants

Spongebob Squarepants was first broadcast in 1999, and it was in its seventh and eighth seasons when the questionnaire data were collected. This animated half-hour show follows the adventures of Spongebob Squarepants, an anthropomorphic sea sponge who lives under the sea in a pineapple home with his pet snail, Gary. *Spongebob Squarepants* was among the top choices for boys (#2) and Grade 4 boys (#2).

One episode of *Spongebob Squarepants*, *The Cent of Money* (Season 7, Episode 139b, 2010), was selected due to its focus on money. However, the episode did not contain any mathematical content; rather, it focused on the use of SpongeBob's snail, Gary, to collect change for SpongeBob's unethical boss, Mr. Krabs, due to a magnet in Gary's stomach. The coins are never counted, no monetary amounts are discussed, and the coins themselves do not have any numeric details, so this episode was not mathematically relevant.

The Suite Life of Zack and Cody

The Suite Life of Zack and Cody (SLZC) was first broadcast in 2005 and ended in 2008 when a spin-off series, *The Suite Life on Deck* (SLOD), began. The half-hour live-action show centers on the adventures of pre-teen twins Zack and Cody, who live in an upscale hotel in which their mother performs. Zack is portrayed as the more adventurous, outgoing twin who struggles with school, whereas Cody is portrayed as being highly intelligent, mature, and sensitive. Due to the ages of the main characters and the topics explored, SLZC is arguably targeted at a pre-teen

or early teenage audience. As noted earlier, *SLZC* was not among the top shows listed by the questionnaire participants, but it was included since it is the precursor to *SLOD*, which was the top television show for all participants and in the greatest number of gender/grade categories.

Three episodes of *SLZC* were included in this analysis. The first episode examined, *Hotel Hangout* (Season 1, Episode 1, 2005), was chosen for its inclusion of mathematics tutoring.

London, the teenage heiress of the hotel, is forced to get a mathematics tutor as her father is not happy with her grades. Maddie, a hardworking and intelligent teenage girl who works at the hotel, is selected as London's tutor after the hotel's manager (who acts as London's guardian) sees Maddie complete what he considers to be an amazing mathematical feat. While working as a cashier, London calculates a customer's bill in her head before the cash register has time to do so: "Okay, that's \$9.12, minus your 8% senior discount is \$8.38. Out of \$10.00? \$1.62 is your change." The hotel manager is flabbergasted, stating, "You beat the cash register!", while Maddie doesn't seem to see it as a remarkable feat. This example highlights stereotypes surrounding mathematical genius, such as the ability to perform complicated calculations rapidly in your head. In this example, the calculation of the change should be relatively simple for a girl Maddie's age, whereas calculating the discount of 8% would be more complex, since neither \$9.12 nor 8% are simple numbers for mental mathematics calculations. However, Maddie's first calculation is actually incorrect – The new price should be \$8.39, not \$8.38. My initial idea was that there was a rounding error. However, the answer would clearly round to \$8.39 if one calculated the remaining price in one step ($9.12 \times 0.92 = 8.3904$). If one calculated the discount first ($9.12 \times 0.08 = 0.7296$) and rounded incorrectly, the discount would be \$0.72, resulting in a discounted price of \$8.40. Although this may seem like a tiny error, it, like the *Glee* example, provides an example of a mathematical error being made by the adults who work on these shows.

The second episode selected, *Cody Goes to Camp* (Season 1, Episode 10, 2005), featured many mathematics-related references due to its focus on Cody attending math camp. This is the episode from which the clip for the Grade 4 focus group interviews was selected (about the ‘nerdy’ stereotype). The episode begins with Cody explaining to the hotel manager, Mr. Moseby, that he and his friend, Tapeworm, will be attending math camp for two weeks. Cody and Tapeworm are very excited and make mathematics-related jokes and comments about the camp (e.g., “They serve three squared meals a day. Get it, squared? You know, math camp?”). When asked if he would be attending the camp, Zack claims that he told his teacher she couldn’t pay him to spend two weeks with “a bunch of math geeks”, although Cody points out that Zack failed his mathematics test. When Zack claims that he failed on purpose to stay away from Cody, Cody reminds him that he also got a D in English, thus challenging Zack’s claim. Zack continues to make comments throughout the show about ‘math geeks’ (e.g., how they can’t get dates) and how math camp can’t possibly be fun, but these comments are primarily driven by the fact that he is missing Cody. At math camp, Cody, Tapeworm, and their new friend, Warren, have fun talking about mathematics, playing mathematics games, and exploring mathematics in nature. There were few references to mathematical concepts, and these references often provided little detail, other than a ‘guess the shape’ game, where the full definition of a spherical polygon was (correctly) given. One small error comes when Warren sits on his compass, and Cody jokes that at least Warren can use the compass to measure the angle of his scar. However, one would need a protractor (or other such tool) to do this, as one cannot measure angles with a compass. When Zack comes to the camp (under the guise of ‘rescuing’ Cody) with Maddie and London, Tapeworm and Warren are excited by the arrival of the attractive young women. Warren states, “That’s never happened in the history of Camp Knock-A-Number”. The girls do not seem

interested in the boys at math camp, which serves to reinforce Zack's stereotypical notions about 'math geeks'. Additionally, this example highlights gender stereotypes about mathematically proficient people (i.e., They are not attractive girls and women). Overall, the examples in this episode perpetuate the notion that mathematically proficient people are 'nerdy'. Even as someone who loves mathematics and mathematics jokes, I found the examples tiresome and corny, and imagine they would be annoying to most viewers. I think the writers did a disservice to mathematics in this episode, as they portrayed mathematically proficient people in a narrow, unflattering, and stereotypical way.

The third episode examined, *Books and Birdhouses* (Season 2, Episode 9, 2006), was selected due to its inclusion of an advanced mathematics course in which Cody attempted to enroll. When discussing the first day of the new semester, Zack explains that he's doing really well in wood shop and that the teacher loves him, which surprised both him and his mother, as he usually struggles with school. Cody was upset that his elective class, "advanced calculus, covering functions, limits, convergence, sequences, and multivariables", was cancelled when he was the only one (including the teacher) to show up. Their mother seems taken aback by the topics Cody lists (mostly reasonable calculus topics, other than 'multivariables', which is not a word; perhaps the writers, incorrectly, came up with this term from 'multivariable calculus'), and suggests he take a less challenging elective. To mock Zack and to prove how easy wood shop is, Cody enrolls in the class – but he ends up struggling, while Zack continues to excel. This example of a 'mathematical genius' struggling with a less 'academic', more 'practical' subject aligns with stereotypes about mathematical geniuses being incredibly book smart, but not very street smart; such stereotypes also underpin nearly every episode of *The Big Bang Theory* and were shown in one of the examples involving Baljeet on *Phineas and Ferb*. These stereotypes

may arise from the notion that mathematically proficient people spend all their time working alone on mathematics problems, and thus fail to interact with the world around them.

Overall, the examples in *The Suite Life of Zack and Cody* perpetuated stereotypes surrounding mathematically proficient people – that they are socially inept, able to complete complicated calculations in their heads, and that they lack ‘practical’ skills. Little mathematical content was shown in the examples, and the content shown occasionally had errors.

The Suite Life on Deck

The Suite Life on Deck (SLOD) began in 2008 as a spin-off from *The Suite Life of Zack and Cody (SLZC)*. The series was in its third and final season when the questionnaire data were collected. *SLOD* follows twins Zack and Cody as they attend high school on a luxury ship that travels the world. As with *SLZC*, *SLOD* is a half-hour live action show, although aimed at a slightly older audience to parallel the ages and experiences of the show’s characters. *SLOD* was the most common ‘top’ response (#1 in six of the nine gender/grade categories), ranking #1 for all participants, Grade 4 students, girls, boys, Grade 4 girls, and Grade 4 boys.

One episode of *SLOD* was selected for analysis: *Smarticle Particles* (Season 2, Episode 5, 2009), in which London, who is portrayed as a ‘ditzzy’ classmate of Zack and Cody, attempts to use ‘special’ perfume to help her do better in mathematics. Bailey, Cody’s highly intelligent girlfriend, bets him that she can raise London’s mathematics mark to a B. Cody is incredulous, as he was unsuccessful helping London in the past, due to her inability to focus. Bailey’s first attempt to help London is very similar, ending with Bailey ripping up the mathematics textbook in frustration. After reading about the placebo effect, Bailey changes her approach to tutoring London. Bailey pretends to forget part of the Pythagorean Theorem, only being able to say ‘a squared plus b squared equals’. She sprays perfume on herself and suddenly states the rest of the

equation, ‘c squared’. She tells London that the perfume has special properties that enhance neurological function. London uses the perfume, works harder as a result, and ends up with a C+ on her mathematics test. Shocked by the result and Bailey’s methods, Cody accuses her of lying to London, which London overhears. Very upset, London cries, “I’m not smart! I only smell smart!”. Bailey tries to comfort London, explaining that she is smart, as she earned the grade on her own, but London is inconsolable. Bailey panics and explains that she has special ‘smart lipstick’, which London gratefully (and gullibly) accepts and uses, resulting in a B+ on her mathematics final.

This example highlights the importance of believing in one’s own mathematical abilities. Before using the ‘smart’ products, London believed that she was unintelligent, potentially due to prior interactions she may have had with her peers, teachers, and/or parents. She was not able to focus on the material because she didn’t think she could learn it. However, when given more confidence in herself (albeit due to the placebo effect), London proved that she could work hard and succeed in mathematics. While lying to students or using placebos is certainly not recommended, this example highlights the importance of getting students to believe in themselves and their mathematical abilities before they can tackle problems. On a more negative note, this example promotes the stereotype of mathematical intelligence being ‘magical’. Granted, London is portrayed as being very gullible in general, but she was quick to believe that Bailey’s success in school, especially mathematics, was due to ‘magic’ rather than hard work.

Summary of the Mathematics-Related References in the Television Shows Examined

The mathematics-related references from the television shows focused far more on stereotypes and ideas about mathematics rather than mathematical content, which is the reverse of the mathematics-related references in the books and movies. The ideas presented about

mathematics and mathematically proficient people in the television shows were overwhelmingly negative and stereotypical, such as racial stereotypes, gender stereotypes, and stereotypes about being ‘nerdy’. The mathematics content tended to contain errors or to just sound ‘mathematical’, rather than making any mathematical sense, which may serve to confuse viewers and make mathematics seem mystifying and difficult to understand. Other than *The Big Bang Theory* and *Phineas and Ferb*, fewer than 5% of any other show’s episodes featured any mathematics-related references, insofar as I could discern from my initial searches. This overall lack of mathematics-related references may suggest to viewers of these television shows that mathematics is not an important part of ‘real life’ (i.e., life beyond mathematics class). Viewing these shows exposes students to a host of negative ideas about mathematics and mathematically proficient people, which arguably can be quite detrimental unless the ideas are unpacked and challenged.

Websites

There were seven websites in the ‘top’ choices, but three were not included in the analysis: *Facebook*, *Google*, and *YouTube*. While there are a few numbers one would encounter when using these websites (e.g., friends’ birthdates on *Facebook*; the number of views for a *YouTube* video), these numbers are incidental and a minor portion of each website. Additionally, each site provides an enormous diversity of options, so it is not clear what students are viewing. The four ‘top’ websites that were analyzed were *Club Penguin*, *Family Channel*, *Miniclip*, and *Webkinz*. No messages or stereotypes about mathematics or mathematicians were found on any of these websites, so the discussions are limited to mathematical content.

Club Penguin

The *Club Penguin* website (www.clubpenguin.com) is a Massively Multiplayer Online Game (MMO/MMOG; i.e., an online game that allows thousands of players to participate

simultaneously). In the virtual world of *Club Penguin*, each player uses a cartoon penguin as an avatar, and participates in various games and social activities with other players' penguin avatars. The *Club Penguin* website began in 2005, and soon after being posted on the *Miniclip* website in 2006, it became the top game therein (Club Penguin, 2012). The *Club Penguin* website targets children aged 6 to 14, although all ages are allowed to play. The *Club Penguin* website was among the top choices for Grade 4 students (#3) and Grade 4 boys (#2).

Since I do not have a *Club Penguin* account, the below information was garnered from descriptions on Wikipedia and the Club Penguin site, rather than from game play. No preview of the virtual world was available. Players earn coins through playing mini-games, and then use the coins to purchase items for their penguin, such as clothing or furniture for the penguin's igloo home. Each player has an inventory card that outlines the items that have been purchased. In the 'Parent's Guide' section of the website, mathematical skills are touted as one of the many benefits of playing *Club Penguin*: "By accumulating and spending virtual coins earned through game play kids practice math and learn about money management" (Club Penguin, 2012).

Family Channel

The *Family Channel* website (www.family.ca) is targeted at viewers of the *Family Channel*, a cable television channel that provides programming for children and young teenagers, ages 2 to 15. Accordingly, much of the website is devoted to links about the shows on the *Family Channel*, including three of the top choices from the questionnaire: *Hannah Montana*, *Phineas and Ferb*, and *The Suite Life on Deck*. The site also has links to games, music videos, contests, and information about young celebrities. The *Family Channel* website was among the top choices only for Grade 4 girls (#2).

A search for the term ‘math’ did not result in any meaningful links on the site. The only examples were questions on three ‘casting call’ quizzes, where one’s responses to multiple-choice questions are linked to a certain character on a television show. For instance, on the *Hannah Montana* questionnaire, the only mathematics-related question was “What is the one thing that people find surprising about you? a) You are super sporty! b) You rock math and sciences!” By selecting b), my character was Hannah Montana. However, when I watched several episodes of the show, I did not see any evidence of this claim.

Miniclip

The *Miniclip* website (www.miniclip.com), which began in 2001, is the world’s largest privately owned online gaming site, with more than 65 million players per month (Miniclip, 2012). The site features hundreds of games, which are organized into more than 70 categories (based on topic, type, or platform). Although the games are free to play, it is recommended that players register so their game-play statistics (e.g., high scores, rankings) can be tracked. The *Miniclip* website was among the top choices for all participants (#3), as well as for Grade 4 students (#1), boys (#2), Grade 4 girls (#3), Grade 4 boys (#1), and Grade 8 boys (#3).

I began by searching through the categories that I thought might feature mathematics-related references: ‘Back to School’, ‘Brain Training’, ‘Educational’, ‘Learning’, and ‘Puzzle’. The first two categories primarily featured word games and sports games, with no mathematics games shown. A few mathematics games, such as ‘Math Blaster’ and ‘Da Numba’, were included in the ‘Educational’ and ‘Learning’ categories, but the focus again seemed to be more on word games. The ‘Puzzle’ category featured hundreds of games, so it was not feasible to investigate the content of each game. Disappointingly, during my search, I found that one of the categories is ‘Games for Girls’, which features stereotyped, sexist games (e.g., games with cute

animals, word games, games about relationships). No parallel ‘Games for Boys’ category exists. A search of the site for the term ‘math’ only resulted in one game, ‘Math Blaster’, even though there were clearly a few other games that focused on mathematics. I played ‘Math Blaster’ and ‘Da Numba’, both of which privileged speed and tended to focus on arithmetic.

Webkinz

The *Webkinz* website (www.webkinz.com), which began in 2005, is unique due to its link to real-world items: stuffed animals. *Webkinz* stuffed animals come with secret codes that allow their owners to access the ‘Webkinz World’. One must own a *Webkinz* stuffed animal in order to access the full virtual world (Free accounts are available, but access is limited). This website and related products have thus been criticized for encouraging consumerism in children (Lazarowitz, 2007). This virtual world is similar to the one in *Club Penguin*, in that players use avatars (in this case, the same animal as the stuffed toy) to interact with other users. *Webkinz* targets a similar age group (ages 6 to 12) to *Club Penguin*. *Webkinz* is quite popular, with the site reporting one million users within the first year (Ogles, 2007). The *Webkinz* website was among the top choices for Grade 4 students (#2), girls (#3), and Grade 4 girls (#1).

The following information was garnered from viewing the ‘Take a Tour’ animated video provided on the website. This video clearly demonstrated the way the virtual world functions. Users begin with \$2,000 in ‘KinzCash’ (virtual money used in the Webkinz World), and then can spend their money on various items. KinzCash can be earned by playing games, doing virtual jobs, and participating in learning activities. Players are expected to care for their virtual pets, and meters are shown that indicate the pet’s health, happiness, and hunger. The meters are bars with the level indicated by both a numeric value (out of 100) and a colour (similar to traffic light colours). In the ‘Parent’s Area’ of the website, mathematical skills are touted as one of the

benefits of playing in the Webkinz World: “Your child can learn about money in Webkinz World; by earning KinzCash, your child learns how to save and spend money.” Lazarowitz (2007) found this claim to be true, as players learn how to budget their KinzCash.

Summary of the Mathematics-Related References in the Websites Examined

None of the four websites examined were found to have any messages about mathematics; thus, only mathematics content was discussed. *Club Penguin* and *Webkinz* were very similar sites – virtual worlds where players used cartoon avatars to interact. Both sites used virtual money, so players were exposed to various money concepts (e.g., budgeting). The *Family Channel* website featured virtually no mathematics-related references, as it primarily focused on the channel’s television shows. While the *Miniclip* website featured hundreds of games, very few of them focused on mathematics explicitly, although it could be presumed that many of the other games may include spatial skills (e.g., jumping, shooting). The mathematics-focused games tended to present the subject area in a narrow way, focused on speed and arithmetic. Other than the websites with virtual worlds, very little mathematical content was present in the sites examined and no messages (other than the message implicit in the lack of content) or stereotypes about mathematics were apparent.

Video Games

Six video games were analyzed (Genres listed in parentheses): two *Call of Duty* (COD) games (*Black Ops* and *Modern Warfare 2*; first-person shooter), *Lego Batman* (action-adventure), *Mario Kart* (go-kart racing), *NHL 11* (hockey), and *Super Mario Bros.* (platform). Information about the video games primarily came from two sources: an online questionnaire completed by my personal contacts (mostly young adults from Canada) and observations of game play. These video games did not feature any messages about mathematics or

mathematicians. Thus, in the findings, I strictly discuss mathematical content. Table 22 provides an overview of each game and its ranking for each of the grade/gender groups (as per the student questionnaire responses). Only ‘top three’ responses that met the 20% cut-off were included in the analysis; thus, some gender/grade groups do not have a third-place video game listed.

Table 22
Information about the Top Video Game Choices

Group	Video Game (ESRB rating)					
	COD: Black Ops (M)	COD: Modern Warfare 2 (M)	Lego Batman (E10+)	Mario Kart (E)	NHL 11 (E10+)	Super Mario Bros. (E)
All participants	#2	--	--	#1	--	#3
Boys	#1	#3	--	--	#2	--
Girls	--	--	--	#1	--	#2
Grade 4	--	--	--	#2	--	#1
Grade 8	#1	#3	--	#2	--	--
Grade 4 boys	--	--	#1	--	--	#2
Grade 4 girls	--	--	--	#2	--	#1
Grade 8 boys	#1	#2	--	--	#3	--
Grade 8 girls	--	--	--	#1	--	--

Note. The Entertainment Software Review Board (ESRB) provides ratings based on game content (e.g., violence, nudity). An ‘M’ rating refers to ‘Mature’ (ages 17+), while ‘E10+’ refers to ‘Everyone ages 10 and older’, and ‘E’ refers to ‘Everyone’. A ‘--’ indicates that a video game did not rank in the top three for a particular group.

As shown in Table 22, gender and grade-level trends related to the video games' genres were shown, such as boys' preference for first-person shooter games and younger students' preference for the two *Mario* games. Although most of the top games are age-appropriate for Grade 4 and Grade 8 students, the two *Call of Duty (COD)* games, due to their realistic violent content, are targeted at an older audience.

Next, Table 23 provides information about each game, related to the (adult) video game questionnaire participants' responses. Specifically, I discuss the percentage of the questionnaire respondents who play each game, their perceptions of the mathematical content in each game, and their perceptions of the mathematical skills needed to play each game.

Table 23

Questionnaire Respondents' Views of the Video Games' Mathematical Content and Skills

Game (Number of respondents)	Percentage of players*	Mathematical content		Mathematical skills	
		Top responses	'None'*	Top responses	'None'
<i>COD: Black Ops</i> (<i>n</i> = 45)	35.6%	Scores/Statistics (50.0%)	25.0%	Spatial Skills (43.8%)	12.5%
<i>COD: Modern Warfare</i> (<i>n</i> = 42)	19.0%	'Same as <i>Black Ops</i> ' (75.0%)	25.0%	'Same as <i>Black Ops</i> ' (37.5%)	25.0%
<i>Lego Batman</i> (<i>n</i> = 42)	21.4%	Scores/Statistics (44.4%) Graphs (33.3%) Money (33.3%)	33.3%	Logic (44.4%) Problem-Solving (33.3%)	11.1%
<i>Mario Kart</i> (<i>n</i> = 42)	92.9%	Scores/Statistics (41.0%) Rankings (38.5%)	17.9%	Spatial Skills (33.3%)	12.8%
<i>NHL 11</i> (<i>n</i> = 36)	19.4%	Scores/Statistics (71.4%)	28.6%	Calculations (28.6%)	57.1%
<i>Super Mario Bros.</i> (<i>n</i> = 36)	83.3%	Scores/Statistics (66.7%)	20.0%	Spatial Skills (40.0%)	33.3%

Note. A 'player' is any respondent who indicated that he or she had experience with the game. 'None' refers to the percentage of players who stated there was no mathematical content or no mathematical skills involved in a game.

For most games, only a small proportion (one-fifth to one-third) of the respondents had any experience playing them. The exceptions were the two Mario games, which had been played by the vast majority of respondents. For all games, the most commonly reported mathematical

content was scores/statistics. Spatial skills were the most commonly reported mathematical skills needed to play the video games. For nearly all the games, a minority (between one-tenth and one-third) of the players claimed that no mathematical skills or content were involved; the one exception was *NHL 11*, where nearly 60% of the respondents claimed no mathematical skills were required (e.g., Some respondents stated that they simply “mash buttons”).

I had the opportunity to observe adult volunteers playing four of the six games: *Call of Duty: Black Ops* (one volunteer), *Lego Batman* (two volunteers), *Mario Kart* (three volunteers), and *Super Mario Bros.* (two volunteers). Each game devotes the majority of the screen to gameplay, with just a few statistics and scores shown. *Call of Duty: Black Ops* and *Mario Kart* also feature small maps on the screen. However, the volunteers consistently reported that they pay little attention to either the scores/statistics or the maps while they are playing. At the end of each race in *Mario Kart*, players’ rankings and points awarded (based on rankings) for the race are shown. The participants noted that it is important to keep track of point totals to see if it is mathematically possible to win the game in the remaining rounds; this requires mental calculations by the players. In contrast to the lack of attention paid to the scores/statistics, the players all argued that spatial skills are essential to success in each game. The games generally adhere to physics laws, so players are attentive to such details (e.g., planning carefully when to fire a weapon, choice of size and type of go-kart). The volunteers who played *Lego Batman* also shared that problem-solving and logic skills were essential in order to solve the game’s puzzles.

Although there were no gender stereotypes related to mathematics, gender was a salient feature in all of the games. Namely, in the *Call of Duty* games, *NHL 11*, and *Super Mario Bros.*, all playable characters in the games are men; the same is also true for the majority of playable characters in *Lego Batman* and *Mario Kart*. Women are occasionally shown as bystanders in the

Call of Duty games, but they cannot be killed (whereas all of the ‘enemies’ who can be killed are men). Notably, the goal of *Super Mario Bros.* is to rescue Princess Peach, which aligns with the ‘damsel in distress’ trope. Additionally, in *Mario Kart*, the characters who are girls and women are heavily feminized (e.g., princesses), as are their vehicle selections (e.g., pink).

Summary of Mathematics-Related References in the Video Games

Six video games were examined for mathematics-related references: *Call of Duty: Black Ops*, *Call of Duty: Modern Warfare 2*, *Lego Batman*, *Mario Kart*, *NHL 11*, and *Super Mario Bros.* None of these video games provided any explicit messages about views of or stereotypes regarding mathematics or mathematicians, although more general gender stereotypes were prevalent. Thus, information was gleaned from implicit messages related to the mathematics content of the games. In all games, spatial skills are essential in order to succeed, and this was readily recognized by the volunteers who were observed, whereas the questionnaire respondents’ views were mixed. This difference perhaps speaks to the questionnaire respondents’ lack of recognition of spatial skills as being mathematically-related. Since the players who were observed had quite strong mathematical backgrounds, they were more likely to understand and recognize that spatial skills are an important aspect of mathematics. While scores and statistics were listed as mathematical content for all the games, the focus was rarely on these data while gameplay occurred, according to the participants observed. Thus, players who do not recognize spatial skills as being mathematics-related could conceivably view mathematics as being completely unimportant to playing video games, since the mathematics content within the games (i.e., scores and statistics) were generally not a focus.

Student Focus Group Interviews

This section addresses the findings from the analysis of the student focus group interviews. Since the Grade 4 and Grade 8 students took part in separate focus group interviews and were exposed to different media prompts, the findings are presented by grade level. However, for the media prompts that were shown to both the Grade 4 and Grade 8 students, grade-level comparisons are made. As discussed in the Methodology chapter, the focus group participants selected their own pseudonyms. For further identification, the participants' genders and grade levels are provided with direct quotations. In this section, the notation FG# refers to the focus group number (e.g., FG3 refers to the third focus group interview that occurred).

Grade 4 Focus Groups

Eleven Grade 4 students, all from one school (E2S6), took part in focus group interviews. The participants were placed into three focus groups (FG1 – one girl and two boys; FG2 – two girls and two boys; and FG4 – three girls and one boy). All Grade 4 focus group participants were shown television clips from *The Simpsons* (highlighting gender stereotypes) and *The Suite Life of Zack and Cody* (highlighting the 'math geek' stereotype). The participants in the first two focus groups (FG1 and FG2) also viewed 10 student drawings of mathematicians. The participants in the other focus group (FG4) did not complete this task, as they were called back to class. Below, I report on the findings related to each media source, as well as additional findings not directly related to the media prompts.

The Simpsons Clip

The clip from *The Simpsons* featured the show's school principal, Principal Skinner, making remarks in front of a large crowd of townspeople about how boys are better than girls at mathematics. His comments included references to mathematics and science being 'the real

subjects'. At the conclusion of his comments, the townspeople booed and threw debris at Principal Skinner. This clip was selected in order to prompt discussion about gender stereotypes.

Overall, the participants felt that Principal Skinner's remarks were both incorrect and cruel. The vast majority of the participants (9 of 11) held an opinion similar to that of Me (Grade 4 boy, FG2): "It doesn't matter if you're a boy or a girl. It's just that you might not be good at some things and you might be good at other things... You're just you." Little Man (Grade 4 boy, FG1) felt similarly, stating that, "Everyone has a special talent". Many participants felt that Principal Skinner was being particularly mean with his comments since there were girls and women in the audience who would have been offended. Only two participants asserted that either boys or girls are superior in mathematics. Hayd (Grade 4 boy, FG2) stated that boys were better than girls at mathematics, claiming that he had heard this on a television show. Hayd was unable to provide further details (e.g., name of the television show) when prompted. However, when another participant, Me (Grade 4 boy, FG2), suggested the *CBC News*, Hayd agreed. In contrast, Cool (Grade 4 girl, FG2) commented several times during the focus group interview that "Girls rule!" (a comment also made by Kitty Cat, Grade 4 girl, FG2) and argued that girls were superior to boys at mathematics. Interestingly, her argument relied on stereotypical notions about girls' preferred activities. Cool (Grade 4 girl, FG2) claimed that "Boys work out more and girls shop"; thus, Cool reasoned, girls are better at mathematics because they have a good understanding of money. Me (Grade 4 boy, FG2) challenged that this would not apply to all kinds of mathematics – although he did accept Cool's claim with regard to girls' superiority with money-related mathematics. No participants in Focus Group #2 challenged the premises behind Cool's argument (e.g., not all girls like to shop; mathematics is involved with working out).

In Focus Group #4, the participant who summarized the video clip misinterpreted what happened: Mishma Oring (Grade 4 girl, FG4) thought that Principal Skinner reversed his position after the audience became upset, thus stating that girls were better than boys at mathematics. During the interview, I decided not to intervene – both in order to see where the discussion would go and in order to maintain my ‘least adult’ role (by not correcting the participant). Both of Principal Skinner’s stances were seen to be wrong, since the participants felt that boys and girls were equally good at mathematics. Sofia Melion (Grade 4 girl, FG4) worried that Principal Skinner’s revised position would hurt the feelings of the boys and men in the audience. Mishma Oring (Grade 4 girl, FG4) noted that this stance would not be logical since Principal Skinner is a man, which suggests the notion of ‘sticking together’ with your own gender. This was seen in the two examples discussed earlier, in which Cool, a girl, claimed that girls were better at mathematics, whereas Hayd, a boy, claimed that boys are better at mathematics. Although Mishma Oring (Grade 4 girl, FG4) argued that Principal Skinner was at liberty to change his position and thus remedy the situation, she reasoned, “If you say something, you can correct it – just you shouldn’t correct it and make other people feel bad [sic]”.

Although most participants felt that girls and boys were equally good at mathematics, participants in Focus Group #1 and Focus Group #2 suggested that there were other fields where gender equality was not the case. The participants in Focus Group #4 denied such a possibility, regardless of the field, although they noted that their classmates routinely claim that boys are better than girls at sports. In Focus Group #1, the participants suggested that it might be true that boys were better than girls at sports and that girls were better than boys at dancing. The participants were quick, however, to offer counter-examples, such as Little Man’s (Grade 4 boy, FG1) breakdancing talents. The participants thus concluded that these statements might be true

for most boys or most girls, but not all boys or all girls. In Focus Group #2, the suggestion of gender differences was similar, with boys being seen as being physically stronger than girls. Again though, the participants noted that this was not always true, with both Cool (Grade 4 girl, FG2) and Me (Grade 4 boy, FG2) arguing that girls can become physically strong as well.

Notions of physical strength were also highlighted when the participants were asked how they would react if they were audience members listening to Principal Skinner's speech, or if someone said something similar to them in 'real life'. Although a few participants suggested that they would have a non-violent reaction, such as telling the person that what he/she was saying was untrue, making a speech to the audience, or booing at Principal Skinner, most of the proposed reactions involved violence. Many participants suggested that they would kick, hit, or shoot the person who made the comments. In a couple of instances, this violence was particularly gendered, such as Mishma Oring's (Grade 4 girl, FG4) suggestion that she would "punch him [the person who made the comments] in the downstairs area". This remark involves the presumption that a person who would make such comments would be a man or boy, and that an appropriate reaction would involve a potentially emasculating injury to the genitals. Related to the earlier discussion about physical strength, Cool (Grade 4 girl, FG4) posited that she would react to such comments by showing the person how (physically) strong she was. Arguably, such a reaction would position Cool as having valued characteristics typically associated with boys.

Finally, the participants uniformly disagreed with Principal Skinner's comment about mathematics and science being the 'real subjects'. This comment was seen as being both offensive and incorrect. As Sofia Melion (Grade 4 girl, FG4) argued, "If that's the kind of thing he's going to say, I don't think he should be a principal". The participants claimed that all the subject areas were important and would be used outside school, both now and later in life. Me

(Grade 4 boy, FG2) acknowledged that mathematics and science are important, but stated that other subjects are also necessary: “They’re [Mathematics and science are] big subjects. You can’t do most things without science, and you can’t do anything without math, but there are other things you need to have.” Both Kitty Cat and Cool (Grade 4 girls, FG2) contended that art was also very important and that it was involved in many subjects, including mathematics. Cool also argued that language arts and social studies were important, in order to learn to read, write, and use computers. She summarized by saying, “Everything is a real subject!” and proposing that one’s job prospects would be limited by only having knowledge in certain subject areas.

The Suite Life of Zack and Cody Clip

As discussed in detail earlier (in the findings about the television shows), the clip from *The Suite Life of Zack and Cody* features a discussion between pre-teen twins Zack and Cody about Cody attending an upcoming math camp, where Zack makes comments about ‘math geeks’. This clip was selected to prompt discussion about the ‘math geek’ stereotype. When asked why they thought Zack was making comments about ‘math geeks’, no participants believed that Zack actually felt that way. The most common explanation provided was that Zack was jealous – both that Cody does well in mathematics and that Cody has the special opportunity to attend math camp. Many participants commented that Zack was ‘dumb’ or ‘not as smart’ as Cody, and this feeling of inferiority led to Zack’s derogatory comments. A few participants thought that Zack would actually like to attend the math camp, despite his comments. No participant felt that being good at mathematics and/or liking mathematics meant that you were a ‘geek’. For instance, Me (Grade 4 boy, FG 2) stated that such people “just want to learn”. During the discussion, a few participants shared that they and/or another focus group participant were good at and/or liked mathematics. Although no participant explicitly stated “But I’m/he’s/she’s

not a geek!”, providing the example of themselves or another socially valued member of the focus group (Recall that students who got along well were placed in the same focus group) acted as a counter-example to the ‘geek’ stereotype.

Although the participants were aligned in their feelings about people who like/are good at mathematics not being ‘geeks’, participants in two focus groups (FG2 and FG4) shared stories of bullying occurring related to being particularly good at or struggling with a certain subject area, such as mathematics, or being a strong or weak student overall. According to the participants’ descriptions, a student like Cody could be at risk socially due to his success in mathematics, since he would be considered a ‘geek’, and so could a struggling student like Zack, since he would be considered ‘dumb’. Cool (Grade 4 girl, FG2) found this particularly troubling: “If you’re too smart, you get bullied. If you’re not smart, you get bullied. It’s not fair!” In Focus Group #2, both Cool and Me (Grade 4 boy) discussed how smart students may pre-emptively act like bullies and ‘cool kids’ in order to avoid being bullied themselves.

Focus Group Participants’ Discussion of the Drawings of Mathematicians

Ten student drawings of mathematicians were selected as prompts for the focus group discussions. Each drawing represented a distinct ‘character’ (e.g., teacher, nerd; see Appendix F). Following the discussions about the video clips, I placed the 10 mathematician drawings on the table in front of the participants. I initially gave the participants time to react spontaneously to the drawings, and then asked some questions. As noted earlier, only Focus Groups #1 and #2 were shown the drawings, since the participants in Focus Group #4 had to return to class early.

In contrast to the participants in Focus Group #2 (who did not discuss the mathematics content in the drawings at all), the participants in Focus Group #1 spent quite a bit of time discussing the mathematics content in the drawings. As soon as I laid out the drawings,

participants in Focus Group #1 commented on the $E = mc^2$ equation that was featured in some drawings. Little Man (Grade 4 boy, FG1) tried to explain the equation's variables to the other participants, while Jordy (Grade 4 boy, FG1) tried to explain to the other participants how to solve algebraic equations (which were shown in other drawings). Certainly, both of these types of equations are well beyond the level of mathematics in the Grade 4 curriculum, but the participants appeared to have a reasonable understanding of their content.

In both focus groups (FG1 and FG2), the participants were in agreement about which ‘characters’ in the drawings were definitely not mathematicians: the ‘wacky character’ (#9), the wizard (#10), the ‘nerd’ (#7), the teacher (#5), and the mathematicians wearing lab coats (#2 and #8). The first three examples were simply seen as being silly characters, not ‘real’ people, while lab coats were seen as indicators of being scientists and therefore, according to the participants, not mathematicians. The participants’ views of teachers being mathematicians were mixed. In Focus Group #1, the participants argued that only mathematics teachers were mathematicians because “you have to be good at math” (Little Man, Grade 4 boy, FG1). In Focus Group #2, the participants tended to think that teachers were not mathematicians, although they allowed that one could be both a teacher and a mathematician. Even though the teacher in the drawing is clearly teaching mathematics, Cool (Grade 4 girl, FG2) argued that the teacher looked like she taught another subject area since “math teachers should wear geeky outfits”. This comment stands in contrast to the earlier discussions about ‘math geeks’, where the participants did not seem to adhere to this stereotype. Drawings #4 (‘professional mathematician’) and #6 (‘Sheldon-like character’) were dismissed since the participants thought these characters looked like students, which implies that the participants do not believe that students are mathematicians. Drawing #3 (‘cool guy’) was seen by the participants to be a ‘cool guy’ or ‘computer geek’, and

a few participants thought the man in the drawing was playing computer games, not doing mathematics. Me (Grade 4 boy, FG2) suggested that the student who drew the picture purposely placed mathematics-related items in the room to make it seem “like math is all the person thinks about”. This comment hints at Me’s awareness of the ‘obsessed mathematician’ trope.

Overall, the participants tended to think that Drawing #1 (‘Einstein-like teacher’) was most representative of mathematicians. When Jordy (Grade 4 boy, FG1) commented that the man in the drawing seemed like a mathematician because he was bald, Coco (Grade 4 girl, FG1) quickly pointed out, “Yeah, but she’s not bald!”, referring to me. This reaction suggests not only that Coco thought of me as a mathematician, but that she viewed mathematicians as having a variety of appearances. Me (Grade 4 boy, FG2) also noted that, while it was funny to see the sleeping student in the drawing, “It’s not funny for him [the mathematician]”. Some participants in Focus Group #2 felt that Drawing #8 could also represent a mathematician if the man’s lab coat was removed and his (Einstein-like) hair smoothed down; these features were seen as being indicative of a (mad) scientist. Finally, the participants in both focus groups were curious about why every mathematician in the drawings was either wearing glasses or had them sitting on a desk. While glasses were commonly featured in the drawings in general, I had not realized that each mathematician in the selected 10 drawings had glasses. Most participants were not sure why the mathematicians were drawn with glasses. Kitty Cat (Grade 4 girl, FG2) suggested that the glasses made the mathematicians look geeky, while Me (Grade 4 boy, FG2) argued that “it’s just a movie thing to do that”, hinting at the production of stereotypical ideas by the media.

Additional Findings

In Focus Group #1 and Focus Group #4, the participants discussed their mathematics classes (two different classes). According to the participants’ descriptions, the classes seem to

feature a mixture of traditional and reform teaching practices. Some examples of traditional-aligned practices were working “chapter to chapter” (Little Man, Grade 4 boy, FG1) in their class textbook (participants in FG1) and copying down notes that the teacher writes on the board (participants in FG4). Both groups stated that they play a variety of mathematics games in their classes, although playing games is not a frequent occurrence. In Focus Group #4, Sofia Melion (Grade 4 girl) stressed that her teacher teaches mathematics concepts in many different ways and frequently uses the class SMART Board.

Since all the Grade 4 focus groups contained both boys and girls, I was particularly attentive to the gendered interactions in each group. One common trend I noticed across the three focus groups was the presence of girls who were quite extroverted and tended to dominate the conversation, regardless of my attempts to better involve the other participants. There was one girl who acted in this manner in each of Focus Groups #1 and #2 (Coco and Cool, respectively); in both instances, these girls nearly always were the first to respond to my questions, and the other group members (two boys in FG1 and two boys and a girl in FG2) seemed content to either wait to respond or simply to listen. Since the participants in each focus group were from the same class, perhaps they had already established a similar style of communication in class (i.e., They were used to this particular person being a dominant speaker). Focus Group #4 included two girls with similar, strong personalities (Mishma Oring and Sofia Melion), and they constantly seemed to be trying to assert their dominance in the group (e.g., cutting each other off, trying to make sure they answered my questions first). At some points, I had to intervene (stepping away from my least adult role) to stop their bickering, requesting that they take turns speaking and listen to each other. Interestingly, Hawkeye (Grade 4 boy, FG4), who previously had been quite quiet and unresponsive to my attempts to involve him in the discussion, finally

spoke up while these two girls were arguing, saying, “Boys are better at being quiet!”, which caused the entire group (and me!) to burst into laughter, momentarily calming the situation.

In this same focus group (FG4), a tense moment occurred during a conversation that I felt was underpinned by gendered posturing. This focus group consisted of three girls (Mishma Oring and Sofia Melion, plus a third girl, Ashley, who was very quiet and rarely offered her opinion, even when directly asked) and one boy (Hawkeye). At one point, after Mishma Oring shared a story about a boy in their class who brags about boys being better than girls at sports, I asked Hawkeye how he felt, as a boy, when other boys made such comments about girls – with regard to sports, mathematics, or any other topic. He began by stating that it made him mad; at this point, the girls seemed to be in agreement with his response. However, he continued by explaining that he would be mad because he wanted to make the comments first and the other boys “beat him to it”. Hawkeye also noted at this point that he was a “good sportsman”. I recall feeling at the time that his statements seemed like gendered posturing (as a strong, ‘cool’ boy) – and out of character from what I had observed. Immediately after Hawkeye made these claims, Mishma Oring asked him, “Don’t you feel bad [*sic*] for the girls?” and countered that Hawkeye would never make comments like that about mathematics since he was not very good at it. Hawkeye countered that he was a “pretty good mathman”, which Mishma Oring again discounted, noting that Hawkeye sometimes cries in their mathematics class and puts his head down on his desk. At this point, I felt the conversation was getting out of hand and tried to refocus the group on the discussion topics, while also admonishing Mishma Oring’s hurtful remarks and helping Hawkeye to feel comfortable in the group. After the interview concluded, I worried that I had instigated the exchange, having singled Hawkeye out as the lone boy in the group. Although I did not pose the question to Hawkeye as a ‘representative’ for all boys, as I

firmly acknowledge that group membership does not imply homogeneity of opinions or responses to situations, questions posed to an individual who is the only member of a group present could potentially be interpreted this way. On a positive note, I feel that I was successful in reintegrating Hawkeye into the group and deflecting away from Mishma Oring's comments. Once I tried to refocus the group, Hawkeye smiled at me and reiterated, "Yeah, what were we talking about again?" and the conversation moved on to another, unrelated topic.

Grade 8 Focus Groups

Eleven Grade 8 students participated in two focus group interviews: one interview (FG3) at E2S6, the same school that the Grade 4 focus group participants attended, and one interview (FG5) with personal contacts, all of whom attend the same school in rural Southwestern Ontario. Focus Group #3 was comprised of six girls, whereas Focus Group #5 was comprised of two boys and three girls. All Grade 8 focus group participants were shown the same three television clips – the clip from *The Simpsons* (about gender stereotypes), plus a clip from *The Big Bang Theory* (about the 'nerd' stereotype) and a clip from *Glee* (featuring a mathematical error). Participants in both focus groups were also shown the 10 drawings of mathematicians. Below, I discuss the findings related to each media source, as well as other findings that were not directly related to the media prompts. For the two media sources the Grade 4 participants also viewed (i.e., the clip from *The Simpsons* and the drawings), grade-level comparisons are drawn within each section.

The Simpsons Clip

As noted above, the Grade 8 focus group participants were shown the same clip from *The Simpsons* (highlighting gender stereotypes) that the Grade 4 focus group participants were shown. Similar to the Grade 4 participants, none of the Grade 8 participants agreed with Principal Skinner's remarks. They felt he was being sexist, and all the participants argued that

girls and boys are equally good at mathematics. Like the Grade 4 participants, the Grade 8 participants felt that mathematical talents were based on individual strengths, not on one's gender. However, in contrast to the Grade 4 participants, who tended to label Principal Skinner as 'mean', the Grade 8 participants were more likely to label him as 'sexist' or 'discriminatory'; no Grade 8 participant identified Principal Skinner as being 'mean'. While this may have simply been due to the older students' exposure to more sophisticated ideas and vocabulary, the focus of the discussion seemed to differ between the younger and older students. The Grade 4 participants were concerned about people's feelings being hurt by hearing such remarks, whereas the Grade 8 participants seemed more concerned that the claims themselves were biased. An additional difference was that all of the Grade 8 participants stated that boys and girls are equally good at mathematics, whereas two Grade 4 participants argued for gendered superiority. I also noticed that there were none of the 'Girls rule!' or 'Boys rule!' types of comments in the Grade 8 focus group interviews. Granted, Focus Group #3 was solely comprised of girls, so one would not expect such comments, but they were also not present in Focus Group #5, which had both boys and girls as participants. However, in Focus Group #3, Gady Lala (Grade 8 girl) argued that the girls in the focus group were better at mathematics than the boys in their class: "Boys wouldn't make comments like that about math because they know we're smarter than them!"

None of the Grade 8 participants reported hearing comments in 'real life' about boys being better than girls in mathematics. Yet, like the Grade 4 participants, the Grade 8 participants shared stories of people claiming that boys are superior in sports and athletic activities. The girls in Focus Group #3, all of whom are in the same class, noted that the boys in their class make sexist comments about boys' supposed superiority in sports. Laylor Tautner (Grade 8 girl, FG3) has also heard similar comments from her father, which particularly bothered her, since she

aspires to a career as a professional basketball player. The three girls in Focus Group #5 all play hockey, and they have heard similar sexist comments – particularly with regard to the notion that girls should figure skate and boys should play hockey. However, they found that these comments have declined in recent years, since more girls are playing hockey. Mayn Zalik (Grade 8 girl, FG5) also shared that her grandfather, upon hearing that she was taking a wood shop class, said, “That’s just for boys”. The participants in Focus Group #5 argued that such sexist, stereotyped views are often generational, with younger people typically being more open-minded. Mayn Zalik (Grade 8 girl, FG5) argued that older people “have developed stereotypes” because they grew up in a very different era, which had narrower views about what was appropriate for boys and girls. Hiall Noran (Grade 8 girl, FG5) argued that the community in which you live can influence your views, positing that people in big cities are more open-minded, whereas people in small, rural communities such as the one in which she lives “have strong views on stuff”. The other participants agreed, stating that stereotypical views were more common in small towns, since, in their experience, people tend to hold the same views and not to be open to new ideas.

If the Grade 8 participants had been in the audience while Principal Skinner made his remarks, they claimed that they would have booed and thrown debris at the stage, like the audience members in the show did. Unlike the Grade 4 participants, none of the Grade 8 participants suggested a violent reaction – either to Principal Skinner or to a ‘real life’ person making similar comments. Most participants suggested that they would challenge such comments by explaining that boys and girls are equally good at mathematics. As Mayn Zalik (Grade 8 girl, FG5) asserted, “It just depends on who you are. Some boys struggle and some girls struggle.” A few of the girls in both focus groups suggested that they would ask the person (presuming the person was a boy, judging by the comments) what their mark in mathematics

was, and then point out that they, girls, have better marks. This suggests that providing a single counter-example, like a girl who has good marks in mathematics, is viewed as sufficient to challenge a sexist assumption. The girls in Focus Group #3 shared that they face sexist assumptions from the boys in their class, even though the girls believe their teacher treats boys and girls equally. The girls reported that the boys complain that the teacher calls on girls more often. The girls noted that they were quick to point out to the boys that there are far fewer of them (only six boys in their class), which explains why girls are called on more frequently.

The Grade 8 participants were again in alignment with the Grade 4 participants regarding the ‘real subjects’ comment: None of the Grade 8 participants felt that there was any merit to claiming that mathematics and science were more important than other subject areas. The Grade 8 participants felt that a subject’s importance was related to one’s interests, especially with regard to university education and career plans. However, all participants reported being exposed to such ideas about mathematics and science being ‘more important’ than other subject areas. The participants in Focus Group #5 explained that these biases were seen in their class in an implicit way. Even though they are allotted to have an art period after their mathematics period, the participants explained that their teacher will often continue with mathematics and leave art as something to work on after they have finished their work in other subject areas.

Glee Clip

As detailed earlier (in the findings about the television shows), the clip from *Glee* features a mathematical error on a whiteboard. Before playing the clip, I simply suggested that the participants pay attention to the whiteboard, without providing any further information. After viewing the clip, three girls in Focus Group #3 immediately noticed that the equation was incorrect, with Bustin Jieber (Grade 8 girl, FG3) pointing out that “when you multiply by a

decimal, the number gets smaller”. Some confusion followed, as Gady Lala (Grade 8 girl, FG3) questioned whether the issue was just that 25 cents had been written as a decimal rather than a whole number. However, others in the group persuaded her that the equation was wrong either way, and Bustin Jieber provided a correct solution (involving division). The participants in Focus Group #5 did not notice what the equation stated, so I replayed the clip. Upon doing so, Ralph Stevenson (Grade 8 boy, FG5) immediately noticed the error and provided a correct solution (involving multiplication). The Grade 8 focus group participants felt that the mathematics content would be at a Grade 4 to 7 level, depending on whether calculators were permitted.

When asked how such an error on a relatively low-level mathematics concept would have been aired on a major network television show that has hundreds of adult employees (e.g., actors, crew members), the participants provided a variety of suggestions. Connie Joe (Grade 8 girl, FG5) suggested that people “expect a teacher to be right”. Saylor Twift (Grade 8 girl, FG3) posited that the nationality of the show’s employees was at fault: “It’s because they’re American” – apparently suggesting that Americans are not good at mathematics. The most common explanation given for this error not being ‘caught’ was that the people working on the show were focused on the bigger ideas of the show: “They don’t think about the math” (Gelena Somez, Grade 8 girl, FG3). Gelena Somez also suggested that the show’s employees may have noticed the error, but didn’t bother to correct it since they didn’t think the viewers would notice – which indeed was the case with the participants who had seen this episode before.

However, when I inquired if a spelling mistake would have been treated the same way, the participants disagreed – on two accounts. First, they felt that they, as viewers, would have definitely noticed a spelling mistake while watching the show, and second, they felt that someone working on the show would have also noticed and corrected a spelling mistake before

the show was aired. Gelena Somez (Grade 8 girl, FG3) argued that the difference was that spelling mistakes are instantly recognized, whereas “you can’t tell right away in math if you’re wrong”. Many participants in both focus groups shared that they had noticed spelling mistakes in public before (e.g., on television, at stores), whereas very few could think of any mathematical errors they had noticed. Thus, it appears that mathematical errors go unnoticed more often than spelling mistakes, both in media representations and public displays.

The Big Bang Theory Clip

The clip from *The Big Bang Theory* features a discussion about the ‘best number’ (amongst four ‘geeky’ characters) and comments about gender and mathematics. This clip was selected to prompt discussion about the ‘math geek’ stereotype.

Similar to the Grade 4 participants’ stances, the Grade 8 participants all disagreed that people who like and/or are good at mathematics and science are ‘geeks’. The participants tended to think that the *Big Bang Theory* characters were ‘geeks’ due to their personality traits and their other interests (e.g., comic books) – not because of their interests and skills in mathematics and science. As Ralph Stevenson (Grade 8 boy, FG5) argued, “Just because you’re good at math, it doesn’t mean you’re incapable of having social skills”. A few participants in Focus Group #5 pointed out that they had seen similar ‘geeky’ characters in other shows, noting that these characters were always boys or men. However, in ‘real life’, the participants felt that both boys and girls could be geeks. The participants in Focus Group #3 argued that the people in their class who were seen to be geeky were students who fit the ‘teacher’s pet’ stereotype. During the interview, Laylor Tautner (Grade 8 girl, FG3) mimicked a girl from their class who makes comments like “I want to learn” when the class gets rowdy or off-topic. In contrast, Gady Lala (Grade 8 girl, FG3) was often mentioned by the other participants as being very bright in

mathematics, but not viewed as a geek in their class. The other participants stated that Gady Lala was not viewed as a geek since she was well-rounded, athletic, and did not act like a teacher's pet. However, even with the other participants' support, Gady Lala felt the need to reiterate this position, strongly stating, "I'm not nerdy!"

On *The Big Bang Theory*, there are also three women who are main characters – Penny, a stereotypical 'blonde bombshell' waitress who is street smart, not book smart; and Bernadette and Amy, biological scientists who are portrayed as being less attractive and less socially adept than Penny. I asked the focus group participants what they thought the show would be like if the men's and women's roles were reversed (i.e., four women who were physicists/engineers, a 'hunky' waiter, and two men who were biological scientists). The general consensus was that the show simply 'wouldn't work' that way. A few participants suggested that it was hard to imagine how the show and the humor therein would function, noting that viewers are used to seeing boys and men in 'geeky' roles. In a troubling comment, Gelena Somez (Grade 8 girl, FG3) argued that "boys are supposed to be smarter". However, Saylor Twift and Gady Lala (Grade 8 girls, FG3) countered that Gelena Somez's claim was not true in real life; it was only a fabrication of television. Saylor Twift noted that "guys are treated better on TV", while Gady Lala suggested that if the gender roles were reversed, men, rather than women, would still be the focus.

Focus Group Participants' Reactions to the Drawings of Mathematicians

The Grade 8 focus group participants were shown the same 10 mathematician drawings that the Grade 4 focus group participants were shown (Appendix F). In several respects, the Grade 8 participants held similar views to the Grade 4 participants. Namely, the Grade 8 participants quickly dismissed the 'nerd' (#7), 'wacky character' (#9), and 'wizard' (#10) characters. Ralph Stevenson (Grade 8 boy, FG5) noted that the 'nerd' was simply a "false

impression”. Saylor Twift (Grade 8 girl, FG3) suggested that the student who drew the wizard may have thought I wanted a drawing of a ‘mathemagician’, not a mathematician. Like the Grade 4 participants, the Grade 8 participants tended to think that Drawings #1 and #8 were the most likely possibilities for a ‘real’ mathematician – again, with the caveat that the mathematician in #8 needed to adjust his Einstein-like hairstyle. Connie Joe (Grade 8 girl, FG5) argued that “You have to present yourself well or nobody will take you seriously.” A couple of participants in Focus Group #5 selected the ‘teacher’ (#5) as one of their top choices, arguing that a mathematician can look differently depending if he or she is doing or teaching mathematics, while Mayn Zalik (Grade 8 girl, FG5) suggested that mathematics could be a hobby or a job.

In contrast to the Grade 4 participants, the Grade 8 participants were not concerned with whether the mathematicians in the drawings were wearing lab coats. There were also no explicit discussions in the Grade 8 focus groups about whether scientists were mathematicians, although two girls in Focus Group #3 sang the theme song from the television show *Bill Nye The Science Guy*, changing ‘science guy’ to ‘math guy’. Unlike Focus Group #1 (Grade 4 students), which featured detailed discussions about the mathematics content in the drawings, the mathematics content in the drawings was rarely mentioned by the Grade 8 participants. One instance involved Rachel Scholey (Grade 8 girl, FG3) saying, “There’s E equals m c two”, which Laylor Tautner (Grade 8 girl, FG3) promptly corrected as “E equals m c squared”. Although this was a brief exchange, I found it interesting that a Grade 8 student was the only participant to not read the exponential expression correctly. Exponents are part of the Grade 8 mathematics curriculum in Ontario (Ontario Ministry of Education, 2005), whereas Grade 4 students would not have been introduced to this concept. Yet, all the Grade 4 participants who mentioned the equation read it

correctly. Another grade-related difference was the Grade 8 participants' ability to separate their mental image of a mathematician from what they think mathematicians are 'really like'. For example, Rachel Scholey (Grade 8 girl, FG3) admitted that she pictures mathematicians looking like Einstein (like Drawings #1 and #8), but she knows that they're not really like that in real life, instead suggesting that the 'professional mathematician' or 'teacher' (#4 or #5) are more realistic.

With regard to teachers, the Grade 8 participants were in accordance that elementary school teachers are not mathematicians since they teach many subject areas and may not have a mathematics degree. Conversely, high school teachers and university professors were considered by all the Grade 8 participants to be mathematicians since mathematics is their specialty. The participants in Focus Group #5 discussed a substitute teacher who taught their class. This young woman referred to herself as a mathematician and told the class that she loved mathematics. The participants reported that all the students were surprised by this claim, since the teacher was very athletic. However, although their surprise was based on stereotypical notions, the participants in Focus Group #5 also claimed that "you can't base it on appearance" (Hiall Noran, Grade 8 girl, FG5) – That is, there is no way to tell if someone is good at mathematics by looking at them.

Additional Findings

The participants in both Grade 8 focus groups discussed their mathematics classes and teachers. Most participants shared that they like mathematics and their mathematics teacher, and that they do well in the subject area. The participants in both Grade 8 focus groups reported mathematics classes that sounded more reform-oriented than those reported by the Grade 4 participants. For instance, the participants in Focus Group #3 mentioned the use of various tools and representations in their mathematics classes, while the participants in Focus Group #5 shared

an example of working on problems in small groups and then presenting their solutions on chart paper to the rest of the class. The general consensus amongst the Grade 8 participants was that the best part of mathematics was the feeling attained once they had comprehension of the topics. Bustin Jieber (Grade 8 girl, FG3) stated, “I like how smart you feel when you get the answer”. In contrast, the parts of mathematics that the participants disliked were those topics for which the participants saw no practical use, such as translations of geometric shapes or the Pythagorean Theorem, which Hiall Noran (Grade 8 girl, FG5) discounted since “it’s so old!” In each focus group, one participant tried to argue that these disliked topics were in fact useful in fields such as interior design and welding, but the other participants seemed unconvinced.

Summary of Findings: Student Focus Group Interviews

The student focus group interviews provided some interesting insights into how students view stereotypes and other ‘big ideas’ about mathematics and mathematicians. When the participants were asked directly about their views about gender/mathematics stereotypes and the ‘math geek’ stereotype, nearly all participants claimed that they did not adhere to these stereotypes. However, other comments made by a few participants (e.g., when discussing the drawings of mathematicians) contradicted their reported stances. It could be that their reported stances may be influenced by social desirability bias (i.e., responding in a way that is seen as socially acceptable), which may have been heightened by my presence as the interviewer, as the participants knew I was a Ph.D. student in Mathematics Education and some participants voiced that they saw me as a mathematician. The participants may have (consciously or subconsciously) responded in ways that they felt would be acceptable to me and to the other students in the group, while some of the contradictory comments made may suggest that they hold some beliefs that are more in line with the messages produced by media and other sources.

The discussions provided evidence that the participants were well aware of these stereotypes and media's role in their perpetuation. However, as discussed above, awareness of the stereotypes did not necessarily predicate a challenge to them. While the participants reported that they had not personally experienced comments about gender stereotypes and mathematics, they all reported being exposed to sexist comments and stereotypes in other domains, such as sports. Gendered posturing was also apparent in the Grade 4 focus group interviews, in terms of the ways the participants interacted with each other.

Teacher Interviews

In this section, I report my findings from the analysis of the teacher interviews. I begin by providing brief profiles of the teacher participants in order to better situate them. Then, I turn to a discussion of the messages about mathematics and mathematicians to which the participants have been exposed, such as messages from the media and from the participants' experiences with mathematics as students. Next, I report on the teachers' current views of mathematics and mathematicians. The section concludes with a discussion of the messages about mathematics and mathematicians that the teachers are producing – namely, for the students they teach.

Teacher Participant Profiles

Ten teachers took part in semi-structured interviews. These participants taught in five different school districts – Eastern 1 (Andrea and Danica), Eastern 2 (Evan, Fiona, and Gail), and Southwestern 1 (Ben and Caroline), plus two school districts in which I had personal contacts – one district in Southwestern Ontario (not Southwestern 1; participants from two different schools – Isabelle and Jill) and one district in Central Ontario (not Central 1; Heather). As noted in the Methodology chapter, although the participants were not all currently teaching Grade 4 or Grade 8, they were classified as such based on their past teaching experience and/or the grade level of

their current teaching placement. Five Grade 4 teachers (four women and one man) and five Grade 8 teachers (four women and one man) participated in the interviews. In terms of age, the teacher participants were between their late twenties and late forties. All of the teacher participants had only taught in publicly-funded school districts. Table 24 provides an overview of the participants classified as Grade 4 teachers.

Table 24
Information about the Grade 4 Teacher Participants

Name (Code)*	Current position		Teaching experience		Post- secondary education	Teaching qualifications	
	Grade	School code	Number of years	Grade levels		Grade levels	Teaching subject(s)
Andrea (T1)	3/4	E1S2	20	2 to 5	Psychology	K to 6	N/A*
Caroline (T3)	4	SW1S1	4	4 to 8	Geography	7 to 12	Geography, Music
Danica (T4)	4	E1S4	12	4 to 5	Second Language Teaching	4 to 10	French
Evan (T5)	5	E2S2	12	4 to 8	Sociology	K to 6	N/A
Gail (T7)	4*	E2S1	15	K to 5	Second Language Teaching	K to 6	N/A

Note. ‘Code’ refers to the participant number (e.g., T7 refers to the seventh teacher who took part in an interview). These codes are used to identify each quotation. Gail’s Grade 4 class is a French immersion class. Teachers who are qualified to teach at the Primary/Junior (K to 6) level in Ontario do not have a teachable subject.

Although Caroline is certified to teach Grades 7 to 12, she was hired to teach younger grade levels due to her music teaching qualifications, a subject area for which it is often difficult to find qualified teachers. Danica’s teaching experience is split between being a core French

teacher (Kindergarten to Grade 8) for the first six years of her career, and being a classroom teacher for Grades 4 and 5 for the past six years. Evan was grouped with the Grade 4 teachers due to his prior experience teaching Grade 4. Prior to becoming a teacher, Evan worked for three years in a group home and for five years as an educational assistant. For the other Grade 4 teacher participants, teaching has been their sole career.

Table 25 provides an overview of the participants classified as Grade 8 teachers.

Table 25
Information about the Grade 8 Teacher Participants

Name (Code)*	Current position		Teaching experience		Post-secondary education*	Teaching qualifications	
	Grade	School code	Number of years	Grade levels		Grade levels	Teaching subject(s)
Ben (T2)	7	SW1S2	2	7 to 8	Business	K to 12	Business
Fiona (T6)	8*	E2S1	4	7 to 12	Forest Science (M.Sc.)	4 to 10	Science
Heather (T8)	7	N/A	12	7 to 8	History, Psychology	7 to 12	History, Mathematics
Isabelle* (T9)	1/2	N/A	18	7 to 8	Family and Consumer Studies	K to 12	Family Studies
Jill* (T10)	8	N/A	14	7 to 8	Science	4 to 12	Science

Note. ‘Code’ refers to the participant number (e.g., T6 refers to the sixth teacher who took part in an interview). These codes are used to identify each quotation Fiona’s Grade 8 class is a gifted class. Unless otherwise indicated, the teachers’ post-secondary education is at the bachelor’s degree level. Isabelle and Jill were interviewed together.

Ben was classified as a Grade 8 teacher due to his experience at that grade level. Additionally, Ben could not teach Grade 8 at his small, rural school the year the interview took place, as there were no Grade 8 students enrolled. Heather’s teaching experience is evenly

distributed between teaching Grade 7 and Grade 8, primarily teaching mathematics and science on a rotary system. Isabelle has mostly taught at the Grade 7 and 8 level, although she was teaching Grade 1/2 the year the interview took place. Her career also includes six years working at the school district's head office as a literacy consultant. Fiona is the only Grade 8 teacher participant who had another career prior to teaching. After completing her master's degree and some doctoral work in Forest Science, she worked for eight years in that field, as a research associate and professor at a university, and as a self-employed contractor. Fiona reported that these jobs involved a great deal of applied mathematics and statistics.

Outside of teaching, all participants reported using mathematics on a daily basis; as Gail noted, "it's part of your day all the time, really" (T7, p. 35). The participants indicated that they use mathematics when dealing with personal finances (e.g., budgeting, banking) and for shopping (e.g., estimating bill totals, comparing prices). Several participants noted that they also have used mathematics, namely geometry and measurement, while doing home renovations. Additionally, many participants mentioned using mathematics while cooking and baking. Ben, Caroline, and Danica all stated that they enjoy doing sudoku puzzles, and Caroline reported that she plays board and card games that involve mathematics. A couple of unique uses of mathematics were also provided: Danica uses mathematics while doing crafts (e.g., symmetry, measurement), while Heather uses mathematics while running (e.g., paces, conversions).

Messages Consumed by Teacher Participants

As discussed in the Theoretical Framework chapter, the messages to which one is exposed can be responded to in a variety of ways. Messages can be rejected or they can be actively consumed. In the latter case, new information can be integrated into existing schemas (without alteration thereof) or the existing schemas can be altered to include the new

information. The term ‘consumed’ is used to refer to information that has become involved in one’s schemas in some fashion. For instance, a participant may have seen a television show where a mathematician was portrayed as a ‘nerd’. Although the participant does not believe that mathematicians are ‘nerds’, this notion is still part of the ideas about mathematicians to which the participant has been exposed. Thus, while the participant’s schema about what mathematicians are like does not include ‘being nerdy’, this idea is still in her consciousness (i.e., consumed).

As with any topic, the consumption of messages about mathematics begins in early childhood. For the teacher participants, key ideas about mathematics consumed during childhood tended to come from their teachers (school experiences) and their parents and siblings (home experiences). This section begins by addressing the roles that these important socialization agents played in shaping the participants’ mathematical views. Next, the role that teacher training programs, as well as teaching practice, played in impacting the participants’ views of teaching mathematics are discussed. The rest of the section deals with the participants’ interactions with popular media (representations of mathematics and mathematicians) and real-life mathematicians; most of these interactions occurred in adulthood.

Student Experiences

Although the participants span approximately 20 years in age and grew up in a variety of urban, rural, and suburban settings (both in Ontario and other geographic locales), their experiences with school mathematics were remarkably consistent. Namely, the participants were taught mathematics in a very traditional manner, with heavy focus placed on drill, memorization, and repetition. Many participants brought up experiences related to drills and games (which some participants enjoyed and others found publicly humiliating) used to help them learn the

multiplication tables. Mathematics lessons tended to be described the same way – take up yesterday’s homework, copy notes on today’s lesson, and work on repetitive practice problems. Heather commented that the types of questions in mathematics class were highly focused on numeration and recall of basic facts, which is less demanding and complex than the mathematics that today’s students experience: “As long as we could add, subtract, multiply, and divide and answer the questions... we’d get 100 percent. But now, that’s – those are, like, Level 2 questions... So, I think it was a lot easier back then” (T8, p. 5). The participants recalled textbooks and workbooks being the focus, with only two participants mentioning any manipulative use (which they noted was quite rare). Other than the occasional use of graphing calculators in high school for some of the younger participants, there was virtually no technology used in the participants’ mathematics classes beyond basic and scientific calculators. No participant recalled using computers in mathematics class, even though computers were used in other subject areas, especially when the younger participants were in high school.

As educators, the participants all felt that there were flaws in learning mathematics in such a traditional manner. For instance, although Danica received high grades in mathematics, she stated that she did so simply because she could memorize well, not because she understood the content: “We [Students of her generation] are prime examples – learn the algorithm. Never mind why. Just learn it... and that’s what we’d do. I was a straight-A student and I had no concept of what I was doing” (T4, p. 8). Only Ben recalled having a bit more latitude with mathematics: His teachers welcomed unusual ways of solving problems, as long as they were mathematically justified. In contrast, many of the other participants recalled being taught that there was only ‘one way’ (or at least, one acceptable way) to do any mathematics question.

There appeared to be distinct differences between the school experiences of the Grade 4 and Grade 8 teachers. Most Grade 4 teacher participants reported that they struggled with mathematics and disliked it when they were students, although they all asserted that they learned to enjoy and better understand mathematics once they were teachers. While they were in school, most of these participants disengaged from mathematics and stopped taking it once they had the opportunity. Evan recalled a particularly troubling instance where his Grade 12 mathematics teacher made fun of him after he dropped out of the course; additionally, he had teachers who “would just humiliate you... [and] who would whack you in the head with a ruler” (T5, p. 15). These experiences continue to disturb Evan, and he focuses on not being a teacher like that. In contrast, the Grade 8 teacher participants enjoyed and did well in mathematics while they were in school, and continued with their education in mathematics after completing their required high school courses. For instance, Jill noted that she “was a strong math student all the way through – elementary, secondary, and university. I like math... It was my thing” (T10, p. 2). All the Grade 8 teacher participants took mathematics and/or statistics courses at university, either as part of their degree requirements (e.g., business, science) or as elective courses, for interest. Although a teaching qualification in mathematics is not required for teaching at the Grade 8 level in Ontario, Heather holds such a qualification, and most of the other Grade 8 teachers hold teaching qualifications in mathematics-related subject areas (e.g., business, science).

Home Experiences

The participants’ experiences interacting with their family members and mathematics were mixed, with half the participants recalling going to their parents for help with mathematics and half the participants not seeking help from their parents. There were no particular trends apparent in this division (e.g., teaching grade level of the participant, whether the participant was

a strong or struggling mathematics student). With the exception of Gail, whose mother was a statistician, the participants who sought help went to their fathers for assistance, as their fathers were viewed as being stronger at mathematics than their mothers were. Some participants explicitly stated that their mothers were not ‘math people’ and/or that their mothers were ‘English people’ (i.e., strong in language arts), as though the two were mutually exclusive. Although Caroline and Heather both continued to ask their fathers for help with mathematics throughout their schooling, they found that their fathers would become frustrated with their lack of understanding, or at least, the speed at which they comprehended mathematics. Caroline described her experience as follows: “We [Caroline and her sister] would end up in tears... Dad wouldn’t understand why we didn’t get it – why we took so long to get it... Dad could never figure out why we couldn’t do it in our heads” (T3, p. 5). Heather also shared that she would end up in tears when getting mathematics help from her father because “he’s so bright that, you know, he didn’t really get why I wouldn’t get something” (T8, p. 7). Most participants who did not ask their parents for assistance simply did not have the option available (e.g., parents who worked long hours). Andrea and Isabelle’s parents were first-generation immigrants with only elementary school education. Beyond the mathematics content, the language barrier was an additional challenge. Isabelle recalled having to write cheques and do banking for her mother at a young age as a result of her mother’s English-language difficulties.

Few participants spoke of doing mathematics-related activities with their parents beyond homework and studying, such as cooking and playing games. Although the participants could now recognize the mathematics content in these activities, they did not feel that it was stressed by their parents at the time. Ben provided the strongest example of parental support: His parents ensured that he had a bank account from a young age, which helped him learn a lot about

budgeting and increased his comfort level with mathematics. For the participants whose parents were unavailable or unable to help them with mathematics, their siblings tended to come to them for mathematics assistance. However, when parental support was available, the participants' younger siblings would also turn to their parents for help, rather than ask the participants.

Teaching Experiences

As discussed, the participants all reported being taught mathematics in a very traditional manner. However, as will be discussed later, the manner in which they currently teach is much more reform-oriented. The participants who attended teacher training programs in the 1980s and 1990s discussed their mathematics methods classes using such terms as 'useless' and 'impractical'. These classes mostly focused on teaching in a manner that was similar to the (traditional) manner the participants learned. For these participants, their exposure to ideas about teaching mathematics in a reform-oriented manner came later in their careers, through attending workshops and conferences, as well as observing colleagues. In contrast, participants who attended their teacher training programs in the past decade tended to be exposed to reform-oriented ideas about teaching mathematics. For both groups, the initial exposure to such ideas tended to be quite positive. For instance, Fiona shared that her initial reaction was: "I thought it was great! Wow! Why didn't we have this stuff back in the day?" (T6, p. 6). Although the participants saw the value in teaching in this manner, most reported taking a few years to begin making changes. For some of the newer teachers, like Caroline, the demands of being a first-year teacher caused her to teach in a more traditional manner than she had hoped. Caroline started moving toward a more reform-oriented manner of teaching once she saw the outcome: Her students were more engaged in mathematics and developed deeper understandings. Indeed, many participants reported that they have continued to move more toward a reform-oriented manner of

teaching since they are seeing such positive results with their students. Since more students understand mathematics when it is taught this way, they feel better about themselves as learners of mathematics; additionally, the variety in mathematics teaching also makes the subject more interesting. The participants also reported that their own understandings of mathematics concepts have been greatly improved since re-learning and teaching mathematics in such a fashion.

Changes in the focus of the Ontario Mathematics Curriculum in recent years have been a key factor in the changes that the participants have made to their teaching practice. This is particularly the case for the teachers who have been teaching for more than a decade, as prior versions of the curriculum did not have the same reform-oriented focus. These participants stated that the change in focus, particularly such ideas as ‘Explain your thinking’, was a challenge to implement – due to the participants’ familiarity with teaching in a manner that was more answer-driven (rather than process-driven), and the students’ familiarity to learning in such a way. Danica noted that, “There is some resistance to that method. We’re meeting... some resistance. And it’s hard! It’s not what we’re used to. It’s new for us. So, our students aren’t used to that kind of learning” (T4, p. 25). Regardless of the challenges, all participants seemed committed to teaching mathematics in a reform-oriented fashion, as they recognize its many benefits.

Mathematics in the Media

The participants all affirmed that they are frequently exposed to mathematics in the media. Caroline reported that she gets “a good dose of math in the media every day... on TV; you hear it on the radio; you see it in the newspaper” (T3, p. 36). The main type of mathematics seen was statistics (e.g., findings of research studies, sports statistics). Data regarding stocks and other financial topics were also commonly seen. Most examples tended to be the types of information that would be seen in the news, although a few participants also provided other

examples. Andrea gave the examples of seeing scores in video games and numerals on cell phones, while Caroline suggested that mathematics was seen in store flyers. Heather declared that “you see math in the media all the time” (T8, p. 26), but cautioned that most people would not notice ‘incidental’ math (e.g., the number of friends a person has on Facebook).

Mathematicians in the Media

In contrast, the participants’ exposure to mathematicians in the media was far less frequent. Most participants could only think of two examples of mathematicians that they had seen in the media, all from movies and television shows. Jill suggested that the lack of examples of mathematicians in the media may be due to a different focus: “It’s more environmental right now. Like, David Suzuki is huge... There’s not a big focus on math” (T10, p. 39). The most commonly reported examples were the movies *Rain Man* and *A Beautiful Mind*, and the television show *The Big Bang Theory*. Both movies feature main characters who are highly mathematically proficient, but also have co-occurring disorders – autism and schizophrenia, respectively. Several of the other examples provided (e.g., *Proof*, *Pi*) also portrayed mathematicians with psychological and emotional disorders. These examples depict mathematicians in a very negative light, as being mentally unstable and/or unable to interact socially; both of these attributes tend to be linked to a singular, obsessive focus on mathematics.

An additional trope discussed was that of the ‘math nerd’: Individuals portrayed as being socially inept – awkward, uncool, and lacking in traits that would make them a desirable romantic partner. *The Big Bang Theory* (which focuses on the lives of four ‘nerdy’ scientists) was the primary example suggested, but the trope was discussed generally, such as Gail’s reference to “pre-teen kind of shows where kids are at schools – There’s always the nerd or the geeky kind of person with the pocket protector and glasses... They’re always considered very

smart” (T7, pp. 35-36). Only Ben related this stereotype to a racialized identity: “People think Asians are a little stronger in math, so I picture this character and it’s not from any particular show” (T2, p. 42). Notably, this was the one of only two examples of racialized identities discussed in any of the teacher interviews – when discussing mathematicians or any other topic.

Positive depictions of mathematicians came from crime-related television shows, such as *CSI* and *Numb3rs*, which featured characters that are more socially adept and well-rounded than those in the previous examples. In the crime-related shows, the characters used mathematics in their jobs as a tool to solve crimes. In this way, mathematics was shown to be useful in ‘real life’, without the negative connotation of mathematics ‘taking over one’s life’ and causing social, emotional, and/or psychological problems. Gail noted that *Numb3rs* was “probably the first time I’d really seen it portrayed in a positive way” (T7, p. 36), highlighting the rarity of positive mathematician portrayals – in a very small pool of media mathematician examples overall.

Notably, the examples of media mathematicians discussed were nearly all men. The only examples of women mathematicians provided were Catherine, a (fictional) young mathematician whose father is also a mathematician, in the movie *Proof*, and Temple Grandin, an animal scientist, in *Temple Grandin* (a fictionalized account of a true story; Temple designed humane slaughterhouses). Like men mathematician characters, these women mathematicians were depicted as having struggles that interfered with their abilities to function on a daily basis, particularly socially: Catherine, experiencing mental illness, and Temple, having autism. The lack of examples of women mathematicians highlights a continued support by the media of the notion of mathematics as a male domain, while the examples of mathematicians tended to perpetuate stereotypes related to mental illness and social ineptitude.

Exposure to Real-Life Mathematicians

The participants' exposure to real-life mathematicians was quite varied, with some participants stating that they had never met a mathematician, whereas other participants indicated that they know or have met several mathematicians. These claims are highly related to the manner in which each participant defined what a mathematician is, which will be discussed later. Several participants noted that the mathematicians they had met were mathematics professors. Having graduate-level degrees in mathematics and working in the field of mathematics at a university were defining features for these people being considered to be mathematicians.

In terms of mathematics-related fields like accounting, statistics, and engineering, the participants who mentioned these fields held differing views: Some considered working in such a field to be a mathematician career, whereas other participants were unsure or did not think those working in mathematics-related fields were 'true' mathematicians. Fiona provided the example of a friend who designs prosthetics: "He's not a mathematician per se, but he has to use a lot of math for what he does" (T6, p. 32). Two participants' definitions of a mathematician related to interest and aptitude in mathematics rather than one's career. Gail argued that "mathematicians are like everyone else, basically. They just happen to be good at math or be interested in math" (T7, p. 36). Caroline differentiated mathematicians as being able to "visualize it [mathematics] in their head and they can see it and do it quite quickly" (T3, pp. 37-38), whereas non-mathematicians work more slowly and need to use pencils and paper. Caroline's definition appears to relate to her childhood experiences working with her father on mathematics, who privileged speed and mental mathematics as being signs of mathematical ability.

Summary of Messages Consumed

The participants' early experiences with mathematics laid the foundation for their later interactions with the subject area. The participants had mixed experiences with home-based support of their mathematics learning, but those participants who had parental support typically received it from their fathers rather than their mothers. The participants consistently reported experiencing a very traditional type of mathematics education as students, with little focus on understanding, exploration, or creativity. These ideas about mathematics would later be challenged with their exposure to the other ways of teaching mathematics – both through their teacher education programs and exposure to professional development, colleagues, and resources while teaching.

In terms of media exposure, the participants all reported high levels of exposure to mathematics, particularly in the form of statistics and key figures in the news. Such suggestions hint at the perception of mathematics as being numbers. In contrast, the participants had little exposure to media mathematicians, and most of this exposure was to negative, stereotyped ideas, such as the 'math geek' stereotype and ideas linking mathematical ability with mental illness. Finally, the participants' exposure to mathematicians in the 'real world' was quite mixed, but this presumably relates to the manner in which the participants defined who a mathematician is.

Views of Mathematics and Mathematicians

This section addresses the teacher participants' current views about mathematics and mathematicians. The participants' views were probed with regard to what mathematics is, why it is important, and how they feel about mathematics. These were investigated through discussions about what makes one a mathematician and how the participants feel about mathematicians.

What is Mathematics?

I posed a hypothetical situation to move the focus away from a definition, while still getting at the essence of what the teacher participants believed comprised mathematics. The situation posed involved an alien arriving on Earth from a planet that did not have mathematics, overhearing the word ‘math’ for the first time, and then asking the participant what math is. After the participant provided an explanation, I followed up with a probing question wherein the alien queries, “Okay, but we don’t have math on my planet. Why do you need it on your planet?”

The participants all strongly acknowledged that mathematics is more than simply numbers, and more than number sense. Heather asserted that, “numbers are just the surface, the calculation, but they mean something” (T8, p. 24). Numbers were seen as a way to represent mathematical concepts. Many participants mentioned that mathematics involves different types of representations, such as numbers, graphs, physical objects, and pictures. Several types of mathematics were also discussed, although the focus tended to be on measuring, quantifying, and patterning. Topics such as algebra and statistics were never mentioned, and only Danica provided an example related to probability. A few participants brought up the general idea of ‘strands’ of mathematics, which relates to the five strands (broad topics, such as patterning and algebra) of mathematics in the Ontario Mathematics Curriculum. The breadth of topics in the curriculum appears to have had an impact on the way these participants view mathematics. However, as noted, certain topics tended to come to the forefront more so than others, which may be an indication of how useful and central the teachers view these types of mathematics.

Caroline and Gail additionally focused on mathematics as a means of communication – using numbers, symbols, and patterns, rather than using words. Caroline explained that the language of mathematics gives us the means to discuss such topics as quantity or proportions in ways that “everybody on Earth understands” (T3, p. 35). Without this shared understanding, our

interactions would be severely limited, she argued. In comparison, Andrea and Evan focused on mathematics as a tool to solve problems. Both ideas (communication and problem-solving) are key aspects of the Ontario Mathematics Curriculum, in terms of mathematical processes. In what could be seen as contradictory to the curricular goals and focus, Ben described mathematics as “a set of rules” (T2, p. 37); the term ‘rules’ tends to evoke notions of memorizing mathematical formulas and algorithms, often without understanding. Evan was the only participant to describe mathematics as an exciting process of discovery: “It’s a constant discovery, learning things... It’s like mining. You learn different things all the time and it’s exciting to just learn about numbers and how they work and how they shape our world” (T5, p. 20).

The participants provided very similar explanations for why we need mathematics: Mathematics is everywhere, and we could not live life as we know it without mathematics. Strong language was used to support these statements, such as Ben’s description that mathematics is “absolutely essential” (T2, p. 38). The participants provided several examples of mathematics encountered in everyday living, such as telling time, measuring, building, and financial transactions. Isabelle and Jill argued how strongly money plays a role in mathematics: “Math is attached to money and money makes the world go round” (T9, p. 37). Interestingly, Danica argued that we need to have mathematics so that we are less dependent on machines such as calculators and computers, while Gail noted that we would not even have computers if we did not have mathematics. Danica may have been referring to ‘knowing mathematics’ as opposed to the existence of mathematics.

As I had hoped, some participants challenged the very premise of the scenario. These participants could not fathom how the alien could possibly live on a planet that does not have mathematics. After pondering the question, Ben exclaimed, “You’re really freaking me out!”

(T2, p. 39); he simply could not conceptualize a world without mathematics. Heather contended that the alien must have encountered mathematics, even if the alien didn't have the language to discuss it: "I don't know how you would not understand concepts of math, even though you don't call it math. You'd still have to understand quantity somehow" (T8, p. 25). Gail reported that she would turn the alien's question back on the alien: "I would probably just ask, 'Okay, how do you do – whatever – without math?' If they explained it to me, then they'd probably be demonstrating that they actually do use math. I'd say, 'That's what it is!'" (T7, p. 35).

While the participants' descriptions of mathematics featured a variety of mathematical topics and tools, the focus tended to be on number sense and measurement. Mathematics was seen by some participants as a way to communicate or a tool for solving problems. The participants all argued that mathematics was ubiquitous in our lives, and that we could not function without mathematics. Indeed, some participants challenged the notion of there being a world without mathematics, as they could not fathom such a world existing due to mathematics' underlying nature in nearly everything in the world.

Feelings about Mathematics

The teacher participants were asked directly about their current feelings toward mathematics. These discussions included a focus on the participants' confidence in mathematics (both generally and for teaching), as well as queries about what sources they felt had most impacted their feelings toward mathematics. Perhaps unsurprisingly, given that the participants were all volunteers in a study about mathematics, they all reported feeling quite positively about mathematics. Presumably, teachers who dislike or feel uncomfortable with mathematics might not volunteer for such a study. The teacher participants stressed the importance of the subject area to their own lives. Several participants mentioned that they find mathematics fun,

particularly solving problems, and that they do mathematics-related puzzles and play mathematics-related games in their free time. Danica shared that she feels that there is a “sense of satisfaction to math... You work really hard on a problem... and then you get an answer, and I just really like that accomplishment” (T4, pp. 52-53). Several participants reported that mathematics is their favourite subject to teach; for some participants, this had always been the case, but for others, teaching mathematics in a reform-oriented manner sparked their interest.

All participants reported feeling at least ‘fairly’ confident in mathematics in general, and quite confident teaching mathematics at their current grade level. Many participants shared that, even though they might not be comfortable teaching mathematics at higher levels, they were confident that they had the ability to re-learn the material in order to teach it well. For instance, Gail stated that, “Regardless of what it is, I can figure it out or I can come up with a strategy to solve it, and I will. I like to figure things out. I don’t just give up on something” (T7, p. 38). As discussed earlier, the Grade 8 teachers tended to have always been confident in their abilities and enjoyed mathematics, whereas several of the Grade 4 teachers lacked confidence and disliked mathematics before they started teaching. Some teachers who had struggled with mathematics as students felt that they were better teachers as a result. For instance, Caroline reflected, “I think I’m a little bit more patient than, I guess, some teachers who – math is their thing... I feel like I get it when the kids don’t get it” (T3, p. 10). As a result, she is particularly sensitive to using a variety of techniques in order to try to find the one that will work for each student.

The two main influences on the teachers’ feelings towards mathematics were mathematics teachers and the experience of teaching mathematics. Many participants mentioned notable high school mathematics teachers or university mathematics professors who taught in an exciting, engaging manner that allowed the participants to understand and appreciate

mathematics; in most cases, this occurred after many years of struggles with mathematics. Gail described her ‘lightbulb’ moment: “I used to hate math and then all of a sudden I got it... They looked at it like it was fun and it was a game... and so, I started to look at it that way” (T7, p. 39). Besides influential educators, the act of teaching mathematics – and the students’ reactions to their teaching – was the other key influence on the participants’ feelings. Some participants noted that their love of mathematics has increased over the course of their teaching careers. Caroline’s increased comfort with mathematics is due to her increased understanding, gained from teaching mathematics in a manner very different from the way she learned it. She shared: “I am not nearly as intimidated as I was in elementary school or high school... I think part of it was that I was mentally ready [while teaching] to handle some of those concepts in different ways” (T3, p. 41). In contrast, Jill has always felt comfortable with mathematics, but she has grown as a mathematics teacher due to student feedback: “You’ve got my general understanding of math and the background I bring to math, but if that’s not good enough to reach those students, then you’re going to have to adapt. You’re going to change to make it work” (T10, p. 46).

Ben and Heather stated that family members had played a significant role in influencing their feelings about mathematics. For instance, Ben’s father was the key influence, helping Ben and his sister with mathematics, and encouraging creativity in problem-solving. Ben viewed his father as a role model: “He really enjoyed it... If someone that you look up to really enjoys something, you’re more apt to enjoy it as well... I had that influence, and I’m grateful for it” (T2, p. 46). Only Evan shared that his views of mathematics had been highly influenced by colleagues – a teacher friend and an instructional coach. These colleagues helped him to see mathematics differently, and their positive attitudes and infectious enthusiasm impacted him. Evan commented that, “She [the instructional coach] has been another real good [*sic*] inspiration

for me as well because she just loves math and she does really creative things... I thought it was really neat. I think I was looking for that” (T5, pp. 24-25). These colleagues helped Evan shift focus from his negative experiences as a student to the positive aspects of mathematics.

Overall, the participants feel quite positively toward mathematics. Several participants reported that mathematics is their favourite subject to teach, and they enjoy working on mathematical activities in their spare time. The participants generally feel confident in their abilities, although for some participants, this confidence is fairly new, buoyed by the increased understanding they have garnered through teaching mathematics in a different way from the way they were taught. Indeed, teaching mathematics was one of two key influences on the positive way the participants feel about mathematics, with notable teachers being the other. For a few participants, family members and teaching colleagues also played an important role.

Views of Mathematicians

Beyond the discussions of ‘real world’ and media mathematicians, the participants’ views of mathematicians were also probed more directly. Participants were asked to describe mathematicians – who a mathematician is or, put another way, what makes one a mathematician. To investigate images of mathematicians, I asked the participants to imagine drawing a picture of a mathematician (the task completed by the student participants), and to describe the picture.

The participants were all clearly aware of how mathematicians are stereotypically perceived and portrayed. However, some participants admitted that this is still how they pictured a mathematician, such as Jill’s description of an “old guy with grey hair who sits in his office with numbers and his calculator” (T10, p. 42). When the participants held such stereotypical images, they pictured a man as the mathematician. Even when the participants’ mental images weren’t as stereotypical, they tended to envision someone working on equations on a chalkboard,

which Fiona recognized as being “ironic because that’s not how we’re supposed to be teaching math right now” (T6, p. 34). In contrast, other participants’ images of mathematicians were purposely in opposition to the stereotype, recognizing that anyone can be a mathematician, and that mathematicians look just like anyone else. As Evan noted, “If you put a line of people together, I couldn’t tell you who the mathematician was” (T5, p. 22). While it was encouraging that the participants were clearly aware of the stereotypical image of a mathematician, it was troubling that several participants did not have an alternative image to challenge the stereotype.

Notably, far fewer participants held stereotypical views of mathematicians in terms of their behaviours, personalities, and social skills. The most stereotypical descriptions of mathematicians’ personalities came from Ben and Fiona, both of whom based their descriptions on real-life mathematicians that they know. Therefore, their descriptions could perhaps be seen as simply descriptions rather than stereotypes, even though they align with mathematician stereotypes. Ben acknowledged that his views were based on his favourite high school mathematics teacher and others he had met who were enrolled in mathematics at the University of Waterloo, a mathematics-focused university that Ben’s high school teacher attended. He described a mathematician’s personality as follows:

He’s a little quirky and a little eccentric. Brilliant... in the mathematical sense... maybe his social cues are slightly off, so that’s what I mean when I say eccentric. And a little strange, but not demeaning, not cruel in any respect. A very unique individual. (T2, p. 41)

Fiona provided similar descriptions of the mathematics graduate students she met while living in an interdisciplinary graduate residence:

Always a bit of a kind of absent-minded professor. Like, super, super, super smart at math, but send them to the grocery store... and they were hopeless. [Laughter] It was like, ‘Oh my goodness! Okay, I’ll go get the milk myself.’ [Laughter] (T6, p. 33)

Fiona found that these individuals also needed prompting to join social activities.

In terms of non-physical traits, the participants were in agreement with regard to two features: Mathematicians have a love for and interest in mathematical topics, and they work on mathematics on a daily basis. These ideas came into play when discussing whether mathematics-related careers, such as those of engineers, accountants, and scientists, were mathematicians. Many participants thought of these careers as being mathematicians due to the focus on mathematics. As Evan noted, a love of mathematics would likely translate into one’s occupation: “It would be top-heavy in math because obviously, they love numbers. They love solving problems. They love digging deep into math types of knowledge, so I think their job would reflect that, obviously” (T5, p. 22). Interestingly, Isabelle and Jill argued that there weren’t any ‘true’ mathematicians now, compared to the time of mathematicians like Descartes and Gauss. Jill stated that mathematics is “a tool to accomplish some goal” (T10, p. 43), rather than simply having a purpose in and of itself. Isabelle and Jill further relayed that if one of their children announced a desire to become a mathematician, they would both ask, “In what field?” (T9 and T10, p. 43). This discussion hints at the notion that mathematics is ‘finished’, with no new discoveries to be made; rather, mathematics is simply there to be applied to other, ‘useful’ fields.

The teacher participants tended not to think of themselves as being mathematicians – either by virtue of their job (which involves teaching many other subjects) or by a lack of confidence in their mathematical abilities. Two participants thought they could potentially be considered mathematicians in some respect, but they would not define themselves as

mathematicians overall. Jill only considers herself to be a mathematician while she is teaching mathematics, while Heather feels that she is only a mathematician on a relative basis. While Heather thought she was a mathematician compared to the ‘average Joe’, she also told me explicitly, “You’re more of a mathematician than me” since I have a mathematics degree, whereas she has only taken a few university-level mathematics courses. Heather also reflected “because it’s been so long since I’ve done harder math... I don’t feel like as much of a mathematician as I maybe did once” (T8, p. 29). However, in contrast to the general consensus to not consider themselves to be mathematicians, some participants claimed that other elementary teachers could be considered to be mathematicians. In some cases, this stance was due to the participants’ lack of confidence in their mathematics abilities, as they felt their colleagues were stronger with the subject area. Andrea reflected, “Would I classify myself as a mathematician? No, I don’t think so. But, I guess just other teachers would be” (T1, p. 43). The participants generally agreed that university mathematics professors and high school mathematics teachers were mathematicians, due to the mathematical focus of their daily work, coupled with their high skill level and knowledge base.

Notably, all but one of the examples provided discussed an adult as a mathematician – often, this related to the focus of the discussion on certain careers, even when a participant defined a mathematician primarily by a love of and aptitude for mathematics. The example of a child mathematician was one of Danica’s former Grade 4 students who was extremely bright and creative in mathematics: “He would have a way of tackling a problem and it was completely unlike things I would have seen before” (T4, p. 52). She felt that this student was a mathematician “in the way that he approaches something in a completely separate method... He’s a very mathematically-technical person in his approach to things” (T4, p. 52). Ben also

mentioned a student he taught the previous year who was very strong in mathematics, but he did not think of the student as a mathematician yet, although he could grow up to become one: “I guess I can’t discount it yet because he hasn’t been exposed to all of it and seen and attempted these more difficult things” (T2, p. 43). Ben’s description seems to imply the importance of having a broad, deep knowledge base if one is to be considered a mathematician.

The participants viewed mathematicians as being heavily involved in mathematics in their careers, plus having a strong love for and interest in the subject area. As such, many participants felt that those who work in mathematics-related fields, such as engineers and accountants, would be considered to be mathematicians. While the participants tended not to view themselves as mathematicians, they acknowledged that other teachers could be, particularly at the high school and university level. Finally, all but one of the participants described mathematicians as being adults, which perhaps is linked to a focus in the participants’ discussions on careers or the influence of the real-life mathematicians the participants have met.

Summary of the Teacher Participants’ Views

Overall, the participants tend to think of mathematics as a varied subject area that encapsulates many topics (e.g., number sense, measurement) and that can be represented many ways (e.g., numbers, graphs). Some participants stressed the importance of mathematics in solving problems, while others focused on mathematics as a way to communicate. All participants argued that we cannot live without mathematics, as it is ‘everywhere’. However, even with these purported definitions, much of the participants’ discussions focused on arithmetic and number sense (e.g., examples of mathematics in the media, use of mathematics outside teaching).

The participants tend to feel quite positively toward mathematics, with some participants expressing that it is their favourite subject to teach. For the Grade 4 teachers in particular, their feelings have become more positive and their confidence has increased since re-learning mathematics in a different way as a teacher. In contrast, the Grade 8 teachers tend to have always enjoyed and felt confident in mathematics. The participants' views of mathematics were mostly commonly influenced by their teachers and by their own teaching experiences.

Finally, the participants all indicated an awareness of the stereotypes associated with mathematicians, particularly with regard to appearance. Several participants admitted picturing mathematicians with a stereotypical appearance, even though they recognized that it was a stereotype. In contrast, other participants were adamant that mathematicians were not like the stereotype, and that they were 'just like everyone else'. The defining features of mathematicians were seen to be a love of mathematics and a focus on mathematics in their work. As such, people working in mathematics-related fields (e.g., engineering) were seen by most participants to be mathematicians. The participants tended not to view themselves as mathematicians, although 'other' teachers, particularly at the high school level, were considered to be mathematicians.

Messages Produced by Teacher Participants

This section addresses the messages about mathematics that the teacher participants produce, either implicitly or explicitly. The focus of the section is placed on the students the participants teach, although I also discuss the messages about mathematics that the participants produce to the parents of the students they teach, and to their own children.

To Students

Students are the main recipients of the messages that the teacher participants produce about mathematics. Implicit messages can be disseminated to the students through the manner in

which the participants teach mathematics. In this regard, the teachers tended to be quite aligned with each other, as well as with the Ontario Mathematics Curriculum. The participants all teach in what would be considered a reform-oriented manner, where the focus is placed upon the students' understanding and exploration of mathematical concepts, and where multiple types of solutions and representations are valued. As discussed earlier, shifts in the participants' practice over the course of their careers, moving toward a more reform-oriented focus, have come about via relearning mathematics in this manner, through teaching, and/or from professional development opportunities. For example, after attending a workshop, Ben changed the way he asked questions to make them more open-ended and thought-provoking, rather than simplistic, with only one correct answer. For example, when discussing area, Ben noted that he used to ask questions like, “‘This box is four by six. What is the area?’, not ‘The area is 24 cm^2 . What could the length be? What could the width be?’” (T2, p. 22). He found that asking questions in this way helped his students to become much more engaged and heightened the level of mathematical discussion.

The participants stated that they tended not to have a ‘typical’ schedule for their mathematics classes. The participants’ mathematics classes frequently featured lessons that were exploratory and hands-on, where students were working on projects and open-ended questions. The mathematics and ‘math talk’ were being done and explored by the students, rather than having the focus placed on the teacher. Students were encouraged to discuss mathematics with one another, and the classrooms were set up in ways that supported collaboration, such as having desks placed in ‘pods’ or having large tables available at which students could choose to work.

The participants reported using a variety of tools in their teaching. Participants with access to SMART Boards described them as a key tool in engaging students in mathematics.

Students quickly learned how to use the SMART Board and were not afraid to explore or make mistakes. Participants who had a SMART Board in their classrooms tended to use it more frequently than hands-on manipulatives. A few teachers had difficulties accessing manipulatives, and the class sets often were insufficient for the number of students in their classrooms; such issues discouraged the teachers from using manipulatives. All participants have a class textbook that is assigned and provided by the school or school board. While they all use a textbook at some points, the participants do not rely on it, and do not necessarily follow it in order. Rather, they select certain textbook lessons and problems that they feel are particularly well-designed and well-aligned with the curriculum. Textbook material is supplemented with activities from teacher websites and activities that the participants create. The participants noted that today's textbooks are vastly different from the ones they used as students, as there are more visuals, multiple strategies presented, links made to the 'real world', and activities that involve manipulatives and technology. Thus, using a current textbook can certainly be in alignment with the goals of the curriculum and these participants' goals in teaching mathematics.

When I asked the participants to describe a mathematics lesson that had gone well, their focus on constructivist-aligned pedagogy was evident. These successful lessons focused on student exploration and rich mathematical discussions, and typically involved open-ended projects and problems that allowed the students to be creative in mathematics. Evan found that such lessons allowed the students to make mathematical discoveries, supported by their peers:

The ones [lessons] that are really good are the ones that, you know, had them down on the ground solving problems... It makes me feel good when they're up there and they're doing the teaching and they're teaching their peers on how they problem-solved...

They're having those a-ha moments where you see them catch onto something or pick something up, which is really neat. (T5, p. 18)

Ben also found that mathematics lessons that incorporated multiple mathematical topics and other subject areas worked very well, such as a project he created for his Grade 8 students where they had to make a gingerbread town. By baking the gingerbread and figuring out the layout of the town, the project incorporated a wide variety of mathematics topics, as well as topics from geography. Interestingly, several of the 'best' lessons the participants shared involved food (e.g., an estimation lesson involving Rice Krispies cereal, a geometry lesson involving Toblerone chocolate bars), which suggests that food is one way to create a link between school mathematics and the students' lives outside school, and to engage students in mathematics.

I posed a hypothetical situation to the participants to query how they would react to a student who said, "I hate math! When am I ever going to use this stupid stuff?" However, it turned out that this situation was not hypothetical – Each participant had encountered students who expressed such sentiments. All participants stated that they try to preempt such situations by focusing on real-world applications of the mathematics concepts they are teaching. Some applications are more relevant to adults, such as building houses and making quilts, so the participants tried to stress to their students how their parents use mathematics every day. Some participants purposely tried to avoid examples that would only be relevant to adults, and instead tried to focus on examples that would be interesting to students, such as cell phone plans and video game scores. A few participants shared that they discuss mathematics and careers, challenging the students to come up with a career that would never use mathematics. The students have yet to come up with such an example, which makes them realize that, even if they dislike mathematics, they will encounter it as an adult. A few participants noted that students

who make such comments are the ones who are struggling and lack confidence in their mathematical abilities; therefore, these participants try to make mathematics more comfortable for the students through the way they teach. Finally, although all participants supported the idea that ‘math is everywhere’, a few participants revealed that they are honest with their students and admit that certain mathematics topics that are not generally that useful, except in specialized fields. Jill will sometimes tell her students that she does not know why they have to learn certain topics, but that it is necessary for their report cards, whereas Fiona will tell her students that they need to learn a topic as a base for later mathematics learning. A few participants stated that they explain to their students that the important part is not the specific mathematics concept, but learning how to learn. As Isabelle stated, “It’s not so much knowing how to do the surface area of a triangular prism. It’s understanding that you have to do each part individually and then add those together... It’s the thinking, not so much the tangible example” (T9, p. 36).

To Students’ Parents

The teacher participants’ interactions with students’ parents typically occur directly in parent-teacher interviews and indirectly through work sent home with the students. Most participants reported that they do not assign any mathematics homework. For some participants, this is a marked change from earlier in their careers, when they would assign nightly mathematics homework. Their views have shifted due to changes in their own teaching philosophy (i.e., moving away from a focus on repetitive practice), feedback from parents and students, and their experiences with their own children. The reasons shared for not assigning homework included a lack of parental support, parents doing the homework for the students, and students being overwhelmed with extra-curricular activities. Some parents would complain that they could not help their children with mathematics homework – more so than other subject

areas – because it did not make sense to them, since it was not done the way they were taught. Gail found that parents would use this as an excuse to ‘tune out’ rather than look into the mathematics with their children. Danica suggested that the parents’ complaints were indicative of their doing the homework for the students, rather than supporting their learning:

My standard line is: I have done Grade 4 already; now it’s your turn. The same with their parents – like, parents would complain at interview time: ‘I find the math homework really hard to do.’ And I say, ‘Well, don’t forget. You’ve done Grade 4. So, I’m not marking you on your homework.’ (T4, p. 43)

One problem most participants had experienced was parents taking issue with the homework their children were doing because it was not the way they were taught mathematics. Andrea shared the following story:

The child will come back the next day, stressed out, and the parent was like, ‘Why do you have them do it this way? I had them do it the way we were taught.’ They made them erase all the work and re-do it all. I was like, ‘Aaah!’... Some parents are like, ‘This is the way I was taught in school, so this is the way you’re doing it. She’s not teaching it right.’... But the last couple of years haven’t been too bad. I think parents are more used to the math program. (T1, p. 25)

Andrea noted that parents tended to become open to the different ways she was teaching mathematics once she explained her reasoning behind teaching the concepts the way she did. Indeed, most of the participants related similar stories of having to explain the focus of the current mathematics curriculum to parents, as they tended to want to do mathematics with their children the way they had been taught – even if they admitted that it had not worked for them! Some participants stated that they were open to their students bringing back different techniques

and strategies after working with their parents. These participants would sometimes share these strategies with the rest of the class, and they would stress that it was acceptable to solve mathematics problems different ways, as long as the mathematics was justified. Getting parents to understand the importance of doing mathematics in multiple ways and showing one's understanding tended to be a struggle for the participants, although some found that parents are slowly become more accepting of the current ideas in mathematics pedagogy.

To Their Children

All the teacher participants except Ben, Caroline, and Danica have children, most of whom are in elementary school. All of these participants, except Evan, shared that they, not the partners, were the ones to help their children with mathematics, which is certainly an understandable finding. Presumably, a child would choose a parent who is a teacher for homework help, since a teacher knows the curriculum and understands current pedagogy. Evan's children typically ask their mother for help with mathematics homework, which Evan speculated has "kind of been perpetuated as well through my wife saying, 'I do the math. Daddy does the language.' So, I guess I just kind of let that slide" (T5, p. 19). Therefore, in all the households with children, mothers tend to be the ones who help with mathematics homework.

The teacher participants with younger children (typically Kindergarten to Grade 6 age) tended to find that their children had little homework assigned – typically only having mathematics homework when they were studying for tests, working on projects, or doing work that was not finished at school. However, these participants all reported working on non-school-related mathematics with their children. In most cases, the mathematics was involved in other activities and thus may not have been apparent to the children. These activities included doing puzzles, baking, working with money, playing musical instruments, and playing with blocks.

Isabelle felt that these activities contributed to her children's mathematics development: "That's [Doing a puzzle is] problem-solving. That's looking at things differently... Building blocks and trying to create towers with Lego, that's all manipulating materials and playing. I think that's very important. That's early math development" (T9, p. 41). In contrast, Isabelle also noted that she and her husband 'drill-and-kill' their children in their mathematics facts "because we know that they might not get it at school" (T9, p. 40). This signals both an awareness of the curricular shift away from rote learning and the importance Isabelle places on fact recall.

Fiona and Heather in particular have spent a great deal of time working with their children on mathematics. Although their children are strong mathematics students, these participants were concerned about circumstances associated with their schools. Fiona and her son lived in the far north for two years, where she felt that the school was behind with the curriculum. Thus, she worked on mathematics with her son to ensure he remained at grade level. Heather's daughter rarely has any homework, so Heather reviews mathematics with her each night for 15 minutes – typically, doing questions or puzzles in mathematics workbooks. Although she tries to keep it a positive experience, Heather shared that, "She [Her daughter] doesn't necessarily like it when I make her do math... Probably, you know, other people think it's kind of funny" (T8, p. 9). Although her daughter is stronger in mathematics than reading, Heather spends more time working with her on mathematics: "Eventually, her reading will catch up, but math is something... if you miss concepts in math, early on, and keep missing them, it sort of snowballs." This statement highlights Heather's feelings about mathematics as a subject area that is highly connected; conversely, she appears not to see language arts the same way, nor does she acknowledge the importance of reading skills in mathematics comprehension.

In summary, seven participants have children, and all but one of these participants reported that they, not their partner, were the main person who worked with their children on mathematics; this is understandable due to their profession. Many participants shared examples of ways that they promote mathematics in their home, such as playing games and building with blocks. Through their actions, the participants are implicitly disseminating messages to their children about the importance of mathematics – both in terms of success in mathematics as a school subject and using mathematics in everyday life.

Summary of Messages Produced

The manner in which the participants reported teaching mathematics and interacting with their own children and mathematics were generally very reform-oriented in nature. Implicit messages were produced regarding the value of using multiple tools and representations, and the importance of explaining one's thinking. Furthermore, messages about the utility of mathematics in the 'real world' and in a wide variety of careers were also reportedly produced, both implicitly and explicitly, to both the participants' students and children.

Interactions with students' parents have been difficult for some teachers in terms of sharing messages about the value of the way mathematics is taught now. In spite of (or perhaps because of) the fact that many parents feel uncomfortable with mathematics, they tend not to be receptive to 'new' ways of doing mathematics. However, the participants have persisted in attempting to help parents understand that there are multiple ways to do any mathematics problem, and that no one way is the 'right' or 'best' way.

Parent Interviews

This section addresses the findings from my analysis of the parent interviews. Since the parent interview data were analyzed similarly to the teacher interview data, the findings are

presented in a parallel structure. That is, I begin with profiles of the parent participants in order to situate the findings. Then, I address their experiences as consumers of messages about mathematics and mathematicians. The participants' views of mathematics and mathematicians are then discussed, followed by a consideration of the messages produced by the participants.

Parent Participant Profiles

Thirteen parents participated in semi-structured interviews; two couples participated in pair interviews, so 11 interviews took place. The participants had children in Grade 4 or Grade 8 who attended schools in the Eastern 1 school district (Kate to Quinn, in Table 26) or the Eastern 2 school district (Robert to Will, in Table 26). In terms of age, the parent participants were between their late twenties and late forties. Table 26 provides an overview of the participants.

Table 26
Information about the Parent Interview Participants

Name (Code)*	Gender	Occupation	Mathematics background*	Child's grade	Child's gender
Kate/Leo (P1/P2)	Woman/Man	Elementary teacher/ Ammunition engineer	University/ University	4	Girl
Miranda/Nick (P3/P4)	Woman/Man	Daycare provider/ Security officer	High school/ College	4	Girl
Owen (P5)	Man	Metallurgist	University	4	Girl
Patti (P6)	Woman	Daycare provider	High school	4	Girl
Quinn (P7)	Woman	Sonographer	University	4	Boy
Robert (P8)	Man	Materials science engineer	University	4	Boy
Samantha (P9)	Woman	Financial analyst	College	4	Boy
Tamara (P10)	Woman	Writer/Assistant manager	High school	4	Girl
Ulysses (P11)	Man	Electrical engineer/Manager	University*	8	Girl
Victor (P12)	Man	Systems analyst	University	8	Boy
Will (P13)	Man	Owner/operator of housecleaning company	University	8	Girl

Note. ‘Code’ refers to the participant number (e.g., P5 refers to the fifth parent who took part in an interview). These codes are used to identify each quotation. Parent participants whose names are listed together (indicated by ‘/’) were interviewed together. ‘Mathematics background’ indicates the highest level at which the participant studied mathematics. Ulysses took master’s-level mathematics courses, whereas the other participants who took university mathematics courses studied at the undergraduate level.

As evidenced by Table 26, the proportion of the participants who work in mathematics-intensive fields is substantial, arguably higher than that of the general population. Thus, all findings should be couched in the understanding that these parents are presumably not representative of most Grade 4 and 8 parents in Ontario. Arguably, the voluntary nature of the interviews may lead to

involvement of parents who have an interest in mathematics. Unsurprisingly, given their occupational fields, the parent participants were generally quite highly educated in mathematics. Among the participants who studied mathematics at university, nearly all took courses beyond the first year level, due to the requirements of their science, engineering, or business degrees. All but one of the participants have been in the same occupational field for the majority of their adult lives: After working as a dental hygienist for 20 years, Samantha became a financial analyst.

All the participants except Nick reported that they use mathematics in their jobs. Leo, Owen, and Robert's jobs involve a great deal of university-level mathematics related to engineering and chemistry concepts. Regarding his job, Owen asserted: "I don't think there's probably an hour that goes by where math is not part of the equation" (P5, p. 4). Tamara and Will reported that they use a substantial amount of financial mathematics in their jobs. Tamara's focus on mathematics was something that she 'fell into', after starting as a writer at a magazine:

She [Tamara's boss] went on vacation, and she was like, "Oh no! My budget is due.

Here, you work out some numbers for me." And I looked at it and I went, "[Boss' name], there are big errors in this!" And that was when it sort of fell into my lap. (P10, p. 8)

For other participants, such as Quinn and Ulysses, the amount of mathematics in their jobs now is less than it was earlier in their careers – either due to movement into a more managerial role or due to an increased use of computer technology. For a few participants, computer programs do most of the calculations required at their jobs, while the participants are responsible for verifying the output. Kate, Miranda, and Patti are involved with teaching mathematics to children, either in a daycare or elementary school setting. Miranda and Patti, both home daycare providers, also are responsible for the financial mathematics associated with running a small business.

Outside of their jobs, the participants all reported using mathematics on a daily basis. However, a couple of participants had trouble thinking of examples. As Samantha suggested, “You don’t think of it because it’s something you’re doing the same every day... I wouldn’t be thinking of it as, ‘Oh, I’m doing math right now’” (P9, p. 17). The most common examples reported involved using mathematics for financial purposes (e.g., budgeting, mortgages, stocks). Several participants also shared that they use mathematics while shopping and while cooking and baking. Mathematics was also involved in several participants’ hobbies, such as participating in football pools (Nick), playing piano (Quinn), playing chess (Robert), and doing wood turning (Ulysses). Robert reported that his wife uses mathematics to make clothing and to examine their children’s academic progress: “She would compare the grades and track their performance at school in Excel charts” (P8, p. 26). In contrast to most of the examples discussed, Leo reported that he uses rather difficult mathematics outside of his job when he conducts horsepower analysis and other engineering calculations for home appliances.

Messages Consumed by Parent Participants

As with the findings from the teacher interviews, the term ‘consumed’ is being used to recognize any messages that are involved in the participants’ schemas in some way. In the following sections, I discuss the same key sources addressed in the findings from the teacher interviews. I first address sources from the participants’ childhoods that may have impacted their views of mathematics: their schooling and home experiences. The section then turns to a discussion of the messages about mathematics and mathematicians to which the participants have been exposed in the media, followed by consideration of the participants’ interactions with ‘real-life’ mathematicians. These final three sections focus on the participants’ adult experiences.

Student Experiences

Like the teacher participants, the parent participants spanned approximately two decades in age and did their schooling in a variety of geographic locales. Regardless of their diverse backgrounds, the parent participants, like the teacher participants, reported remarkably consistent educational experiences in mathematics. Namely, the parent participants all reported being taught mathematics in a very traditional manner. In both elementary school and high school, the participants' classes were characterized by teacher lectures, narrow views of 'acceptable' mathematics, and repetitive textbook questions. For instance, Robert stated that in his mathematics classes, "We [The students] got stuffed" (P8, p. 2), referring to the notion of filling one's head with knowledge from the teacher. Victor found that his teachers were very stuck in their ways and only viewed one way of solving problems to be the 'right' way, which stifled students' mathematical creativity: "They followed the established procedures and they would not step outside of it, which was unfortunate... You were penalized for thinking outside the box, even if you came up with the right answer. And so, consequently, no one did" (P12, p. 7).

In terms of tools, nearly all participants reported using pencils, paper, and, in some participants' cases, calculators or slide rules to do mathematics. No participant recalled using computers for elementary or high school mathematics. Only Quinn recalled using manipulatives: An abacus was used in her elementary mathematics classes. As a result of not having multiple representations at her disposal, Tamara created her own system to do addition and subtraction, which involved drawing dots on her page to enable her to complete the calculations in a manner she understood. Several participants claimed that little emphasis was placed on understanding while they were learning mathematics. Rather, memorization, particularly of the multiplication tables, and repetition were the methods used to 'learn' mathematics. As Victor stated:

It was always assumed that by doing more, eventually it was going to stick. Because here was the curriculum; this is the way we're teaching it. You should understand it from this. And the only – just continue doing other stuff. Repetition – do it again, do it again, do it again, and eventually, this will stick into your brain. (P12, p. 5)

Victor and many of his classmates found that this method did not work for them. Both Victor and Will reported that there was never any explanation provided for why they were learning the mathematics content to which they were exposed, or how it could be useful in the 'real world'.

All participants except Patti reported that they did well in mathematics and found it easy for the majority of their educational careers. Patti shared that she struggled partly because of changing schools every three years (due to having a parent in the military) and because of a learning disability that went undiagnosed until she was in Grade 11. For the other participants, mathematics was one of their stronger subject areas and typically one that they enjoyed; some participants explicitly stated that they liked mathematics because it was easy for them. Two participants had unusual educational experiences – Quinn skipped a grade during elementary school, whereas Tamara was placed in enriched mathematics classes in high school. When the participants struggled in mathematics, the issues tended to be with calculus – either at the high school or university level. After doing well in mathematics for so many years, having difficulties for the first time shook some participants' confidence. As Kate suggested, the roadblock in calculus may have been due to the fact that memorization was sufficient to do well in prior mathematics courses, whereas calculus required thinking and understanding:

I think I was very good at memorizing, but I don't think I understood a lot behind it because I went to first year university calculus, and it was like – even though I thought I had understood math, it was like a new language... I remember answering maybe two

questions on the final exam... and I think that left me feeling like I really didn't know math. (P1, p. 1)

Although Kate's mathematics education ended after her negative experience with calculus, most of the other participants who encountered difficulties continued to take mathematics and eventually reached their former levels of achievement and understanding.

Home Experiences

Nearly all participants reported that they tended to complete their homework on their own, rather than asking a parent or sibling for help. No participant recalled assisting younger siblings with mathematics. Tamara suggested that this tendency may have been related to the era in which she grew up: "I didn't get a lot of help. But I think back then, we didn't. Like, there wasn't an emphasis on your family helping you out with stuff like that" (P10, p. 7). For a few participants, help from parents was not an option due to their low levels of education.

While most participants reported that they worked on their homework alone, their parents generally were available and willing to help if asked. The participants were mixed in whether they would approach their mothers or fathers for assistance with mathematics. While the choice of parent for mathematics assistance was typically based on the parent's (perceived) strength in the subject area, this was sometimes disregarded due to other factors. For example, Patti's mother is not very strong in mathematics, but Patti did not like going to her stepfather, who is strong at mathematics, for help because "he was the kind where – 'Okay, write it out 20 times'... Okay, five times five is 25... So, I had to write it out all the time" (P6, p. 17).

While the participants tended to report that their parents were supportive of education in general, parental involvement with mathematics outside homework was quite limited. In fact, Quinn was the only participant to report parental involvement in promoting mathematics outside

of the school context. Her mother, a teacher, placed a high importance on education in the home. Quinn recalled that her mother “definitely did lots of math stuff with us [Quinn and her sisters]” (P7, p. 34), especially when they were young. Quinn’s father, a doctor, helped her to learn to play the piano and explained the link between music and mathematics: “I do remember being told by my dad... ‘This will help you with your math. Piano is all math. It’s all fractions.’ Well, I understood!” (P7, p. 34). Quinn shared that her parents were particularly proud and impressed when, as a child, she came up with a theory about the relationship between two times tables.

Mathematics in the Media

Like the teacher participants, all the parent participants reported seeing mathematics in the media, and the examples provided tended to be those found in news reports, particularly business data (e.g., stock market data, currency values). Several participants also reported seeing mathematics in the form of statistics presented in the findings of various studies, such as those from medical and scientific fields. Tamara, who works at a magazine, shared that magazines sell better when there is some sort of statistical data shown on the cover.

Within the magazine, we’ll look for a statistical thing to put on our cover because it always [emphasized] sells more... Our brains work that way – that we want – I think we believe, or we know instinctively, that if there’s a number attached to it, it carries more weight... It’s been scientifically proven somewhere. (P10, p. 23)

These comments highlight the notion that the use of mathematics helps to add authority to one’s claims, as well as to a media source in general.

Some examples provided by the participants were topics that were highly featured in the news during the time of the interviews: polls related to the federal election and debates about the cancellation of the long-form census. Other examples included sports statistics, gas prices (listed

on the news), and weather data. However, as argued by Victor, these types of statistics and data may not be recognized as being mathematics: “Do you realize it’s math? No. But I mean, that’s what it is.... It’s just not jumping out in your face saying, ‘Hey! I’m math! Look at me!’” (P12, p. 44) Potentially, the ubiquitous nature of such statistics and data decreases the possibility that they are seen as mathematics. Only Patti provided examples of television shows where mathematics itself (as opposed to mathematicians) figured prominently. Specifically, Patti noted that there is business-related mathematics on *The Dragons’ Den*, a show in which entrepreneurs make business proposals to millionaire financiers, and money-related mathematics on *The Price is Right*, a game show that involves many tasks involving estimations and comparisons of prices.

Mathematicians in the Media

Similar to the teacher participants, the parent participants were much more likely to be exposed to mathematics than mathematicians in the media. However, the parent participants were even less likely than the teacher participants to be able to provide examples of mathematicians in the media; more than half of the parent participants were unable to provide any such examples. A few participants explicitly stated that mathematicians are simply not seen very often in the media: “It’s rare... You don’t see them very often on TV – except in diminutive roles” (Victor, P12, p. 43). The only examples provided by more than one participant were the movies *A Beautiful Mind* and *Good Will Hunting*, and the television show *Numb3rs*. As discussed earlier, *Numb3rs* provides a more positive image of mathematicians than does *A Beautiful Mind*; the former portrays socially adept characters who use mathematics in their jobs, whereas the latter portrays mental illness associated with mathematical genius. *Good Will Hunting* provides a very different image of a mathematician: Will is a janitor who exposes himself as a mathematical genius after solving a graduate-level mathematics question posted on a

chalkboard at M.I.T. (Massachusetts Institute of Technology). Victor found that the portrayal of Will stood in stark contrast to the portrayal of the other mathematicians in the movie.

They portrayed him as being this brilliant math guy, but you'd never know it. He did everything in his power to avoid being that brilliant math guy... All the other mathematicians were... sort of stuck up and at a higher level than everyone else, and he was down to earth – but he was smarter than everyone else. (P12, p. 45)

Notably, all the examples of fictional mathematicians provided by the participants were men.

A few participants discussed the trope of the 'math geek' as being a stereotyped representation of mathematicians. Leo brought up the 'geeky' characters on *The Big Bang Theory*, while a few other participants discussed the 'geek' trope more generally, typically in the context of television shows that take place in school settings. These participants discussed how mathematically proficient characters are depicted as being socially awkward, physically weak, and unpopular. Victor discussed the lack of mathematician role models in the media: "You don't see too many mathematician heroes... The math kids are not the physical [jocks]... and unfortunately, we glorify the athlete as opposed to the smart guy" (P12, p. 43). Leo claimed that the people he knows who are good at mathematics are not like these 'geeky' characters, but he acknowledged the influence that viewing such stereotypes can have:

It's [Television is] forming a lot of opinions, and I think people generally tend to think of folks that are good at math as, you know, a little bit odd, off on their own, don't quite fit in. You know, certainly not physically competent. (P2, p. 21)

Leo noted that he and Kate try to counter these stereotypical representations that their children see on television, discussing how 'real' people are not like that.

Exposure to Real-Life Mathematicians

The parent participants' exposure to real-life mathematicians was rather mixed, with approximately half the participants claiming that they had met or know a mathematician and the other participants claiming that they had never met one. As with the teacher participants, the parent participants' claims were highly related to the manner in which they defined what a mathematician is. For instance, Samantha and Tamara held opposing views about statisticians: Samantha felt that a statistician was a mathematician, whereas Tamara did not view statisticians, or people in other mathematics-related fields, to be mathematicians. As Tamara discussed: "I see a mathematician as being a genius. That is how I envision mathematicians" (P10, p. 24). The notion of being highly intelligent also featured in Victor and Will's descriptions of the mathematicians they know. In Victor's job, mathematicians sometimes work on portions of joint projects with his team; however, Victor admitted "What they do, I have no idea" (P12, p. 44). Will struggled with whether his father-in-law was a mathematician or not: "I would think of him as a mathematician, even though he isn't. He fronts a store. But anybody who can multiply like that [using an abacus to do multi-digit multiplication questions more quickly than one could with a calculator] is a mathematician" (P13, p. 34). Will initially discounts his father-in-law due to his job, but then reconsiders due to his father-in-law's multiplication prowess. This example highlights the notion of mathematicians being good with calculations and arithmetic.

Of the 13 parent participants, only Owen reported that he thought of himself as a mathematician. He sees mathematicians as being people who do mathematics, and he reported that he uses a lot of mathematics in his job. Related to this broad definition, Owen also provided examples of high school teachers and accountants that he considered to be mathematicians. The interview with Kate and Leo provided an interesting discussion. When I posed the question 'Have you ever met a mathematician in the real world?', Kate immediately agreed and provided

the example of Leo and his colleagues. Leo challenged this claim, and suggested that Kate's university mathematics professors were a better example. Leo's suggestion of Kate's university professors related to his ideas about what makes one a mathematician: "They all had doctorates. They were all honest-to-God, you know... mathematics professors" (P2, p. 27). Leo, on the other hand, stated that he has never thought of himself as a mathematician, even though he is strong in mathematics and uses university-level mathematics daily in his job.

Beyond mathematicians that the participants had met, a few participants also provided examples of real-life mathematicians, both historical and present-day, that they had seen in the media (e.g., documentaries, biographies). For instance, Ulysses discussed Isaac Newton and Gottfried Leibniz, while Owen discussed Steven Hawking and Bill Gates. Robert referred to a mathematician in his home country of China who became very well-known and respected for solving a famous equation (Unfortunately, Robert did not know the man's name or the equation).

It's earned him quite some honours. So, the government kind of raised – presented him as a great guy. Yeah. And a good model – he worked really hard and... so, he's totally devoted to math. To the Chinese government, he's the perfect model. [Laughter] He worked hard and concentrated and not worry [*sic*] about anything else. (P8, p. 25)

A few examples of statisticians and physicists (e.g., the Chief Statistician of Canada, physicist Richard Feynman) were also suggested by the participants, who were undecided on whether these individuals were mathematicians or not. Similarly, participants who brought up fictional examples of characters who deal with cryptography (e.g., Sherlock Holmes, characters in the movie *The Da Vinci Code*) were unsure as to whether they would be classified as mathematicians.

Summary of Messages Consumed

The parent participants' exposure to ideas about mathematics during their formative years involved a mixture of positive and negative experiences. While the participants did not value the traditional manner in which mathematics was taught, most participants did well and enjoyed mathematics. As students, the participants had tended to do their homework alone. When asking a parent for assistance, the participants were divided between seeking help from mothers and fathers. Only one participant recalled any parental promotion of non-school mathematics.

With regard to media exposure, the participants reported seeing a great deal of mathematics content, namely in news reports, although the type of mathematics content reported tended to be narrow in scope (e.g., numbers, statistics). Media examples of mathematicians were rarely seen and tended to be stereotypical in nature, such as the 'math geek' trope. The participants were divided in terms of reporting that they had met or knew a mathematician. These claims were highly related to the manner in which the participants defined mathematicians, with some participants having much broader definitions. Notably, only one participant viewed himself as being a mathematician, and he had a very broad definition of a mathematician.

Views of Mathematics and Mathematicians

In this section, the parent participants' current views of mathematics and mathematicians are discussed. The section begins by addressing the participants' views regarding what mathematics is and why it is important. This is followed by a discussion of the participants' feelings about mathematics, including the consideration of influences on these feelings. Next, the participants' views of mathematics education (e.g., stance on homework) are discussed. The section concludes by addressing the participants' views about mathematicians – both their beliefs about what makes one a mathematician and their feelings toward mathematicians.

What is Mathematics?

The parent participants' views of what mathematics is were probed with the same scenario posed to the teacher participants: Explain to an alien from a planet that doesn't have mathematics what it is and why it is important. While there were some similarities in the groups' responses, the overall conceptions of mathematics were rather different. Namely, the teacher participants explicitly described mathematics as being 'more than numbers', provided examples of different types of mathematics, and discussed various representations of mathematics. Such views were generally not evidenced in the parent participants' discussions.

The participants' views of what comprises mathematics were clearly divided into two different stances. Four participants (Miranda, Nick, Patti, and Samantha) expressed a view of mathematics as being numbers – or, at least, anything involving numbers. Notably, these participants all have the lowest levels of mathematics education (i.e., high school or college level) of the parent participants. These participants' views may suggest a narrow exposure to mathematics and its breadth during their educational experiences. In contrast, the other participants explained mathematics in a much deeper manner: as a way to understand and explain our world and universe. Essentially, these participants felt that mathematics underpinned everything in our world; for some participants, this was described on a physical level, while others described this relationship in terms of interactions in our day-to-day lives. In addition to this view, Tamara stated that she sees mathematics as being an 'objective' way to communicate:

It's another language... just another way that we use to express ideas, concepts, relations to one another... It's an absolute, pure thing... It kind of anchors us. It helps – It's a point of reference that allows us to see things the way other people see it. (P10, pp. 21-22)

Importantly, Tamara did not use the term 'absolute' with a negative connotation; rather, she saw the 'absolute' nature of mathematics as being key to our shared understanding. Tamara provided

the example of discussing 10 eggs versus discussing a blue sky, arguing that 10 always means the same number of items, whereas there are many ways to describe ‘blue’.

An interesting point of comparison arose during the interview with Kate and Leo, when they were discussing how they would explain mathematics to the alien. Although they held similar views of mathematics – as a way of understanding the universe – the manner in which they stated that they would begin explaining mathematics to the alien differed vastly.

LEO: [Laughter] But, you know, if you can find a way to actually communicate –

JENNIFER: Right.

LEO: Then you could, you know, do a simple calculus equation that shows the area under a curve.

KATE: [Laughter]

LEO: And then extend it along that way. You’ve got unified theory, good old Einstein and his crew, and all that fun stuff.

KATE: And I would just take a cookie and ‘half for you, half for me’. [Laughter] There’s [sic] the basics of math. (P1 & P2, p. 17)

These explanations highlight very different conceptions about what comprises ‘simple’, introductory mathematics. The influence of their occupational fields can be seen, as Kate’s explanation is much more related to the way mathematics is taught to children, whereas Leo’s explanation assumes a level of comprehension required in engineering fields. Similarly, Robert, another engineer, suggested presenting advanced mathematical equations and concepts, such as $E = mc^2$ and trigonometry, as the starting point when explaining mathematics to the alien.

All participants asserted that mathematics is a vital part of our daily lives and that the world could not exist as we know it without mathematics; these views are very aligned with

those expressed by the teacher participants. Accordingly, the parent participants provided similar examples of mathematics' involvement in their everyday lives, such as measurement and financial interactions. Kate argued that, without mathematics, we would lack a sense of fairness and accountability in a variety of interactions: "In order to feed ourselves, we need to know how much food we're going to need and how we'd divide it and share it evenly... You need to have a basic number system in order to make things fair" (P1, p. 16).

Like some of the teacher participants, approximately half of the parent participants questioned the premise of the question, arguing that it would be impossible for the alien to build a spaceship and fly to Earth without using mathematics. For instance, Will argued that "They [the alien] would have done something that involves math to get here. Yeah, I would just not accept that answer" (P13, p. 33). Some participants posited that the alien simply did not realize that his planet has mathematics. Quinn felt that the alien would come to this conclusion on his own while she was explaining fundamental mathematical concepts to him:

You'd have to make it really basic, and chances are that within a short time, they [the alien] would realize they'd been using math their whole life. They just didn't know what it was... I would like to think that they have math; it just has a different name. And they just don't know that they knew it. (P7, p. 23)

Similar ideas were discussed by Owen when he was talking more generally about mathematics. He argued that mathematics is always there, whether we understand it or not. Owen provided the examples of air travel and catapults, arguing that the mathematical potential was always there: "You just have to get someone who comes along and sees it a different way. But a solution wasn't created – It was just discovered. So, whether we understand math or not, it's there" (P5, pp. 28-29). Owen's stance appears to be aligned with Platonism, which argues that "the object

and structures of mathematics have a real existence independent of humanity, and that doing mathematics is the process of discovering their pre-existing relationships” (Ernest, 1991, p. 29).

Overall, the participants were divided in their conceptions of what mathematics is: While a few participants saw mathematics as simply being related to numbers, most participants conceived of mathematics as being a fundamental tool for understanding and explaining the world and universe in which we live. Regardless of their view of mathematics, the participants were aligned in their claim that mathematics is essential to our lives.

Feelings about Mathematics

Most participants reported that they have a fairly positive relationship with mathematics, although the way they discussed their relationships with mathematics typically was not in terms of whether they liked the subject area or not. For instance, the participants who are engineers discussed mathematics as an important tool, something that is essential to understand in order to do their jobs. Ulysses argued that, “It’s a good thing to learn and a good thing to know – but as a means to an end and not an end in itself” (P11, p. 28). Many participants voiced similar opinions regarding mathematics’ importance, and Samantha even claimed that it was the most important subject area since “it’s the basis for so much and it’s something that they [her children] can carry with them always and use always” (P9, p. 29). However, some participants felt that only basic mathematics was useful in their lives. These participants reported that they never have used higher levels (i.e., high school and above) of mathematics, but they could appreciate how such mathematics was useful for certain fields. The few participants who explicitly stated that they liked or loved mathematics tended to appreciate the (perceived) objective nature of mathematics, and they enjoyed working at mathematics questions until a solution was reached. Quinn reported,

“I find it very satisfying. It’s something you can sink your teeth into and get an answer, and you know you’ve done something properly when you get that answer” (P7, p. 32).

In terms of confidence, the participants nearly all reported that they feel confident with the mathematics that they use on a regular basis. The participants all claimed that they feel confident helping their children, most of whom are in elementary school, with their mathematics homework. Some participants worried that they would be unable to understand and/or remember high school mathematics and thus would be unable to help their children with homework once they reached that level. In contrast, other participants stated that they were very confident with high school mathematics, but lacked confidence in doing mathematics beyond that level, since it had been so long since they had done it. A few of these participants suggested that they were confident that they would be able to understand higher-level mathematics if they studied it again.

Kate and Patti were the only participants who reported a generalized lack of confidence in their mathematics abilities. Kate stated that she feels confident with the mathematics she encounters as an elementary teacher, but that she would get ‘panicky’ if a high school student asked her for help with mathematics. She does not consider herself a ‘numbers person’, but she has come to the realization that her feelings and experience may actually help students.

I still get scared of it. I still feel like I don’t get it at times... On the other hand too, I think I am able to see how others might feel that way, and so I try to give myself more credit and then I try to instill in kids that it’s not that hard to get. (P1, p. 44)

Similarly, Patti feels fairly confident with the mathematics she does with the children (preschool to Grade 4) in her home daycare, but she sometimes struggles with the financial mathematics involved in running her business. Patti admitted that she is very calculator-dependent and feels

very unsure about mathematics without a calculator. She has come to the realization that it is important to like mathematics, or at least appreciate its utility – particularly in her field.

I have learned through the years that I cannot dislike math. Like, you need it. No matter what, you need math... In my field, I have to know that I like math because I can't teach something if I don't like it. The kids will get that vibe from me. They will say, "Oh, I guess she really doesn't like it, so why should I learn it?" So, I have to be enthusiastic about math and numbers. (P6, p. 18)

This realization is vital – both for daycare providers such as Patti and teachers such as Kate.

The participants' views of who or what had made the greatest impact on the way they feel about mathematics were quite varied. A few participants claimed that there was no particular person or experience that had influenced the way they feel about mathematics. These participants all noted that they were strong mathematics students, so they did not need to ask for help; thus, the possibility of having a meaningful interaction was minimized. Yet, as Tamara suggested, if her mathematics teachers were better, her future educational and career plans may have changed:

There was no teacher that helped me think of it as being fun [emphasized], as being a challenge, a mystery that you've got to solve – never, never – which is a shame...

because it would have made a difference. I was that kind of student who is influenced by my teachers... I think I did have the potential to be very good at it... but it was never exciting for me. It was just something to get through. (P10, pp. 30-31)

Indeed, no participant reported having a mathematics teacher who acted as a mentor and/or influenced their views in a positive way. However, a few participants' university mathematics experiences more generally impacted their views. For instance, struggling with first year calculus contributed to Kate's lack of confidence.

Only two participants, Miranda and Ulysses, reported that they were influenced by their parents: Miranda's father assisted her with homework, while Ulysses' mother made a more substantial impact through her support in what turned out to be an important life event. Although Ulysses didn't feel that he was good enough in mathematics to attempt the University of Waterloo mathematics contest (for high school students), his mother, a high school mathematics teacher, encouraged him to attempt the contest and helped him prepare for it. Ulysses' success on the contest helped to build his confidence in his mathematical abilities:

I was in the top 100, I think, in the province, which I thought was pretty good... This other kid in my class who was, like, really, really high marks, he didn't even place. So, I thought, 'Maybe I'm not as dumb as I thought'... I don't want to say it was pivotal, but it was something that helped me realize that I'm probably not too bad at it. (P11, p. 29)

A couple of participants felt that their day-to-day mathematics experiences influenced their feelings toward mathematics, as their confidence was increased, and they learned how useful mathematics can be. Robert was highly influenced by the Chinese culture in which he grew up.

It's the entire society, I would say... I do think they promoted math by painting this big picture of mathematician doing this nuclear bomb development and energy development and stuff like that, which is – to a boy's mind – I think it's very, very cool... It's the entire society. Yeah. They put things in our minds and press them... It's permanently pressed in. (P8, p. 34)

Robert has not lived in China since he was in university, but he claimed that being raised in such a mathematics-focused culture continues to influence his feelings about mathematics.

Overall, the parent participants reported that they feel rather positively toward mathematics – viewing it as a key tool on the job, an important subject area, or simply an

enjoyable field. The vast majority of the participants stated that they are comfortable with the mathematics that they use on a daily basis, both at home and in their jobs. The influences on the participants' feelings toward mathematics were quite varied, and in some cases, participants reported that no person or experience had influenced the way they felt about the subject area.

Views of Mathematics Education

The participants were overwhelmingly in agreement that the current way that mathematics is taught is vastly different from the manner in which they were taught as children. The participants reported that their children have more variety in their class experiences (i.e., not just lectures), greater use of tools (e.g., manipulatives, technology), a variety of assessments (e.g., projects), and more group work. Although the participants were generally appreciative of these differences, there were some concerns regarding the manner in which the mathematics concepts were explained and the methods that are suggested to solve problems. A few participants shared that they and/or their partners have become frustrated and confused while attempting to help their children with homework. Since the concepts are explained in multiple ways in textbooks, many of which are new to the participants, they can lose sight of what the questions are asking. For instance, Quinn described the textbooks as follows:

It's bizarre. It's like some egghead somewhere came up with this great [sarcasm] idea to teach... The wording is atrocious... It's like they had some very higher-learning ideas...on how to teach kids to become better mathematicians – but rather than dumbing it down for the poor mom or dad who hasn't got a math background or perhaps isn't great at reading, a lot of kids are sunk when they try to help their kids out at night because they don't understand what's being asked, let alone the kid figuring it out. (P7, p. 21)

While Quinn has a strong mathematics background and is usually able to figure out what the questions are asking, her husband tends to become confused and cannot decipher the questions, thus being unable to assist their children. Arguably, Quinn's husband's experiences are likely more representative of most parents than are the experiences of the parent participants; recall that the participants have very high levels of mathematics education and mathematics-focused careers, compared to the general public. A few participants reported that if neither parent can figure out the questions, they will instruct their children to ask the teacher, while others direct their children to online resources. Some participants reported experiencing frustration when they attempt to explain a concept to their children a different way than in was taught in class, especially for concepts that were traditionally memorized when the participants were in school (e.g., multiplication tables). Overall, the frustrations described by the parent participants when dealing with textbooks and the 'new' ways mathematics is taught are reflective of the frustrations the teacher participants reported being experienced by the parents of the students they teach.

A few participants reported drilling their children on 'math facts' because they were worried that the children were not getting the experience at school. In an interesting example, when Samantha's daughter started to struggle in mathematics, she asked Samantha if she could attend Kumon, an after-school mathematics program that focuses on repetitive practice and speed. Samantha noted that she was surprised by this request, as her daughter had always done very well in mathematics, so much so that she was called a 'nerd' and 'brain' by her classmates. Samantha suggested that her daughter might have felt pressure to live up to those 'titles' in class. Although attending the Kumon program helped Samantha's daughter regain her confidence in her mathematics abilities, it also decreased her interest in the subject area. As her daughter's year in the Kumon program wore on, Samantha noticed that her daughter became bored with the

mathematics exercises and “especially when she was getting tired of Kumon [her daughter would ask] ‘When am I ever going to use this?’” (P9, p. 11).

Generally, the parents reported that their children, particularly those in younger grade levels, have very little mathematics homework. Most parents reported that they were pleased about the lack of homework, citing such reasons as being busy with extra-curricular schedules, feeling that the school day was already long enough, and feeling that it was the teacher’s responsibility to cover the material. However, two participants reported that they felt the mathematics homework (and content) was insufficient, so their children attend extra schools on weekends to do more (and more difficult) mathematics, as will be discussed in detail later.

Views of Mathematicians

The participants’ views of mathematicians were probed directly through questions that asked them to describe mathematicians and to discuss what comprises a mathematician. To probe the participants’ mental images, I asked them to imagine drawing a picture of a mathematician, the task that the student participants competed, and to describe their drawing.

Although most participants readily admitted that their images were stereotypes, nearly all participants saw a mathematician as being a skinny man with ‘Einstein hair’, wearing glasses and a pocket protector. Patti suggested that her stereotypical view was influenced by the images she saw as a child, particularly with regard to the mathematician’s gender. In contrast, Patti argued that “nowadays, the kids will pick anyone... Then, it was always the stereotypical view, but now, it’s not. So, anyone can do the math” (P6, p. 15). Additionally, the participants tended to view mathematicians as working on complicated equations at a chalkboard or with a pencil and paper. Only Nick and Ulysses claimed that they held no particular image, arguing that mathematicians are ‘normal’ people who can look like anyone. Only one example of a woman was provided:

After joking about drawing a stereotypical mathematician, Quinn said that her ‘real’ picture would be her sister, who is a real estate appraiser, a mathematics-intensive job.

In terms of personality traits, the participants again listed several stereotypes, although these were not as prevalent as the stereotypical physical features. When the participants held stereotypical views, mathematicians were seen as brilliant, socially awkward, highly devoted to their work, and absent-minded. A few participants shared that these stereotypical views came from real-life mathematicians that they had met, like their university professors. Leo claimed that mathematically proficient people develop a socially awkward image due to the way they are treated by their peers. Due to these individuals’ interest in mathematics, Leo argued:

You get treated as a little odd and pushed aside... You’re not cool enough... They don’t deal with you regularly and they don’t understand what you do... which is generally the thing that engenders fear of something... I suspect the perception of people being really good at math is also at least the feeling of being threatened because the people who make the most noise about the kid who’s smart not fitting in... are usually the good-looking kids that are dumber and don’t put any effort into their math. (P2, p. 23)

Leo posited that physical attractiveness tends to be the most important contributing factor to popularity in school settings, which often leaves ‘geeky’ students socially excluded, increasing the likelihood that they will act in ‘awkward’ ways in social settings. Leo’s comment suggests that ‘geeky’ students – including ‘math geeks’ – are typically physically unattractive.

In contrast to the aforementioned stereotypical traits, several participants argued that mathematicians were just ‘normal people’ who tend to focus on mathematics and gravitate toward it. For some participants, working in a mathematics-intensive field was not required in order to consider someone to be a mathematician. For instance, Quinn views people as being

mathematicians based on their ‘personality type’, or mathematical disposition: “Someone could be a famous artist – and actually have a great head for math, where a lot of people would think, ‘Oh, artists – They’re awful at applied sciences’. Right? Well, not necessarily!” (P7, p. 29).

Holding a broad view of what mathematicians are like was highly related to what jobs the participants felt that a mathematician could do. While all participants agreed that university professors were mathematicians, the participants held mixed views on whether teachers below that level were mathematicians. Participants who held broader views tended to believe that all mathematics teachers, as well as those who work in mathematics-intensive fields (e.g., accounting, engineering), are mathematicians.

Will was one of the only participants who held a very narrow and rather negative view of mathematicians: “Somebody that studies purely for... abstract or non-practical matters, whereas if it’s practical, it’s usually given a different name... [A mathematician is] not really working on anything that would necessarily be of practical use to anybody” (P13, pp. 35-36). Additionally, Will argued that mathematicians were “apart from normal society” whereas a scientist is “successful, interacts” (P13, p. 36). In contrast, Owen argued that “Everybody, deep down, is a mathematician to one degree or another” (P5, p. 28), citing such examples as electricians and plumbers. He views mathematicians in a very broad, general way – not solely labelling people who do mathematics all day as mathematicians. Owen suggested that having a narrow view of mathematicians could be detrimental: “Math has to serve a purpose. So, if it’s just in the hands of a few people, then it’s never going to serve the purpose that it was meant to do” (P5, p. 30).

The participants’ views were also probed by inquiring how they would feel if their children decided to become mathematicians. The participants generally reported that they would be supportive of their children becoming mathematicians. Some participants elaborated that they

would be supportive regardless of the occupation their child entered, whereas other participants offered comments specific to mathematics. For example, Patti said, “I would be happy because then I’d have someone to help me with my numbers. [Laughter] Crunching numbers” (P6, p. 15). In contrast, Quinn stated that she would be quite pleased with such a career choice because it would indicate that her children enjoyed mathematics. Two participants, both engineers, reported that they would support their children becoming mathematicians, but that they would be concerned about the job prospects if their children did not enter an applied mathematics field. Robert shared that he did not view jobs focusing on pure mathematics as being ‘practical careers’. Another couple of participants were initially not sure how they would feel, since they did not understand what types of jobs a mathematician could do. However, once I provided some examples (primarily in applied mathematics fields, as that is my area of expertise), these participants were very receptive to their children becoming mathematicians.

Summary of Parent Participants’ Views

The parent participants’ views of what mathematics is clearly fell into two camps: Mathematics as simply being (related to) numbers, and mathematics as a tool for understanding the world in which we live. Regardless of the viewpoint taken, the participants were all in agreement that mathematics is an important subject area that is vital to our everyday lives. This notion of importance was again highlighted when the participants talked about their feelings toward mathematics, which tended to be quite positive overall. Participants also discussed mathematics as being a useful tool and an engaging subject area. Arguably related to this stance, the participants also tended to be quite confident in their abilities regarding the mathematics they use regularly. Notably, the participants’ suggestions of who or what had an impact on their views toward mathematics were varied, and some participants did not cite any particular influence.

The participants all viewed the way mathematics is currently taught as very different from the mathematics education they experienced as students. Many changes were viewed positively, such as the focus on thinking, reasoning, and justification, plus the acceptance of a greater variety of ways of doing mathematics. However, some of the parents struggled with the ‘new’ ways of doing mathematics, since these differed so greatly from the way they were taught. This resulted in challenges when attempting to assist their children with homework.

The parent participants tended to view mathematicians as having very stereotypical appearances. However, the participants were less likely to attribute stereotypical personality traits to mathematicians, with many participants claiming that mathematicians were simply ‘normal’ people who were interested in mathematics. The more broadly the participants described a mathematician, the more occupations they ascribed to them. Finally, the participants all reported that they would be supportive of their children if they decided to become mathematicians, but two participants were concerned about the perceived lack of utility and job prospects for pure mathematicians. Although the participants often held stereotypical views of mathematicians, the occupation was still generally seen as a positive career.

Messages Produced by Parent Participants

This section focuses on the messages that the parent participants disseminate to their children. In contrast to their own experiences as students with regard to parental support, the participants all reported parental involvement in their children’s mathematics homework. The participants tended to report that younger children would do their homework in a communal area, such as the kitchen table, whereas older children would work independently in their bedrooms and emerge to ask questions. Having readily-available parental support for homework may suggest to the children an implicit message that (mathematics) education is important,

which is evidenced by the questionnaire responses, and a ‘family affair’. A few participants reported that they consult online resources, such as the *Khan Academy* website (which provides videos in which mathematics concepts are explained) and a local school district website in which certified teachers offer assistance to students through instant messaging, as supports for helping their children with homework.

The participants who have a partner reported that both parents help their children with homework. In some cases, though, work schedules lead to one parent helping more often. Homework help was also reported to be divided by subject area. Mathematics tends to be the subject area in which the participants reported that the fathers are the ones who usually help. Even among participants who reported that both parents help with homework, the mothers tended to tell the children to ‘Go ask your father’ when it came to mathematics. Ulysses expressed an awareness of how this messaging could be problematic for his daughters: “I sometimes chastise my wife for saying that they have to come to me for math. She was a good student. She should be able to help them, but I’m more patient with them, so they tend to come to me” (P11, p, 9). Being directed toward their fathers for mathematics assistance may suggest to the children that mathematics is a male domain. Indeed, some participants mentioned that their children had developed the perception of their fathers being better at mathematics, so they tended to come to them with questions, even if the mothers offered help with mathematics.

Beyond homework, all participants reported that they work with their children in other ways to promote mathematics. The most common example provided was playing games with their children that involve mathematics. Sometimes, the games were played as a family, particularly card and board games, whereas the children tended to play online and computer games by themselves. In some instances, websites were suggested by the children’s teachers,

such as websites linked to the class textbook. A few participants offered examples of informal ‘games’ involving mathematics, such as Ulysses giving his daughters ‘skill-testing questions’ to complete before they could eat dessert. Other examples of mathematics support were baking, telling time, music lessons, and working with money (e.g., allowances, bank accounts). Some participants with younger children reported their children engaged in mathematics spontaneously through make-believe play (e.g., playing ‘store’). For instance, Miranda and Nick’s daughters enjoy playing ‘waitress’, where they will write up bills and collect play money during mealtimes.

More extensive support for school mathematics was seen in the examples of Robert and Will, both of whom have ties to Asian cultures. Namely, both Robert and his wife were born and raised in China, while Will’s wife was born and raised in Japan. These participants send their children to, respectively, Chinese school and Japanese school, which take place every weekend during the school year and more intensively during the summer months. Beyond providing instruction and exposure to Asian language and culture, the schools heavily focus on mathematics. Both participants reported that the level of mathematics at these schools is much higher than their children’s ‘regular’ school and that the teaching style is very different. Robert described the Chinese school as very strict, similar to what he experienced as a boy growing up in China. Additionally, when Will and his wife go to Japan to visit her parents, both of whom are abacus teachers, their children receive abacus lessons. Both participants reported that, as a result of this extra, above grade-level mathematics instruction, their children do very well in mathematics in ‘regular’ school and often are bored in their classes.

Overall, the participants very much seem to provide home environments in which their children have support for their mathematics development, both with regard to school mathematics and otherwise. As such, the children arguably receive the message that mathematics

is important and that it is used beyond mathematics class. Some participants stated that they talk about these ideas with their children explicitly, while these ideas may be more implicit through the parents' actions in other cases. For instance, the tendency of the participants to direct the children to their fathers for mathematics help may implicitly provide the suggestion that mathematics is a male domain. Although there is no direct evidence that the parents share with their children the views they hold on mathematics education (discussed earlier), such as the role of homework, it seems highly likely that the children would be exposed to these ideas as well.

CHAPTER 6: DISCUSSION

In this chapter, I discuss four broad themes that emerged when the findings from all of the data types (i.e., student questionnaires, student drawings, student focus group interviews, parent interviews, teacher interviews, and children's media) were considered as a whole. In comparison to Chapter 5, where the findings from each data type were considered separately, these four broad, emergent themes draw on multiple data types. The first theme addresses the ways that mathematics was viewed or portrayed by the participants and the media. This discussion underpins the second theme, which addresses the ways that mathematicians and/or mathematically proficient people were depicted. The third theme relates to issues regarding views of school mathematics in particular. The chapter concludes with a discussion of the fourth theme: the ways that the relationships between gender and mathematics were portrayed, including a consideration of representations of gender more generally.

Views of Mathematics

While mathematics was overwhelmingly seen by all the participants (i.e., Grade 4 and 8 students, parents, and teachers) as being an important subject area, the manner in which mathematics was conceptualized might be considered to be narrow and stereotypical. Mathematics tended to be understood as being numbers/arithmetic or related to money/finances. Additionally, certain types of mathematics appeared to be more valued by the participants.

The student, parent, and teacher participants consistently expressed a strong view that mathematics is an important subject to learn and understand. This perceived importance related to the use of mathematics in everyday life, its relevance to several fields of study and careers, and the life skills (e.g., problem-solving) it teaches. The student participants demonstrated both a

personal stance of viewing mathematics as important, as well as an awareness of the importance their parents place on the subject area. In the focus group interviews, when discussing a comment from *The Simpsons* about how mathematics and science are the ‘real’ subjects, the student participants all acknowledged that mathematics and science were very important subject areas (although not necessarily more so than other subject areas). Some focus group participants shared that they receive implicit messages in class about mathematics being a ‘more important’ subject area, as their teacher spends extra time on mathematics, to the detriment of their art period. The student questionnaire participants also indicated receiving strong messages about mathematics’ importance from their parents: Among the five questions each about mothers and fathers, the ones with the highest mean scores were ‘My [parent] thinks math is an important subject to study’, with approximately 85% of participants agreeing with these statements.

These views were certainly supported by comments made by the parent participants, who reported that mathematics is a very important subject area and that they wanted to ensure that their children succeed in it. Some parent participants even claimed that mathematics was the most important subject area. The parent participants’ explicit statements were supported by their actions, with all participants reporting that they assist their children with their mathematics homework and promote mathematics in their homes, such as playing mathematics-related games and doing activities (e.g., cooking) with their children that involve mathematics. A few parent participants also reported that they have enrolled their children in extra mathematics classes outside of their ‘regular’ schooling in order to ensure they succeed in mathematics.

Similarly, the teacher participants who have children all reported supporting them with their mathematical development, through both homework assistance and other activities at home. Two teacher participants reported doing supplemental mathematics study with their children in

order to ensure they did not fall behind in mathematics. The teacher participants also reported placing high importance on mathematics in their teaching, with many participants stating that mathematics is their favourite subject to teach and/or that they have taken extra courses and attended workshops to further develop their mathematics teaching, whereas they did not report doing so for other subject areas. In one example, the importance that a teacher participant, Danica, placed upon mathematics led to an act of subversion: When she was told by her school's administration that the focus of the posters and displays on her walls needed to be literacy, not mathematics, for a school district review, Danica refused to take down her mathematics resources and instead moved them to a less prominent area in the classroom. Even so, she feels there is "a large deficit when it comes to math because we were... prescribed... I like math. I like language too, but I just get so sick of language. [Laughter] So, that math will stay up if I have anything to say about it." (T4, pp. 31-32). Thus, by refusing to adhere to her school district's overwhelming focus on literacy (to the detriment of mathematics), Danica is disseminating a message about mathematics' importance to her students. Indeed, the teacher participants all stated that they regularly discuss the importance of mathematics with their students, both by making links to real-world applications of the mathematics content in the curriculum and by discussing how relevant mathematics is to every occupation.

However, the importance placed on mathematics was tempered by the ways in which mathematics was defined by the participants – often, simply defined or depicted as being numbers and/or arithmetic. This narrow viewpoint was surprising, particularly given that the students and teachers (and parents, through homework assistance) would have been exposed to five different strands of mathematics (i.e., broad topics; specifically, Number Sense and Numeration; Measurement; Geometry and Spatial Sense; Patterning and Algebra; and Data

Management and Probability) in the Ontario Mathematics Curriculum (2005). The representation of mathematics as numbers/arithmetic was clearly apparent in the students' drawings of mathematicians: The most common type of mathematics shown was whole-number calculations, particularly simple one-digit arithmetic. Numerals and arithmetic also were common in the examples of children's media examined; as will be discussed in the next section, the ability to do rapid calculations in one's head was seen as an indication of mathematical talent. Such narrow views of mathematics were also present in the parent interviews, as approximately half the parent participants defined mathematics as (involving) numbers. Furthermore, some parent participants noted that they do not use any mathematics in their daily lives beyond 'the basics' (i.e., arithmetic) – although they could see how other, more advanced mathematics was useful for specialized careers. While the teacher participants tended to define mathematics as being 'more than numbers', involving many representations and types of mathematics, their discussions tended to focus on number sense and numeration, and several common types of mathematics (e.g., probability) were not discussed by any teacher participants in their description of mathematics. The focus on number sense and numeration was prevalent in the teacher and parent participants' discussions of where they use mathematics in their everyday lives and where they have seen mathematics in the media: Most of the examples provided solely involved numbers and arithmetic rather than other mathematical topics.

Mathematics was also commonly associated with money and finances. For instance, on the student questionnaire, the third most common reason reported why one would hire a mathematician was to help with personal finance (e.g., income taxes). Such responses hint at an association between financial professions and mathematics. Similarly, several teacher and parent participants claimed that those involved in financial professions (e.g., accountants, bankers) were

mathematicians. With regard to the earlier discussion about why it is important to learn and understand mathematics, many of the examples provided related to money. For instance, when discussing with their students how mathematics is involved in all careers, the justification for careers that appear less mathematics-related (e.g., modelling) was that everyone receives a pay cheque, so everyone needs to know how to manage money. Additionally, when the parent and teacher participants were asked where they use mathematics in their day-to-day lives, many examples related to finances (e.g., mortgage payments) and shopping (e.g., estimating bill totals). Interestingly, the sole student focus group participant who claimed that girls were better than boys at mathematics based her argument on girls' supposed propensity for shopping; this participant claimed that girls' greater experience with shopping would lead to superior performance in mathematics.

Many of the examples of mathematics in the media provided by the parent and teacher participants involved finances, such as stock prices and currency exchange rates. One parent participant discussed *The Dragons' Den* and *The Price Is Right* as examples of television shows involving mathematics, both of which focus on money and finances. Although the examples of media mathematics provided by the parent and teacher participants tended not to focus on financial mathematics, money and finances were featured in several of the examples of children's media that were examined. Some examples were incidental (e.g., wizard currency in *Harry Potter*), while other money-related examples were more detailed, such as 'beating the cash register' in *The Suite Life of Zack and Cody* and discussing fundraising on *Glee*. Additionally, money figured prominently in some of the websites and video games examined, such as budgeting and shopping in the *Club Penguin* and *Webkinz* virtual worlds. The participants' and media focus on money and finances reflects a broader societal focus on

financial literacy, particularly in the wake of recent financial crises in North America and abroad. This societal focus is highlighted in a recent document (2011) published by the Ontario Ministry of Education entitled *Financial Literacy: Scope and Sequence of Expectations*. In this document, financial literacy is linked to expectations from a wide variety of subject areas, including mathematics. While becoming financially literate is certainly necessary to function in adult society, concerns have been raised about the links between topics addressed in mathematics class (e.g., interest rates) and consumerism. In many cases, financial literacy can be viewed as being synonymous with learning how to be a ‘good consumer’ and how to amass wealth. While learning financial literacy, students may also be exposed to an implicit curriculum that focuses on greed and middle-class values, topics that may exclude and isolate students from low SES backgrounds. In order to still address financial literacy topics, mathematics educators who focus on social justice topics (e.g., Gutstein & Peterson, 2006; Stocker, 2007) have suggested an emphasis on such topics as wealth distribution and big business practices (e.g., sweatshops).

With mathematics tending to be associated with numbers/arithmetic and money/finances, it was unsurprising that certain types of mathematics tended to be portrayed as more useful and practical than others. Such views were apparent with the student, parent, and teacher participants, as well as with the media examples. For instance, some focus group participants questioned when they would ever use some types of mathematics that they were learning in class (e.g., Pythagorean Theorem, translations). Even when one participant provided examples of careers that would use those types of mathematics, the other participants seemed unconvinced. Indeed, the teacher participants all stated that they had been questioned by students about when they would ever use the mathematics they were learning. Although the teacher participants claimed that they try to make mathematics real-world applicable and provide examples of careers that use

the mathematics content they are teaching, the examples from the student focus groups suggest that not all students are receptive to these messages about mathematics' utility. Additionally, some teacher participants reported that they admitted to students that they did not know why they had to learn certain mathematics topics, but that it was necessary for their report cards; in contrast, other teacher participants argued that the specific mathematics topics were not necessarily important, but that the skills learned from doing the mathematics were important and transferable. Notably, although approximately half of the parent participants described mathematics as underpinning everything in our world, most of these participants related mathematics to everyday tasks (as opposed to a deeper appreciation of mathematics, for instance, underpinning physical structures in nature) – and most of these everyday tasks related to numbers, arithmetic, and finances. The teacher and parent participants' views about what types of mathematics are useful were evidenced in their discussions about the possibility of their children becoming mathematicians. Concerns were raised by some of these participants about whether there was even such a thing as a 'true' mathematician anymore, with some participants suggesting you could only be a mathematician in another field (e.g., geology, biology) – that is, applying mathematics in a 'useful' way in another field. Some participants argued that being a mathematician would not be a meaningful career as it was too theoretical and would not have any practical applications, while others suggested they would only be happy if their children went into an applied mathematics field. As discussed earlier, many of the media examples – both those provided by the adult participants and those children's media examined – focused on numbers/arithmetic or money/finances (e.g., scores/statistics in the video games, financial information in news media). While there were some references to other mathematics topics (e.g., probability in *The Hunger Games*), these examples were rare. Overall, mathematics was not

featured very frequently – particularly not in detail – in most of the children's media examined, which may suggest mathematics' irrelevance to the characters' daily lives. In fact, the view of (school) mathematics as being particularly irrelevant was parodied in two examples of 'classic' word problems (e.g., travel-oriented problems) on *Family Guy*.

Views of Mathematicians and Mathematically Proficient People

By far, the most common description of mathematicians and mathematically proficient people was that they were highly intelligent. The notion of an extremely high level of intelligence being associated with mathematical ability was discussed by student, parent, and teacher participants, as well as portrayed in the media representations. Both the student questionnaire participants who had met a mathematician in real life and those who had seen one in the media described mathematicians as being intelligent; in fact, this descriptor was among the most common responses for both groups. Furthermore, 'the brain' was the third or fourth most common response for each of the nine gender/grade groups when the student questionnaire participants were asked what tools mathematicians use, which indicates their recognition of thinking as a key part of a mathematician's job. More than one-third of the student drawings featured mathematicians wearing glasses, which are commonly used as an indicator of intelligence, and more than 10% of the write-ups discussed mathematicians as being generally intelligent, good at mathematics specifically, or highly educated. Similarly, the parent and teacher interviews provided evidence of a view of mathematicians and mathematically proficient people being very intelligent. For instance, one teacher participant described mathematicians as "brilliant... in the mathematical sense". Some participants described mathematicians as 'geniuses', and there was a general perception of mathematicians having abilities far beyond the average person. Such ideas were certainly perpetuated by media representations of

mathematicians and mathematically proficient people – both in the examples provided by the adult participants and in the children’s media examined. For example, in the movie *Good Will Hunting*, which was suggested by both parent and teacher participants, Will is a janitor who is able to solve graduate-level mathematics problems without any formal training. An example from the children’s media is the character Cody on *the Suite Life of Zack & Cody* and *The Suite Life on Deck*, who is portrayed as doing such advanced mathematics as a preteen that his mother cannot even understand the title of the course in which he is enrolled. In many cases though, a high level of mathematical ability and overall intelligence were seen as barriers to social interactions, as these characters were often portrayed as thinking at such a high level about such esoteric topics that others could not relate to them.

Linked to the earlier description of mathematics as arithmetic/numbers, mathematical ability was portrayed as being associated with the ability to rapidly do calculations in one’s head. Such ideas were prominent in the children’s media examined, such as card-counting in *The Hangover* and ‘beating the cash register’ in *The Suite Life of Zack and Cody*. Notably, in these examples, no explanation is given for how these individuals were able to perform such rapid mental calculations, which further serves to make mathematics seem mysterious, difficult, and only accessible to a ‘select few’. Indeed, the rapid mental calculations performed by some of the characters had the immediate impact of confusing other characters and making mathematics seem difficult and ‘magical’ to them (e.g., mental calculations by *Harry Potter*’s Hermione to solve a logic puzzle – without explanation – seem like magic to Harry); if the other characters were confused, it is likely that the readers/viewers might become confused as well. Being quick at mental calculations also figured in some parent and teacher participants’ descriptions of mathematicians and mathematically proficient people. For instance, one teacher participant

demarcated the difference between a mathematician and a non-mathematician as the ability to do mathematical calculations rapidly in one's head, rather than using a pencil and paper.

Another stereotypical notion about mathematicians that was featured prominently in the participants' discussions was the idea that mathematicians work alone. While the student questionnaire participants' views were somewhat mixed, the overall (mean) perception was that mathematicians usually work alone. As well, when asked to draw a picture of a 'mathematician at work', none of the student participants included any other people in their drawings (beyond students included with a few of the 'teacher' mathematicians). That is, no mathematician was shown to be working collaboratively with colleagues, and many were shown in rooms by themselves, working with chalkboards full of equations. Several parent and teacher participants pictured mathematicians in a similar fashion. These views aligned with the examples of media mathematicians provided by the parent and teacher participants – most of whom were depicted as working alone, spending hours on difficult problems. Other than examples involving teaching or tutoring, most of the examples of mathematically proficient people in the children's media also showed the person solving mathematics problems alone.

Stereotypes of mathematicians working alone and being solely focused on mathematics problems are linked to stereotypes of mathematicians being socially inept 'geeks' who lack 'street smarts'. However, in all three methods of data collection with the student participants, the overall trend was to consider mathematicians to not be 'geeks'. This was particularly the case when the students' views were queried directly, although some contradictory stances were apparent in less explicit ways. For instance, on the student questionnaire, the mean response was to not consider mathematicians (in general) to be nerdy people. Additionally, none of the participants who had met a mathematician in real life or seen one in the media described them as

‘nerdy’ or ‘geeky’ – although those participants who had seen a mathematician in the media tended to describe their appearances in stereotyped ways (e.g., lab coat, glasses), and a few participants described these media mathematicians as ‘weird’. In the drawings, the mathematicians tended to be depicted as very mainstream-looking, with only two ‘nerdy’ mathematicians amongst the 94 drawings. However, less explicit indicators of ‘nerdiness’ (e.g., glasses, pants that are too short) were shown in several of the drawings. While the focus group participants explicitly stated that people who were good at mathematics and/or liked it were not geeks, the participants’ awareness of (and in some cases, alignment with) the ‘nerdy’ trope was evident in subtle ways in the discussions. For example, some of the focus group participants who were identified as being strong at mathematics made sure to distance themselves from associations with ‘nerdiness’. Similarly, although the parent and teacher participants all indicated that they were aware of the ‘math geek’ stereotype and knew that ‘real’ mathematicians weren’t like the stereotypical representations, many lacked any alternative representations and admitted that they pictured mathematicians in stereotypical ways. In a few cases, the teacher and parent participants argued that their stereotypical images were like ‘real’ mathematicians that they knew (e.g., professors, graduate students), and that these people just happened to adhere to the stereotype. However, many of the parent and teacher participants stated that they had never met a mathematician in real life, so their images were arguably comprised of media representations. Indeed, several of the media examples provided by the parent and teacher participants were reflective of the ‘math geek’ trope. Similarly, examples in television shows – both the students’ top choices and examples provided by the adult participants – also adhered to this stereotype, such as the four main characters on *The Big Bang Theory*. These four men, all scientists, are depicted as lacking in social skills and being obsessed with ‘nerdy’ pursuits, like comic books

and science fiction movies. An example from the children's media is Baljeet, a mathematically proficient character on *Phineas and Ferb*; not only is Baljeet explicitly referred to as being a nerd (and his mathematical pursuits nerdy), but he is also depicted as being focused on grades, a rule-follower, and lacking in practical, real-world skills (i.e., being 'book smart', not 'street smart').

The racialized identities of mathematicians and mathematically proficient people were rarely brought up by the participants, although the racialized identities of mathematically proficient and/or generally intelligent people were made prominent on three of the television shows examined. In two episodes of *Family Guy*, the stereotype about Asian people being superior at mathematics was explicitly highlighted; in one of these examples, the suggestion that Black people are not strong at mathematics (at least, in contrast with Asian people) was also made. In a more subtle example on *Glee*, many members of the Academic Decathlon teams were depicted as Asian. The third example is *Phineas and Ferb*, which features a mathematically proficient character, Baljeet, a young Indian boy. When discussing media mathematicians, only one teacher participant suggested a generic example of an Asian person who was good at mathematics. None of the student focus group participants or parent participants discussed the racialized identities of mathematicians or mathematically proficient people, and the only other mention of a racialized identity by a teacher participant was Danica's generic description of a mathematician as a 'White guy'. Notably, all of the teacher participants (10 of 10) and nearly all of the student focus group participants (20 of 22) and parent participants (12 of 13) presented as White. Therefore, the lack of discussion of the racialized identities of mathematicians and mathematically proficient people could be indicative of a presumed Whiteness (i.e., White as 'default'). That is, when a racialized identity is not discussed, there is a presumption of

Whiteness (Daniel-Favors, 2009). For instance, when a White participant says she sees a mathematician as an ‘old guy’, one could presume that she means an ‘old White guy’. Indeed, other than the aforementioned examples from *Family Guy* and *Glee*, the other media examples of mathematicians and mathematically proficient people were nearly all White. Similarly, although the student drawings of mathematicians were not coded for racialized identities, none of the drawings provided any evidence of a non-White racialized identity (e.g., skin coloured with a brown marker or pencil crayon), and many of the mathematicians were either drawn with non-coloured skin (i.e., white like the paper on which the pictures were drawn) or skin coloured with peach-coloured markers or pencil crayons. Similar depictions of racialized identities were found in other studies that involved students drawing pictures of mathematicians (e.g., Picker & Berry, 2000, 2001; Rock & Shaw, 2000)

Mathematicians were commonly associated by the student, parent, and teacher participants with being teachers, although the association often depended on the level of the teacher (i.e., elementary school, high school, or university). Interestingly, such representations were not common in the media examples – either in the children’s media or the examples suggested by the parent or teacher participants – other than a few instances of university mathematics professors and university mathematics students (e.g., *Good Will Hunting*). Teachers were the second most common ‘character category’ in the student drawings, representing more than one-quarter of the drawings. Only a few of these teachers were indicated as teaching at a post-secondary level, while most were depicted as teaching younger students. Additionally, some of the teachers were specified as being the student participants’ own teachers, which suggests that these students see their (generalist) classroom teachers as mathematicians since they teach mathematics. More generally, when the student questionnaire participants were asked why one

would hire a mathematician, three of the four most common responses (representing more than 70% of the responses to the question) related to teaching ('to help with mathematics', 'to teach', and 'to tutor'). However, in the focus group interviews, the student participants' responses were mixed. Upon seeing an elementary classroom teacher (teaching mathematics) amongst the sample drawings, some participants discounted the teacher, claiming that she was not a mathematician since mathematics was not her specialty. In contrast, the focus group participants generally agreed that high school mathematics teachers and university mathematics professors were mathematicians, due to their focus on and high levels of education in the subject area. Similar views were also reflected in the teacher and parent participants' feedback regarding who is a mathematician. None of the teacher participants viewed themselves as mathematicians overall, although a few allowed that some of their mathematics-focused elementary teacher colleagues could be considered mathematicians, particularly if the participant viewed the colleague to be particularly skilled in mathematics.

Similarly, although several of the student, teacher, and parent participants self-identified as being good at mathematics and enjoying mathematics, the participants seemed disconnected from personally being implicated with the notion of being a mathematician. For instance, even though the student questionnaire participants generally reported that they enjoy doing mathematics and feel confident in their abilities, they were overall not interested in becoming or marrying a mathematician, with less interest in the former than the latter. However, participants who reported meeting a mathematician were more likely than participants who had not met a mathematician to want to become one, indicating the importance of making a personal connection. Notably, a parallel outcome did not occur for those students who had seen a mathematician in the media. Additionally, even though the vast majority of the student

questionnaire participants agreed that their parents thought mathematics was an important subject to study, far fewer thought that their parents would be proud if they became mathematicians. Specifically, 85.3% of participants reported that their mothers thought mathematics was an important subject to study, but only 42.9% of participants reported that their mothers would be proud if they became mathematicians; similar proportions of participants provided the same responses for their fathers (84.6% and 46.2%, respectively). Furthermore, only a few of the students' drawings of mathematicians were of themselves, either now or as an adult. As discussed, none of the teacher participants viewed themselves as mathematicians overall, and only two felt that they were mathematicians in any way (e.g., only when teaching mathematics). Although most parent participants had high levels of mathematics education and a few used university-level mathematics in their careers, only one parent participant identified himself as a mathematician. For the teacher and parent participants, narrow views of who a mathematician is tended to underpin their dissociation from the career.

Views of School Mathematics

As discussed earlier, mathematics was viewed by the student, parent, and teacher participants as being a very important subject area, although certain types of mathematics tended to have more importance and emphasis placed upon them as they were seen as more practical and real-world relevant. Beyond the discussions of these topics, school mathematics was implicated in discussions regarding how much today's school mathematics differs from that experienced by the teacher and parent participants in the study.

Specifically, these adult participants found that both the mathematics content and the manner in which it is being taught differed vastly from the mathematics they experienced as students, with the latter focusing on number sense, drill, memorization, and repetition, and the

former focusing on a variety of mathematics topics, understanding, multiple representations, and explanations of solutions (as opposed to priority being placed on the answer). While the parent and teacher participants generally agreed that the way mathematics was currently being taught was an improvement from the way they were taught due to the focus on understanding and multiple approaches to answering a question, there were still concerns raised. Parents tended to find today's school mathematics very confusing, particularly the way questions were worded in textbooks, which made it hard for them to help their children with their homework. Even though most of the parent participants had high levels of mathematics education, they still reported becoming frustrated when helping their children with homework, as they often could not understand what the questions were asking. Such concerns were reported by the parent participants and corroborated by the teacher participants with regard to the parents of the children in their classes. In some cases, parents dismissed the 'new' ways of doing mathematics and would teach their children how to do mathematics the way they were taught – even if they admitted it had not worked for them! This sometimes resulted in clashes between the teachers and parents, as well as confusion for the students. These struggles were highlighted in an example in the book *Diary of a Wimpy Kid: The Ugly Truth*, where Greg, the Wimpy Kid, is frustrated by (and does not understand) the rule-bound, algorithmic manner in which his father attempts to help him with his mathematics homework.

However, the teacher participants reported that parents are usually receptive to 'new' ways of doing mathematics once explanations of the underlying theories are provided, whereas the parents initially tend to 'write off' these 'new' ways of doing mathematics. In contrast, the teacher participants were initially receptive to the ideas behind teaching mathematics in such a way, but they often struggled to change the way they taught due to their familiarity with teaching

the way they were taught (again, even though it often had not worked well for them). Once the teacher participants, particularly those who struggled with mathematics as students, relearned mathematics in these ‘new’ ways and garnered a much greater understanding, they were far more receptive in teaching in such ways. This suggests the importance of personally experiencing learning mathematics in these ways before a true appreciation of its value can be gained.

Views of Mathematics and Gender

The links made between mathematics and gender in this study were complex and varied: In some cases, mathematics was purported to be a gender-neutral field, while in others, stereotypes about gender and mathematics emerged. Encouragingly, in most instances, the student participants’ views tended toward linking mathematics with gender equality. On the student questionnaires, most of the questions about gender and mathematics had a modal result of ‘no difference’ (as opposed to ‘boys’ or ‘girls’), indicating that the student participants generally have the perception of no gender difference with regard to, for instance, being good at mathematics. Additionally, a few student participants provided comments on the questionnaire that indicated that both men and women were equally capable of being mathematicians. These sentiments were corroborated by the data provided by the student focus group interviews and the student drawings of mathematicians. Namely, nearly all of the focus group participants, upon seeing a clip from *The Simpsons* about gender stereotypes, disagreed with the stereotypes, arguing that boys and girls are equally capable in mathematics. With regard to the student drawings, the mathematicians drawn were nearly evenly divided by gender, which again suggests that the student participants view both men and women as capable in mathematics.

However, even with these encouraging findings, some gender stereotypes were evident. There was some indication of in-group bias – but only for girls – on the few ‘gender’ questions

on the questionnaire for which there were gender differences in the distribution of responses. Within the nearly gender-balanced drawings of mathematicians, the professions to which the mathematicians were assigned were highly gendered: Most teacher mathematicians were drawn as women and most professional mathematicians were drawn as men. Additionally, girls were more likely than boys to draw a teacher, whereas boys were more likely than girls to draw a professional mathematician. The student questionnaire participants also indicated that they viewed their parents and mathematics in gendered ways. That is, fathers were overall viewed more favourably than mothers with regard to mathematics (i.e., perceived to be better at mathematics and like it more). These differences were particularly pronounced with regard to the student participants' perceptions of whether their parents are good at mathematics and like mathematics, with fathers being viewed much more positively than mothers.

While the parent and teacher participants were not asked about their views of gender and mathematics, these issues occasionally arose during the interviews. For instance, when discussing their experiences as students, most of the parent and teacher participants reported receiving homework help from their fathers, not their mothers, with several participants explicitly stating that their fathers are better than their mothers at mathematics. The pattern of fathers tending to be the ones to help with homework continued with the parent participants and their own children, whereas the teacher participants (most of whom were women) tended to be the parents who helped their children. However, this gender difference is arguably highly related to the fact that these women are teachers, not due to perceptions about their gender.

In addition to the gendered discussions about homework help, issues regarding gender and mathematics were also brought up in some of the parent and teacher interviews in other ways. For instance, a few participants shared that their experiences as children tended to involve

exposure to the messages that boys are better than girls in mathematics, and that men, not women, are mathematicians. One parent participant also stated that she was concerned that her daughter might struggle with mathematics later on, as the participant recalled that several of her girlfriends did well in mathematics at the elementary school level, but then struggled by the end of high school – although the participant acknowledged that it could have been a loss of interest, as she stated that her girlfriends were all very bright and capable. One teacher participant reflected that the boys in her family (i.e., her brothers) were stronger than the girls at mathematics, and the same pattern is holding true for her own children; as such, she wondered if the pattern was a ‘gender thing’. The notion of a ‘gender thing’ was also brought up by a parent participant who claimed that his son did well at mathematics, but struggled with language arts, whereas his daughter does equally well with both subject areas. In both of these examples, the reference to a ‘gender thing’ is actually a reference to stereotypes – that boys are better than girls at mathematics, and that boys are better at mathematics than language arts.

Stereotypical notions were also brought up more generally with regard to gender and schooling by one parent participant, who claimed that girls were just a naturally better fit for the education system as they were happy to sit and listen to lectures, whereas boys needed to be engaged and having fun in order to learn. This participant also argued that the reason girls do better throughout most of their schooling than boys is because boys simply do not apply themselves, not that there are any gender differences in ability. Another parent participant suggested that teachers still hold stereotypical beliefs about mathematics and gender. He maintained that teachers would not be as concerned about a girl struggling in mathematics (as long as she still did well in language arts) as they would be about a boy struggling in mathematics. This participant also reported reading about the success of single-sex classes in

encouraging girls in mathematics. This same parent participant, as well as another parent participant, also indicated an awareness of the pressure placed on girls not to appear smart in order to be appealing to boys, particularly in their teenage years.

While most of the media examples provided by the parent and teacher participants featured men, several of the children's media examined featured girls and women who are mathematically proficient. Notably, the characters of Hermione in the *Harry Potter* series, Katniss in the *Hunger Games* series, and Thea in the *Geronimo Stilton* series were all depicted as being very strong with mathematics. These characters were all shown solving mathematics problems in their lives in fairly detailed examples in these books. In what could be seen as both a positive and negative sign, these characters were all depicted as being conventionally attractive, feminine, and socially adept. In one sense, having social skills along with mathematical ability could be seen as a challenge to the 'math geek' stereotype (which still persisted in many of the media examples involving mathematically proficient boys and men), while the feminine attributes and conventional beauty may indicate a narrow standard to which girls and women must adhere, even with (or perhaps because of) their success in a traditionally male-dominated field.

There were also a few stereotypical representations in the children's media of girls and women who struggle with mathematics and/or have a great deal of mathematics anxiety. For instance, on *The Big Bang Theory*, Penny, a conventionally attractive restaurant server/actor, is depicted in contrast to the four men who are scientists: Penny has street smarts but lacks book smarts, particularly with regard to mathematics and science, while the men are depicted as having the reverse skill sets. Additionally, Penny is depicted as being completely disinterested in mathematics and science, finding both subject areas 'boring' and 'uncool'. Notably, when I

asked the student focus group participants what the show would be like if the gendered roles were reversed, the consensus was that the show simply ‘wouldn’t work’ and wouldn’t be as funny. Some participants suggested that the focus would still be placed on the men, which indicates an awareness of the gender inequity of the media, while one participant (Grade 8 girl) stated that boys are supposed to be the smart ones, a highly troubling statement.

The representations of gender and mathematics are situated more broadly within a children’s media landscape that depicts gender in narrow, stereotyped ways. Namely, girls and women are represented in stereotypically feminine ways, while boys and men are represented in stereotypically masculine ways. Additionally, there is an overall lack of representation of girls and women in the media, relative to their proportion of the population. This underrepresentation was especially pronounced in the video games examined, as many of the games did not feature any girls or women as characters at all. When girls and women were featured, they were always vastly in the minority, and depicted in stereotypical ways, such as being princesses. Additionally, the tools linked with these characters were similarly feminized, such as the pink, more ‘delicate’ vehicle options for the characters in *Mario Kart*. Similar stereotypical notions of femininity were apparent on the *Miniclip* website, which features a wealth of games. One of the categories of games is ‘Games for girls’, which features such stereotypical topics as language-based games and games about relationships. Overall, while some indications of progress with regard to gendered representations in the media are present, several stereotypes continue to be perpetuated, suggesting narrowly defined ways to be a girl/woman or a boy/man.

CHAPTER 7: CONCLUSIONS

This chapter begins by addressing the study's research questions, during which I also connect the findings to the study's theoretical framework and the extant body of literature. Next, implications for practice in mathematics education are outlined, and limitations of the study are addressed. I then raise some concerns and questions that remain for me upon concluding this study. The chapter and thus the thesis are brought to a close by discussing the contributions of this study and providing concluding comments about the study's findings.

Addressing the Research Questions

In Chapter 5 (Findings) and Chapter 6 (Discussion), the study's research questions were addressed in an implicit fashion in great depth. Now, I address the research questions in an explicit manner, drawing on the material from the previous two chapters. That is, I return to the research questions in order to summarize the study's findings and make assertions based on the evidence that has already been presented in the previous two chapters.

In order to address the research questions, multiple data sources were required. Namely, the data collection consisted of questionnaires, drawings of mathematicians, and focus group interviews with Grade 4 and Grade 8 students; an analysis of children's media; interviews with Grade 4 and Grade 8 teachers; and interviews with Grade 4 and Grade 8 parents. The data sources were combined to address the three multi-part research questions, which are as follows:

- 1) What images of mathematics and mathematicians exist in a child's world as:
 - a) produced by media portrayals?
 - b) produced by parents' views?
 - c) produced by teachers' views?

2) How do elementary students view mathematics and mathematicians?

- a) Are there differences between boys' and girls' views?
- b) Are there differences between middle (Grade 4) and senior (Grade 8) elementary students' views?

3) What is the relationship between elementary students' views of mathematics and mathematicians and:

- a) media portrayals?
- b) parents' views?
- c) teachers' views?

Research Question #1

This research question focused on the representations of mathematics and mathematicians that are produced by key socializing agents in the students' worlds: specifically, media portrayals, parents' views, and teachers' views. Thus, the analysis of children's media, parent interviews, and teacher interviews was required to address this research question.

Research Question #1a: What images of mathematics and mathematicians exist in a child's world as produced by media portrayals?

The images of mathematics and mathematicians that were produced by children's media were few in number and tended to be stereotypical in nature. However, the types of images that were produced varied widely depending on the type of media examined. To begin, there were very few mathematics-related references in any of the media types examined, relative to the number of media sources initially examined. Even within the sources that were selected as potentially containing mathematics-related references, several did not contain any such examples – or only contained very surface-level examples. This finding aligns with my prior research into magazine advertisements (J. Hall, 2008) and other research about representations of mathematics

in popular culture (e.g., Mendick, Epstein, & Moreau, 2007). This paucity of examples leads to a lack of mathematical focus in our cultural consciousness, as well as more weight being placed on each example viewed.

With regard to media portrayals of mathematics and mathematicians that were found in the sources examined, the messages produced about mathematics and mathematicians differed greatly by media type. For instance, the websites and video games examined contained very little mathematical content and no mathematical messages whatsoever. Similarly, the movies examined contained very little mathematics content (less so than any ‘matched’ books), but a few stereotypes – namely about the link between mathematical ability and intelligence. In contrast, the books examined contained several examples (mostly incidental) of mathematics content, but tended not to focus on messages about mathematics and mathematically proficient people. Finally, the television shows examined had the reverse focus: Very little mathematics content, but several examples of negative, stereotyped images of mathematics and mathematically proficient people (e.g., racial stereotypes, ‘math geek’ stereotypes). Thus, in order to better understand the mathematics-related messages to which young people are exposed, an understanding of their patterns of media use (by media type) should first be garnered.

The stereotypes produced by the children’s media sources were very much in alignment with those portrayed in mathematics-focused media sources that have been examined by prior researchers (e.g., Mendick, Epstein, & Moreau, 2007). As noted, the mathematics-related messages produced very much depend on the media used. Typically, the messages produced about mathematicians and mathematically proficient people were quite explicit in nature, whereas the messages about mathematics were more implicit in nature. For instance, an implicit message about the utility of mathematics may arise from reading the books examined, as the

characters are shown using mathematics in their day-to-day lives, whereas explicit messages (stereotypes) about mathematically proficient people, such as racial stereotypes, were present in the television shows examined. Importantly, the student participants did not report being heavy media users overall, and there was a great variety in the student participants' media 'favourites', suggesting little consistency in the messages to which the participants are exposed. As per the economic theory of the Long Tail (Anderson, 2008), these findings are not surprising given the current proliferation of 'new media'.

Research Question #1b: What images of mathematics and mathematicians exist in a child's world as produced by parents' views?

The messages about mathematics that are produced by the parent participants are encouraging, particularly with regard to the implicit messages evident in their relationships with the subject area and their interactions with their children and mathematics. In the interviews, most parent participants reported holding positive views about mathematics – both in terms of their own relationship to the subject area, and about the subject area in general. A common stance taken by the participants was that mathematics was an extremely important subject area, and this was reflected in their actions involving their children and mathematics. Namely, the participants provided a great deal of support – both for school mathematics (e.g., homework assistance) and for non-school mathematics activities (e.g., playing games). Through these actions, the parent participants promoted the notion that mathematics is important, both for education and for everyday use. However, as discussed in prior studies (Bhanot & Jovanovic, 2005), assistance with homework can be viewed by students as intrusive rather than supportive, and can have different gendered impacts. Notably, the students in the study reported far more homework assistance from their parents than did the adult participants in the study, suggesting a generational shift (perhaps related to the notion of 'helicopter parents'). A gendered and

stereotypical message was depicted through the tendency of fathers, rather than mothers, to assist with mathematics homework. By directing their children to their fathers for mathematics assistance, mothers are suggesting that they themselves are not capable, and, by proxy, that mathematics is a male domain.

In contrast to the mostly positive messaging via their attitudes toward mathematics and their actions involving mathematics, the messages that the parents produce regarding what mathematics is and the ways it should be taught may be confusing to children and contradictory to the other messages produced by the parents. Although the parents all purported holding a view that mathematics was a very important subject area that is useful in ‘real life’, their focus tended to be only on certain types of mathematics – namely, arithmetic and financial mathematics. Indeed, several of the parent participants defined mathematics as being (related to) numbers. It follows that their children may receive the message that only certain types of mathematics are useful and relevant, and thus ‘worth learning’. Some parent participants expressed confusion and frustration with the way that mathematics is currently being taught, admitting that they struggle to help their children with homework. Such challenges may provide their children with implicit messages about the validity of the school system.

With regard to messages about mathematicians, most of the parent participants were arguably producing few messages at all, and those messages tended to be stereotypical in nature. Many parent participants reported being unsure about who a mathematician is or what a mathematician does, and those who held an image of a mathematician tended to hold a stereotypical image, even though they were aware that such an image was not necessarily representative of ‘real’ mathematicians. Thus, it is unlikely that mathematicians would be

discussed with the participants' children, and if such discussions were held, it is possible that stereotypical ideas would be perpetuated.

Research Question #1c: What images of mathematics and mathematicians exist in a child's world as produced by teachers' views?

The images of mathematics produced by the teacher participants are both implicit (via their teaching practices) and explicit (via their statements to students) in nature, and tend to be complex and contradictory in their messaging. To begin, many implicit messages are produced to students via the manner in which the teacher participants teach mathematics. In the teacher interviews, the participants were generally aligned in reporting that they teach mathematics in a reform-oriented manner, with emphasis placed on multiple representations, varied tools, and a focus on process rather than product. As such, the students receive the implicit message that mathematics is a broad subject that can be approached in many ways, where many knowledges are valued. The teacher participants reported that they explicitly discuss mathematics' utility in everyday life and occupations with their students. The teacher participants also stated that they incorporate real-world applications of the mathematics concepts they are teaching whenever possible. Furthermore, all of the teacher participants explicitly stated during their interviews that mathematics is 'more than just numbers'. However, the teachers' discussions of mathematics tended to focus on number sense, arithmetic, and financial mathematics. Thus, although the teachers purport to produce the message about mathematics being a broad subject area, it is possible that their students are receiving messages to the contrary, particularly if the teachers' focus (as exhibited in the interviews) on certain mathematical topics is reflected in their time allotment while teaching. Potentially, the teachers' in-class discussions about the utility of mathematics may be focused on only certain types of mathematics being useful in the 'real world'.

Additional messages about mathematics are produced to the students through observation of their teachers' relationships with the subject area. The teacher participants generally reported feeling confident in their mathematics abilities and enjoying mathematics. Several participants claimed that mathematics is their favourite subject to teach, and they have done extra professional development in this subject area due to their interest in mathematics. Holding such positive views of mathematics arguably translates into the level of enthusiasm and interest that these teachers convey to their students about mathematics while they teach. Additionally, the Grade 4 teacher participants, many of whom struggled with and disliked mathematics as students, noted that they are particularly sensitive to students' struggles.

The messages that the teacher participants produce about mathematicians, like the messages about mathematics, are not consistent and often contain stereotypical ideas. Such stereotyped ideas were particularly found in the teacher participants' images of mathematicians' appearances. Although the teacher participants clearly understood that such images were stereotypes, they did not have alternative examples with which to challenge the stereotypical images (many of which arose from media examples). Many teacher participants described mathematicians in terms of their interest in mathematical topics and the focus of mathematics in their careers. Thus, the teacher participants tended to view a broad range of mathematics-related fields as being mathematician careers. The production of the teacher participants' views to students could be encouraging in that the teachers view mathematicians as being involved in a broad range of occupations. However, the images of mathematicians that the teachers hold could arguably perpetuate (often negative) stereotypes.

Research Question #2

Research Question #2 focused on the students' views of mathematics and mathematicians overall, as well as with regard to gender and grade-level trends. To address this question, the analyses of the questionnaires, drawings, and focus group interviews were combined.

Research Question #2: How do elementary students view mathematics and mathematicians?

The student participants' views of mathematics were generally very positive – both with regard to school mathematics and the participants' views of themselves as mathematics learners. As reported in both the questionnaire ('Mathematics' section) and the focus group interviews, the participants understood the importance of mathematics for success in life, not just in school; felt they were competent in mathematics; and tended to enjoy doing mathematics. Furthermore, mathematics was viewed as a subject area in which girls and boys were perceived as equally suited and competent, according to the questionnaire results ('Gender' section) and focus group discussions. However, mathematics tended to be viewed in a narrow way by the student participants – typically focused on number sense and numeration, even though the students are exposed to a wide variety of mathematics topics in their classes, as per the Ontario Mathematics Curriculum. Such narrow views were particularly apparent in the student participants' drawings, in which the most common type of mathematics drawn was whole-number arithmetic (typically simple one-digit calculations). Another common association drawn by the student participants was that of mathematics with money and finances, as demonstrated by the questionnaire data: The third most common response provided for hiring a mathematician was to help with personal finance (e.g., income taxes, mortgages). As will be discussed, the students' focus on number sense/numeration and money/financial mathematics may be indicative of the teachers' focus and perceptions of what types of mathematics are most important and useful.

In comparison to their reported experiences with mathematics, the participants' views of becoming or marrying a mathematician were far less encouraging, as they seemed to distance themselves from becoming personally implicated with the career. These views were reported explicitly in the 'Mathematician' section of the student questionnaire, as well as more implicitly during discussions of the 'nerdy' stereotype with the Grade 8 focus group participants (when discussing *The Big Bang Theory*). Such findings have long been reported in studies with regard to students' views of scientists and mathematicians (e.g., Mead & Metraux, 1957; Picker & Berry, 2000, 2001). Many participants lacked an understanding of what mathematicians do and who they are, as indicated by high proportion of 'not sure' responses to the questions about meeting a mathematician or seeing one in the media, as well as several 'What is a mathematician'-type questions provided in the 'Comments' section of the questionnaire. This lack of understanding was corroborated by the parent and teacher interviews, where some of the adult participants reported being asked what mathematicians are/do while the students were completing the questionnaires and drawings.

Additionally, as shown in both the questionnaire (in the responses to the question about hiring a mathematician) and the drawings, the student participants tended to relate mathematicians to teaching. As will be discussed later, such associations have also been found in other studies (e.g., Gadanidis, 2011; Picker & Berry, 2000, 2001), but with different interpretations from those I draw. Generally, the roles of a mathematician were seen very narrowly, with the majority of drawings of mathematicians falling into two 'character categories' (teacher and professional mathematician). On an optimistic note, mathematicians were described by the student participants as being intelligent, being both men and women, and not being 'geeky' – although a few other stereotypes, particularly with regard to appearance, persisted. The

overall gender balance in the drawings stood in contrast to findings from most prior research, in which younger children tended to draw women and older children tended to draw men as mathematicians (e.g., Rock & Shaw, 2000; Picker & Berry, 2000, 2001).

Research Question #2a: Are there differences between boys' and girls' views?

Gender differences were generally not present in the participants' views of mathematics or mathematicians, with regard to school mathematics or themselves as learners of mathematics, or their relationships with their parents and mathematics (when considering the aggregate variables 'Math View', 'Mathematician View', 'Mom View', and 'Dad View'). Such findings are certainly encouraging, suggesting that the participants are having gender-equitable experiences with the subject area, particularly in school and at home. Moreover, the findings regarding students' confidence and interest in mathematics stand in contrast to previous research (e.g., J. Hall, 2012; Lupart, Cannon, & Telfer, 2004) that found that boys were more likely than girls to report feeling confident in their mathematics abilities and liking mathematics.

However, a contradictory finding with regard to students' views of mathematicians occurred in the drawings, which were highly gendered – both in terms of the gender of the mathematician drawn (i.e., the same gender as the student) and in terms of the occupational roles presented. Namely, girls were more likely than boys to draw mathematicians as teachers, while boys were more likely than girls to draw 'professional mathematicians'. Potentially, such gender differences relate to girls' and boys' different levels of exposure to mathematicians. As per the questionnaire responses, boys were more likely than girls to have both met a mathematician and to have seen one in the media.

Research Question #2b: Are there differences between middle (Grade 4) and senior (Grade 8) elementary students' views?

In contrast to the similarities in the comparisons by gender, grade-level differences occurred in many of the data examined. Specifically, on the questionnaire, Grade 4 students were more likely than Grade 8 students to report positive views of their mathematics classes, of themselves as learners of mathematics, of mathematicians, and of their relationships with their parents and mathematics (according to the aggregate variables 'Math View', 'Mathematician View', 'Mom View', and 'Dad View'). Such findings were not surprising, given the body of prior research (e.g., Chouinard & Roy, 2008; Ma & Cartwright, 2003; Thompson, 1995) that has found that attitudes toward mathematics tend to become more negative in the pre-teen/early teenage years.

Although some similarities existed with regard to views of mathematicians, as portrayed in the drawings, Grade 8 students were more likely than Grade 4 students to depict mathematicians with stereotyped appearances, as well as more likely to draw men mathematicians who held a 'professional mathematician' role. These grade-level differences may potentially be attributable to the older students' greater levels of media exposure. Additionally, meeting a mathematician in 'real life' appeared to positively impact Grade 4 students' views of becoming personally implicated in the field (i.e., becoming or marrying a mathematician), no such impacts were evident for Grade 8 students (i.e., no statistically significant differences in the views of students who reported meeting a mathematician and those who had not).

Research Question #3

In order to address Research Question #3, the findings from Research Questions #1 and #2 were examined in relationship to one another. Importantly, when examining these findings, any links reported are solely discussed in terms of correlational trends, not causal links.

Research Question #3a: What is the relationship between elementary students' views of mathematics and mathematicians, and media portrayals?

In many ways, it is difficult to draw any conclusive findings with regard to the link between the media portrayals to which the student participants are exposed and the students' views. Not only do the portrayals vary by media type (although messaging regarding stereotypes tends to be consistent), the participants' use of media is quite disparate. The clearest link occurs with respect to mathematicians: Students who have been exposed to mathematicians in the media tend to view them in stereotyped, appearance-focused ways – compared to positive, personality-focused ways for students with real-life exposure to mathematicians. However, when drawing comparisons between the views of students who reported seeing a mathematician in the media and those who had not, viewing a media mathematician did not impact students' views of mathematicians in general or of being personally implicated (i.e., becoming or marrying a mathematician). Thus, it appears that exposure to media mathematicians may impact students' views of mathematicians in complicated and contradictory ways. When considering media exposure more generally (as opposed to media exposure to mathematicians), higher levels of media use were shown to be associated with more negative, stereotypical views of mathematicians. However, as discussed, this association may be more complicated, linked to the home environments of students who are heavy media users, as opposed to the media use itself.

The tendency of the media to portray mathematics in narrow ways (i.e., typically focused on number sense and numeration) may have also influenced the students' views of the subject area: Arithmetic and whole-number calculations were the most common type of mathematics in the drawings, even though the students are exposed to a great variety of mathematical topics in their classes, as per the Ontario Mathematics Curriculum. Additionally, although the focus group participants explicitly claimed not to adhere to stereotypes about mathematics and

mathematically proficient people, there was some evidence to the contrary in other comments that were made during the focus group interviews. Thus, it appears as though the stereotypical messages, many of which come from the media, may be influencing students' views on an unconscious level. Such evidence of media's impact has also been found in prior studies where participants claim to not be influenced (e.g., Morge, 2006).

Research Question #3b: What is the relationship between elementary students' views of mathematics and mathematicians, and parents' views?

Research Question #3c: What is the relationship between elementary students' views of mathematics and mathematicians, and teachers' views?

The messages produced to the students from the parents and teachers are highlighted by similarity of messaging, and thus are addressed together. In the interviews, both groups of adults proclaimed the importance of mathematics in school and everyday life, messages that are clearly being received by the students, as they were reflected in the students' own views, as reported in the questionnaire ('Parent' questions) and in the focus group interviews. The students' interest in becoming mathematicians was correlated to the notion that both their mothers and their fathers would be proud of them if they became mathematicians. It appears that parental messages about the importance of mathematics are being promoted with regard to occupational choices.

Gender-specific (i.e., regarding parental gender) links were also clearly shown between the messages produced to the students through the tendency of fathers rather than mothers to help with mathematics, as reported in the parent interviews, since students tend to view their fathers more positively than their mothers with respect to mathematics (as reported on the questionnaire). These gendered interactions were corroborated by the correlational analyses: Statistically significant relationships existed between the 'Dad View' and 'Math View' variables,

but not between the ‘Mom View’ and ‘Math View’ variables. Thus, it appears that fathers are playing a greater role and having a greater impact on their children’s views of mathematics.

Arguably, parents and teachers play a more important role in disseminating messages about mathematics in general, rather than mathematicians specifically. Many of the parents and teachers expressed uncertainty about mathematicians, so messages about mathematicians are presumably rarely provided by the adults in the students’ lives. As such, messages about mathematicians likely arise from students’ varied media exposure. Notably, as discussed above, the tendency of both the parent and teacher participants to link mathematics with arithmetic and money/finances was evidenced in the students’ views, both in terms of the mathematics included in the drawings and the student questionnaire participants’ suggestions for reasons one would hire a mathematician.

Implications for Practice

The findings from the study indicate that the student participants generally enjoy their mathematics classes, feel confident in their mathematical abilities, and feel that mathematics is a useful subject both within and outside of school. While these findings need to be couched in the fact that all students were volunteers (Thus, the views of the participants were likely more positive overall than those of all Ontario students), they are also encouraging signs with respect to the ways that mathematics is being taught and the content that is being covered. Additionally, messages from teachers about mathematics’ utility and its role in everyday life are clearly getting across to students. However, there were some indications, both from the teacher and student participants, that more focus and importance tends to be placed on number sense and numeration than on the other mathematical topics. Some of these ‘other’ topics were viewed both by teacher and student participants as not being terribly useful or relevant to most people and professions. It

may be suggested that teachers evaluate the amount of time and emphasis they place on number sense and numeration, and see if it is to the detriment of the other topics. Furthermore, websites such as those suggested in the email sent to parents and teachers (Appendix O) could be utilized as resources to help teachers and students better understand how a broad range of mathematical topics are useful and applicable.

With regard to mathematicians, many prior studies (e.g., Morge, 2006) have suggested that mathematics classes are a prime location to dispel stereotypes and inform students about the profession. The challenge arises, as found in this study and discussed previously by mathematicians (e.g., Lockhart, 2009), when teachers admit to holding stereotypical images of mathematics and lacking an understanding of what mathematicians do. While teachers and students could become better informed about the profession using such resources as those discussed above, more powerful messages likely would come using more interactive sources. First, having mathematicians come to visit the school on career days or simply during a ‘regular’ mathematics period could make a substantial impact on students’ views. As noted, students who had actually met mathematicians (as opposed to seeing them in the media) had more positive and less stereotypical, appearance-focused views. A second suggestion would involve a cross-curricular link between mathematics and language arts. One strand in the Ontario Language Curriculum is media literacy, which “explores the impact and influence of mass media and popular culture by examining texts” (Ontario Ministry of Education, 2006, p. 13) such as television shows, video games, toys, and clothing. Therefore, to address both stereotypes about mathematics and mathematicians and the requirements of the language arts curriculum, examinations of media portrayals such as the ones examined in this study could be undertaken by students.

At the level of teacher education programs and professional development, the findings from this study point to the need for immersion into learning (and re-learning) mathematics in a reform-oriented manner. As discussed by the Grade 4 teacher participants in particular, hands-on experience learning mathematics in such a way helped them to really appreciate the benefits reform-oriented teaching. It was through gaining understanding and insight as a learner of mathematics that these teachers truly comprehended how teaching in such a manner could vastly improve their students' experiences with the subject area – both in terms of understanding and enjoyment. The teacher participants' experiences suggest that exposure to reform-oriented mathematics needs to be in-depth and sustained. Without sufficient exposure, it is difficult for teachers – even those with full intention of doing so – to implement such practices in their classrooms, given the many demands on teachers' time.

Limitations

The findings from this study may be limited by the fact that the participants were all volunteers. Therefore, the findings must all be couched in the presumption that those who were involved typically had more positive relationships with mathematics than the average person. That is, those who dislike mathematics would not be likely to voluntarily participate in such a study. There is no way of knowing how the study's findings would have been altered if, for instance, all students from a class were required to participate. An interesting consideration relates to the parents' views. The parent participants were generally very highly educated in mathematics, yet they often struggled to understand and appreciate the 'new' ways of doing mathematics that they experienced when helping their children with homework. In some respects, these views appeared related to the notion that the 'old' ways of doing mathematics worked for the participants. It is unclear whether parents with weak mathematics backgrounds

would have even further shut down and disengaged from these ‘new’ ways of doing mathematics, or if they, like many of the Grade 4 teacher participants, would have re-learned mathematics in a way that finally made sense to them, and in doing so, garnered an appreciation for the subject area.

Although students, teachers, and parents from a wide variety of locations within Ontario were involved in the study, it is unclear whether similar findings would occur in other locations. For instance, in other Canadian provinces that follow a different mathematics curriculum, differences might occur in students’ views of the utility of mathematics. As demonstrated in this study, the cultural milieu in which one is raised plays a significant role in the ways mathematics and mathematicians are viewed. For instance, while several examples of mathematicians being linked to violence were found in the studies by Picker and Berry (2000, 2001) that were conducted in other countries, no such references were made by any of the participants in my study (students, teachers, or parents). Thus, it seems unlikely that similar findings would be replicated in a culture that is very different from that of Ontario, or Canada more broadly.

In retrospect, adding questions to the parent and teacher interview that directly inquired about their views of gender and mathematics may have added to the richness of the data. Without any direct questions about this topic, the only information I garnered about the parents’ and teachers’ views came through discussions that they initiated and comments that they shared. While I certainly followed up on these gendered discussions, perhaps other discussions were missed by my not directly querying these views. However, directly asking about views, particularly on such a topic, may lead to participants responding in ways that are seen as politically correct (e.g., ‘Boys and girls are equally good at mathematics’), even if they do not

actually hold such views. In this sense, perhaps learning about gendered views that the parent and teacher participants hold in an indirect, emergent manner was advantageous.

Finally, it is possible that the participants' responses were affected by their perception of me as a mathematician. When communicating with the participants, I referred to myself as a 'researcher' and/or a 'Ph.D. student/candidate in Mathematics Education', rather than a 'mathematician'. However, in each data collection method with the students (i.e., drawings, questionnaires, and focus group interviews), a few participants explicitly referred to me as a mathematician, as did a few of the adult interview participants. It is possible that other participants viewed me in a similar fashion, but did not explicitly voice their views. Participants who viewed me as a mathematician may have been reluctant to voice negative views of mathematicians for fear of offending me. While the anonymity of the student drawings and questionnaires may have provided students with more freedom (compared to the face-to-face methods of data collection; i.e., student focus group interviews, parent interviews, and teacher interviews) to voice their honest opinions about mathematicians, however negative, knowing that I would be viewing their data may have still inhibited some participants from being fully candid in their responses.

Remaining Concerns

As I conclude this project, I remain concerned, as initially discussed in the Theoretical Framework chapter, about the ways that the gender-related findings from this study may be disseminated and interpreted by others. While I have tried to be very specific with my language choices (i.e., using 'gender' language consistent with my theoretical stance) and the ways in which I reported my results (e.g., recognizing the importance of 'no gender difference' results, disrupting the common ordering of gendered groups), there is still the possibility that this type of

research, which explored boys' and girls' relationships with mathematics, could be perceived as further contributing to a gender binary, as well as reifying and naturalizing differences. However, as asserted by Esmonde (2011), "ignoring gender hides the fact that gender is part of the foundation of the cultural houses we inhabit" (p. 30). Findings of gender differences in prior research have often been reported (both by researchers and by others, such as mass media) as though they apply to all boys and all girls, with each gender being treated as a homogeneous group. As noted by Francis, "it is usually we researchers, rather than respondents, who categorize children according to gender... the education system freely and pervasively categorizes pupils as boys and girls, making it difficult for pupils to resist such identification within an education context" (2006, p. 15). As I explained earlier, my decision to use 'boys' and 'girls' as my gendered groups pertained to pragmatic concerns regarding the age of my participants and the focus of my study; these choices were, however, aligned with my theoretical stance insofar as I was attempting to get the student participants to disclose their gender identity, not their biological sex (hence the choice of 'boys' and 'girls' rather than 'male' and 'female'). Doing research in this area is a challenge because researchers seek to understand participants' experiences in the (gender-binaried) world as it is, not the world as it could be. There are no easy solutions to this research issue, but at the least, I advocate for being particularly sensitive to language choices and to the way that findings are reported with regard to the gender of the participants, as well as always considering both in-group variance and between-group variance. Further, as argued by other researchers (e.g., Glasser & Smith, 2008), authors' theoretical positioning and operational definitions must be made readily apparent.

I also remain concerned about reports from research involving perceptions of who a mathematician is and what he/she does. Some researchers (e.g., Picker & Berry, 2000, 2001)

have claimed that, since many students draw pictures of teachers when asked to draw a mathematician, they do not understand who mathematicians are and what their jobs involve. However, these researchers typically do not provide their own definition or description of a mathematician, so it is not clear what ‘accurate’ view the researchers are implying that students should be striving toward (although the implication typically seems to be a university mathematics professor and/or someone with a Ph.D. in Mathematics). No conclusive definition exists for the term ‘mathematician’ (or, to complicate the matter further, the term ‘mathematics’; see Gold, 2003, for a discussion of this topic). All existing definitions are human constructions, influenced by the culture, history, and experiences that the person writing the definition has experienced. Instead of trying to strive for a goal of students understanding what a ‘true’ mathematician is (which, in my conception, is not possible to achieve), I believe it is important to focus on the characteristics that are ascribed to mathematicians. As shown in my study’s findings, many of the students, teachers, and parents reported holding stereotypical views of mathematicians, and these views were perpetuated by the media representations. Thus, when mathematicians are associated with stereotypical attributes, it may lead to a dissociation from the field, as was seen in the student questionnaire participants’ responses to the questions about becoming or marrying a mathematician. Returning to the claims made by other researchers that students’ depiction of teachers as mathematicians implies that students lack an understanding of the profession, I believe that such claims result from viewing mathematicians in a narrow way (e.g., by job title). Rather, I view such findings (which were replicated in my study) as a positive sign: Students view (their) teachers as liking and being competent in mathematics. This is a particularly encouraging finding at the elementary level, where many teachers struggle with and dislike the subject area.

I also continue to question the ways that representations of mathematics and mathematicians fit into the broader social milieu regarding intelligence and ‘nerdiness’ in general. While there are certainly segments of society that are very anti-intellectual in nature (e.g., many political climates), there has also been a rise of a hipster/geek counter-culture in recent years. This counter-culture has become increasingly more mainstream in the past few years, with ‘geek chic’ becoming fashionable (e.g., glasses with thick black frames, short pants) and the ‘smart is sexy’ notion being promoted by celebrities (e.g., actor Ashton Kutcher’s acceptance speech at the 2013 Teen Choice Awards, in which he said, “The sexiest thing in the entire world is being really smart”). In such a cultural milieu, the popularity of *The Big Bang Theory* may in fact be indicative of both stances: Some viewers may relate to the intelligent yet socially awkward characters, while other viewers see them as examples of ‘what is wrong’ with academics and highly intelligent people (e.g., inability to function well in social situations). Therefore, portraying the show’s characters in such a way may serve to both challenge and perpetuate stereotypes. Although the characters are stereotypical ‘nerds’, they also are portrayed in ways that serve to endear them to viewers and show a more ‘human’ side. In the example of *The Big Bang Theory*, the media representations purport to show things as they are (as interpreted by the show’s employees), rather than pushing boundaries in any meaningful way.

Contributions and Concluding Remarks

While this study raised many questions, it also had many significant findings. The overall gender-balanced views of mathematicians in the student drawings was a new finding in the field, whereas most prior research has shown age-related preferences for drawing women or men mathematicians. Nevertheless, as discussed, gendered trends and stereotypes were present within this broader gender balance. My creation of a detailed checklist for the analysis of mathematician

drawings provided far more detailed information about such drawings than that reported in prior studies. Additionally, my use of gendered lenses of comparison allowed for new perspectives on young people's views of mathematics and mathematicians, and their relationships with both.

The novel way in which media examples of mathematics and mathematicians were found (i.e., examining media that young people report viewing/using rather than examining media with known examples of mathematics and mathematicians) is also a significant contribution to the field. By searching media sources in this way, examples of mathematics and mathematicians in new and different media sources – particularly those targeted at young people – were found. Not only does this contribute to the extant body of known examples of mathematics and mathematicians in popular culture, the examination of a wide range of media types (as opposed to most prior research, which solely focused on television shows and movies) provided information regarding the different trends of representation in each media type. Moreover, my examination of such a vast number of media sources in my initial searches for mathematics-related references provided noteworthy data regarding the paucity of examples, particularly of mathematicians and mathematically proficient people, in children's media. Such data provide a tentative explanation for young people's lack of awareness of who mathematicians are and what they do (e.g., as evidenced by the number of 'not sure' responses to the questions about meeting a mathematician or seeing one in the media). Therefore, due to a lack of understanding of who mathematicians are and what they do, young people may become increasingly reliant on the few (typically stereotypical) examples to which they have been exposed.

On a more theoretical level, the use of the consumer-producer conceptual framework provided a structure to understand the complex interplay among students, parents, teachers, and media in the development and maintenance of ideas about mathematics and mathematicians.

Moreover, the framing of the study by a feminist and social constructivist epistemological stance resulted in a unique perspective being provided on the topics examined, as has been discussed.

This study plays a contributing role by providing a better understanding of the cultural milieu regarding views of mathematics, mathematicians, and gender; in order to make changes, an understanding of the existing situation first must be garnered. I anticipate that my contact with hundreds of students, parents, and teachers has sparked discussion about these topics, hopefully challenging some preconceived notions and stereotypes about mathematics and mathematicians – both among the study’s participants and with others with whom they discuss these topics. As stated by Robert F. Kennedy, “Few will have the greatness to bend history itself, but each of us can work to change a small portion of events. It is from numberless diverse acts of courage and belief that human history is shaped”. It is my hope that this research project has contributed in some small way to moving toward a world in which ‘I’m too pretty to do math’ pyjama pants are viewed as wholly unacceptable by all.

Footnotes

¹Certainly, mathematicians are not the only professionals with which children (and most adults) have little to no ‘real life’ exposure. Most children have probably not met, for instance, a researcher or a meteorologist. Therefore, they are reliant on media for their understanding of these professions. The degree to which children accept media representations of a profession is likely related to their ‘real life’ exposure to such professionals, regardless of the field.

²The data provided by Statistics Canada are aggregated, with mathematics, computer science, and information science grouped together. Thus, it is not possible to obtain statistics solely on (and thus make claims about) enrolment and graduation from mathematics degrees.

³The data provided by Employment Ontario are aggregated, with mathematicians, statisticians, and actuaries grouped together. Thus, it is not possible to obtain statistics solely on (and thus make claims about) mathematicians.

⁴I use the term ‘children’s media’ to refer to media that are watched/used by the children in my study; these may or may not be media that are intended for an audience of children. Indeed, research (e.g., Comstock, 1991; Roberts & Foehr, 2004) has shown that children’s preference for adult programming over children’s programming tends to occur at age eight.

⁵For the sake of brevity, children’s guardians will be referred to as ‘parents’ in this document, although I recognize that the children who participate in the study may be in living arrangements where their guardians are not their biological parents.

⁶An earlier version of this section (My Position on ‘Sex’ and ‘Gender’) appeared in the following: Hall, J. (2012, July). *Unpacking ‘gender issues’ research*. Paper presented at the 12th International Congress on Mathematical Education (ICME-12). Seoul, South Korea.

⁷Although I also agree with the ‘child as participant/co-researcher’ stance, it does not align well with my proposed research as children do not typically have a great deal of personal experience with mathematicians, so they would not be able to significantly contribute with the research design or enactment.

⁸As detailed in the Theoretical Framework chapter, my preference is to use ‘gender’ language (i.e., girls, boys, women, men) to reflect my feminist, social constructivist stance. However, in some of the studies discussed in the Literature Review, findings were only stated as pertaining to ‘males’ and ‘females’ (particularly with regard to characters). There is no way to know whether these characters were, for example, boys, men, or boys and men. Thus, the terms ‘male’ and ‘female’ will be used in these instances. Additionally, the term ‘male’ will be used when discussing ‘mathematics as a male domain’, as this phrase historically related to women’s presumed biological mismatch from the subject area. Wherever possible, I attempt to both align with my theoretical stance and make my writing linguistically palatable.

⁹In the province of Ontario, both Public (i.e., secular, non-denominational) and Catholic schools are publicly funded, and this has been the case since the 19th century, as per the British North America Act. Thus, in text, ‘publicly-funded’ refers to both the Public and Catholic school districts, whereas ‘Public’ only refers to the secular, non-denominational publicly-funded school districts. In contrast, a ‘public school’ refers to either a Catholic or Public school (i.e., one that is publicly-funded; not a private school).

¹⁰In 1990, the name of the SAT test changed from ‘Scholastic Aptitude Test’ to ‘Scholastic Assessment Test’. Given that *Family Guy* was first aired in 1999, and Peter has been depicted as an adult with teenage children since the show’s first episode, he presumably wrote this test when it was known as the ‘Scholastic Aptitude Test’.

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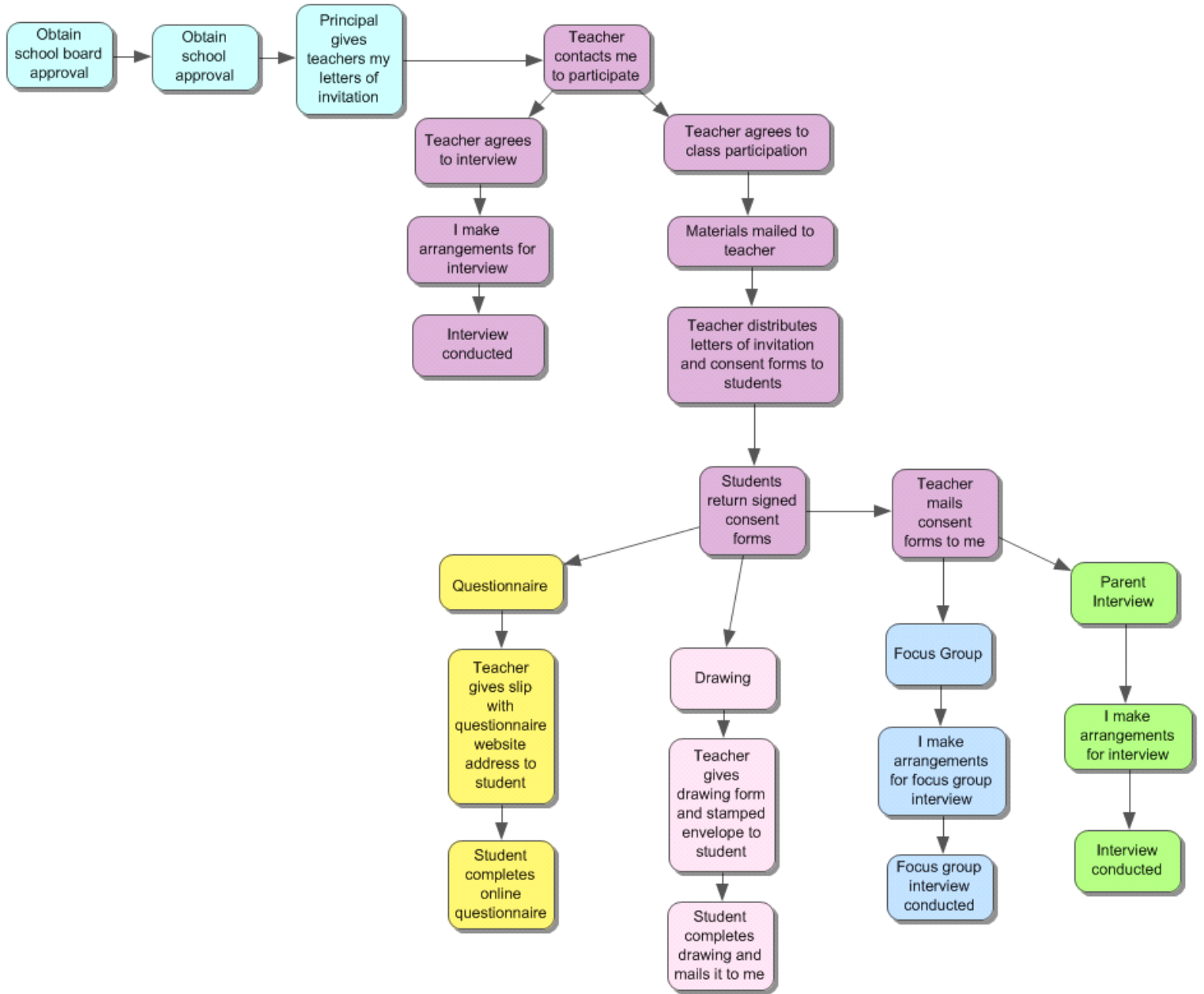
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Appendixes

Appendix A: Detailed Flow Chart of Data Collection



Appendix B: Online Questionnaire for Students

Welcome!

This questionnaire is part of a study that is trying to learn about elementary students' views of math and mathematicians. The study is also trying to learn how parents' and teachers' views and the media (TV, movies, books, etc.) impact your views.

Your answers to the questions are anonymous, which means that you do not need to give your name, so nobody will know what you answered. Also, you can skip questions or stop at any time.

If you have any questions about this study, please contact Jennifer Hall ([REDACTED]), the study's researcher.

By clicking on 'Next', you are agreeing to participate in this questionnaire (with your parents'/guardians' permission).

Thank you for your participation.

Part 1: Media Habits

In Part 1, you will answer questions about your media habits, such as watching TV and playing video games.

1. I am a

☐ Boy

☐ Girl

2. I am in Grade

☐ 4

☐ 8

Other (Please type your grade in the box.)

3. What school do you attend?

4. What town or city is your school in?

Television

1. How many hours per day do you usually watch TV on school days (Monday to Friday)?

- ☐ I don't watch TV on school days.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

2. How many hours per day do you usually watch TV on the weekend (Saturday and Sunday)?

- ☐ I don't watch TV on the weekend.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

3. What three TV shows do you watch most often?

- 1)
- 2)
- 3)

Internet

The questions on this page are about using the internet for fun, not during school or for homework.

1. How many hours per day do you usually spend on the internet for fun on school days (Monday to Friday)?

- ☐ I don't use the internet for fun on school days.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

2. How many hours per day do you usually spend on the internet for fun on the weekend (Saturday and Sunday)?

- ☐ I don't use the internet for fun on the weekend.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

3. What three websites do you visit most often, not counting email or social networking sites such as Facebook or Twitter?

- 1)
- 2)
- 3)

Movies

1. How often do you watch movies, either at home or in a movie theatre?

- ☐ At least once per week
- ☐ At least once per month
- ☐ Less often than once per month
- ☐ I don't watch movies.

2. What are your three favourite movies?

- 1)
- 2)
- 3)

Video Games

1. How many hours per day do you usually play video games on school days (Monday to Friday)?

- ☐ I don't play video games on school days.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

2. How many hours per day do you usually play video games on the weekend (Saturday and Sunday)?

- ☐ I don't play video games on the weekend.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

3. What three video games do you play most often?

- 1)
- 2)
- 3)

Reading

The questions on this page are about reading for fun, not in school or for homework.

1. How many hours per day do you usually read for fun on school days (Monday to Friday)?

- ☐ I don't read for fun on school days.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

2. How many hours per day do you usually read for fun on the weekend (Saturday and Sunday)?

- ☐ I don't read for fun on the weekend.
- ☐ Less than one hour
- ☐ 1-3 hours
- ☐ 3-5 hours
- ☐ More than 5 hours

3. What do you read most often when you read for fun?

- ☐ Books
- ☐ Magazines
- ☐ Comics

Other (Please specify)

4. List the titles of your three favourite books/magazines/comics/etc. below.

- 1)
- 2)
- 3)

Part 2: Math and Mathematicians

In this part, you will answer questions about math and mathematicians. Remember, nobody will know what you answered, so please be honest.

Math

1. For each statement, pick one answer to show how much you agree with it.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I enjoy my math class.	☐	☐	☐	☐	☐
I don't do very well in math.	☐	☐	☐	☐	☐
In my math class, I usually work alone.	☐	☐	☐	☐	☐
Math makes me feel uncomfortable and nervous.	☐	☐	☐	☐	☐
I don't know when I will ever use the math I learn in school.	☐	☐	☐	☐	☐
I have fun working on math problems.	☐	☐	☐	☐	☐
Math is a subject you either 'get' or don't 'get'.	☐	☐	☐	☐	☐
Being good at math makes you popular.	☐	☐	☐	☐	☐

Mathematicians

1. For each statement, select one answer.

	Yes	No	Not sure
I have met a mathematician in real life.	☐	☐	☐
I have seen a mathematician in the media (for example, on a TV show or in a book).	☐	☐	☐

2. If you have met a mathematician in real life or seen one in the media, where did you meet or see him or her?

5

6

3. What was the mathematician like?

5

6

Mathematicians

1. If you have a leaky toilet, you need to hire a plumber. If you break your leg, you need the services of a doctor. List all the reasons you can think of why someone would need to hire a mathematician.

	5
	6

2. What tools do mathematicians use?

	5
	6

Mathematicians

1. For each statement, pick one answer to show how much you agree with it.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Mathematicians usually work alone.	☐	☐	☐	☐	☐
I would like to become a mathematician when I grow up.	☐	☐	☐	☐	☐
I would like to marry a mathematician when I grow up.	☐	☐	☐	☐	☐
Mathematicians seem like nerdy people.	☐	☐	☐	☐	☐
A mathematician's work looks like fun to me.	☐	☐	☐	☐	☐

Your Parents/Guardians

1. For each statement about your Mom*, pick one answer to show how much you agree with it.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
My Mom helps me with my math homework.	☐	☐	☐	☐	☐
My Mom thinks math is an important subject to study.	☐	☐	☐	☐	☐
My Mom hates to do math.	☐	☐	☐	☐	☐
My Mom is good at math.	☐	☐	☐	☐	☐
My Mom would be proud if I became a mathematician when I grow up.	☐	☐	☐	☐	☐

*or female guardian. If you do not have a female guardian, please skip these questions.

Your Parents/Guardians

1. For each statement about your Dad*, pick one answer to show how much you agree with it.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
My Dad helps me with my math homework.	☐	☐	☐	☐	☐
My Dad thinks math is an important subject to study.	☐	☐	☐	☐	☐
My Dad hates to do math.	☐	☐	☐	☐	☐
My Dad is good at math.	☐	☐	☐	☐	☐
My Dad would be proud if I became a mathematician when I grow up.	☐	☐	☐	☐	☐

*or male guardian. If you do not have a male guardian, please skip these questions.

Girls, boys, and math

1. For each statement, pick whether you think it is more true for boys or more true for girls.

	Boys	No difference	Girls
Who is more likely to say math is their favourite subject?	☐	☐	☐
Who is more likely to distract other students from their math work?	☐	☐	☐
Who is more likely to be good at math?	☐	☐	☐
Who do math teachers usually spend more time with?	☐	☐	☐
Who is more likely to tease girls if they are good at math?	☐	☐	☐
Who is more likely to tease boys if they are good at math?	☐	☐	☐
Whose parents would be more upset if they do not do well in math?	☐	☐	☐

Comments?

1. Did you fill out this questionnaire:

- ☐ By yourself
- ☐ With help from one of your parents
- ☐ With help from someone else

If someone other than your parents helped you, type who it was in the box below. For example, 'my sister'.

2. If you have any other comments about math or mathematicians, please type them in the box below.

5

6

3. If you have any comments about the questionnaire, please type them in the box below.

5

6

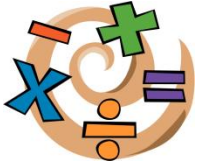
Thank you! :)

Thank you for taking the time to complete this questionnaire.

Your answers will help me to better understand what media elementary school students are using, as well as your views of mathematics and mathematicians.

Please click on 'Done' to finish the questionnaire.

Appendix C: Drawing Form for Students



Mathematics Education Research Project
Jennifer Hall, University of Ottawa



Thank you for participating in this research. I am glad you are willing to take part.

Everything you write or draw on this page is anonymous, which means that you do not need to give your name, so nobody will know that you wrote or drew it.

1) I am a ☐ boy ☐ girl

2) I am in Grade ☐ 4 ☐ 8 ☐ other: ____

3) I attend _____ school.

4) In the space below, please draw a picture of a mathematician at work. Please use colour (pencil crayons, markers, etc.) in your drawing if possible.

5) Look back at the drawing you made of a mathematician at work. In the space below, write a paragraph that explains the drawing so that anyone looking at it will understand what your drawing means and who the person is in it.

Appendix D: Focus Group Interview Protocol for Grade 4 Students

Interview Protocol – Grade 4 Focus Group Interviews

Clip #1: The Suite Life of Zack and Cody – Math Camp

- Key idea: nerd stereotype

Questions:

- Please tell me in your own words what happened in this video.
- What did you think of the joke Tapeworm told (three ‘squared’ meals)?
- Why do you think Zack said that he didn’t want to go?
- Why do you think Zack said that the people at Math Camp were ‘geeks’?
- Would you want to go to Math Camp? Why/why not?

Clip #2: The Simpsons – Girls Just Want to Have Sums

- Key idea: gender stereotypes

Questions:

- Please tell me in your own words what happened in this video.
- What do you think about what Principal Skinner is saying? Do you believe that boys are better than girls at math?
- Why do you think the creators of The Simpsons made an episode about this topic?
- Have you heard such things about girls and math before? Do you believe them?
- What do you think the director meant when she said, ‘Surely Principal Skinner doesn’t mean that differences are inherent’?
- How does it make you feel when you hear things like what Principal Skinner said?
- Have you ever heard anything like this in other media? In real life?
- Has anyone ever said anything like this to you? If so, how did you react?

Appendix E: Focus Group Interview Protocol for Grade 8 Students

Interview Protocol – Grade 8 Focus Group Interviews

Clip #1: The Big Bang Theory – The Best Number

- Key idea: nerd stereotype

Questions:

- Please tell me in your own words what happened in the video.
- Why do you think the girls don't want to hang out with the guys?
- Would you want to hang out with guys like these? Why/why not?
- What do you think the show would be like if these four characters were girls instead?
- Do you consider any of the characters on the show to be mathematicians?
- If so, do you think that's an accurate representation of what mathematicians are like?
- Have you seen any characters like this in other media examples?

Clip #2: Glee – Math Error

- Key idea: innumeracy

Questions:

- Please tell me in your own words what happened in the video.
- What do you think about the equation Mr. Schuester wrote? Does it make sense? (Provide pencils and papers to try it out. Suggest this if the participants don't think there's any issue.)
- What's wrong with the equation? How would you fix it?
- If you saw the episode before, did you notice this?
- Why do you think nobody at the show noticed it?

Clip #3: The Simpsons – Girls Just Want to Have Sums

- Key idea: gender stereotypes

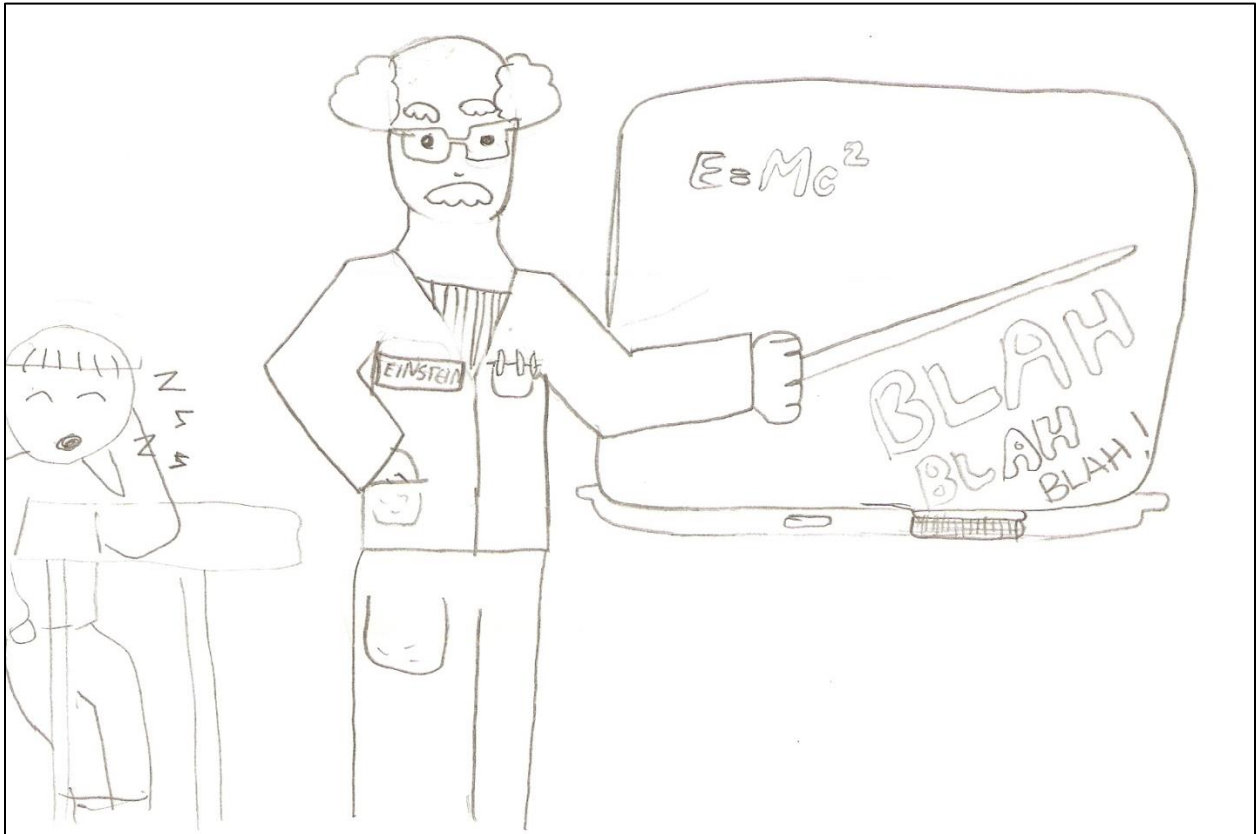
Questions:

- Please tell me in your own words what happened in this video.
- What do you think about what Principal Skinner is saying? Do you believe that boys are better than girls at math?
- Why do you think the creators of The Simpsons made an episode about this topic?
- Have you heard such things about girls and math before? Do you believe them?
- What do you think the director meant when she said, 'Surely Principal Skinner doesn't mean that differences are inherent'?

- How does it make you feel when you hear things like what Principal Skinner said?
- Have you ever heard anything like this in other media? In real life?
- Has anyone ever said anything like this to you? If so, how did you react?

Appendix F: Student Drawings Used as Prompts in Focus Group Interviews

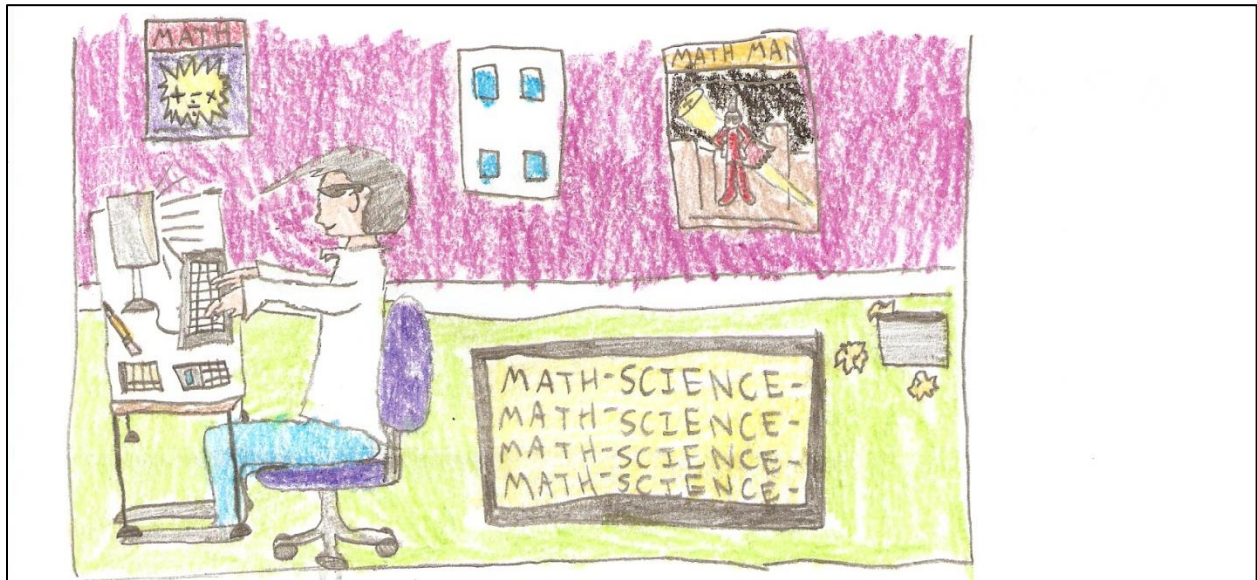
Drawing #1: 'Einstein-type teacher with a sleeping student' (by D2, Grade 8 girl)



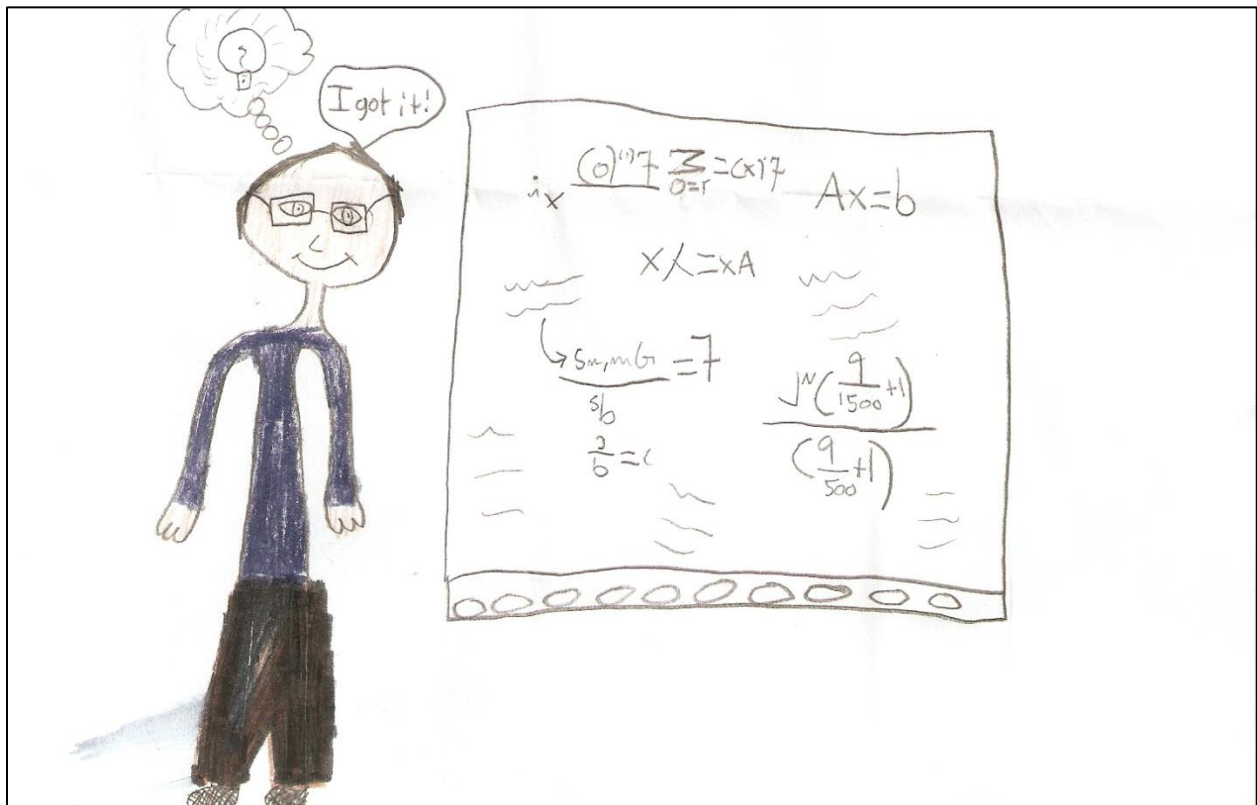
Drawing #2: 'Inventor' (by D4, Grade 4 girl)



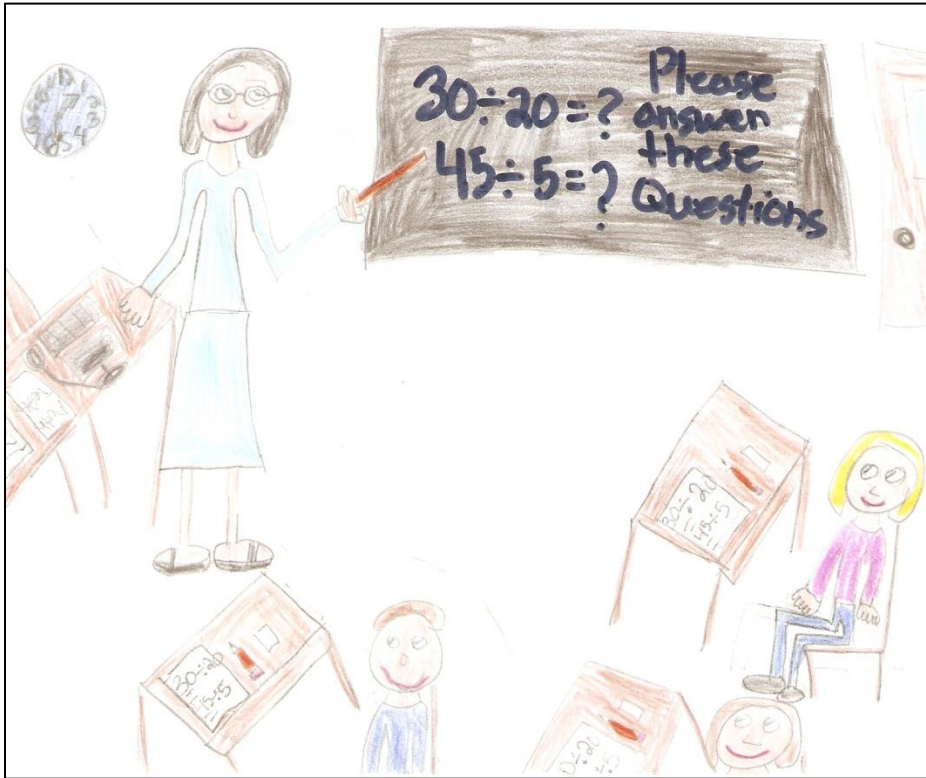
Drawing #3: “Cool guy’ office worker’ (by D18, Grade 4 girl)



Drawing #4: ‘Professional mathematician’ (by D31, Grade 4 boy)



Drawing #5: 'Elementary teacher' (by D37, Grade 4 girl)



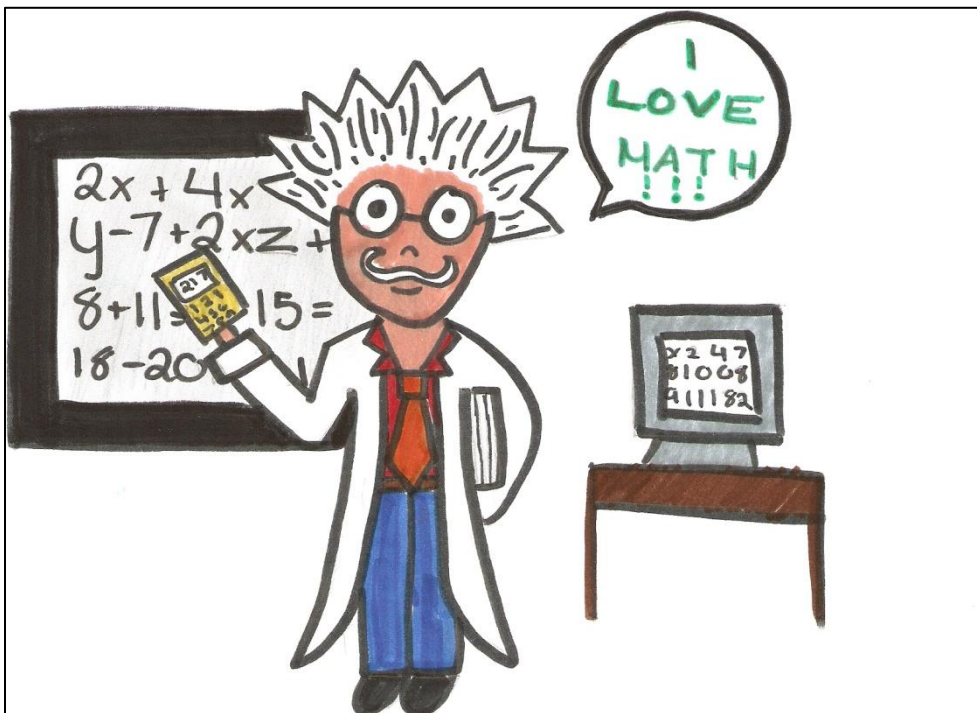
Drawing #6: 'Sheldon-like character' (by D40, Grade 4 girl)



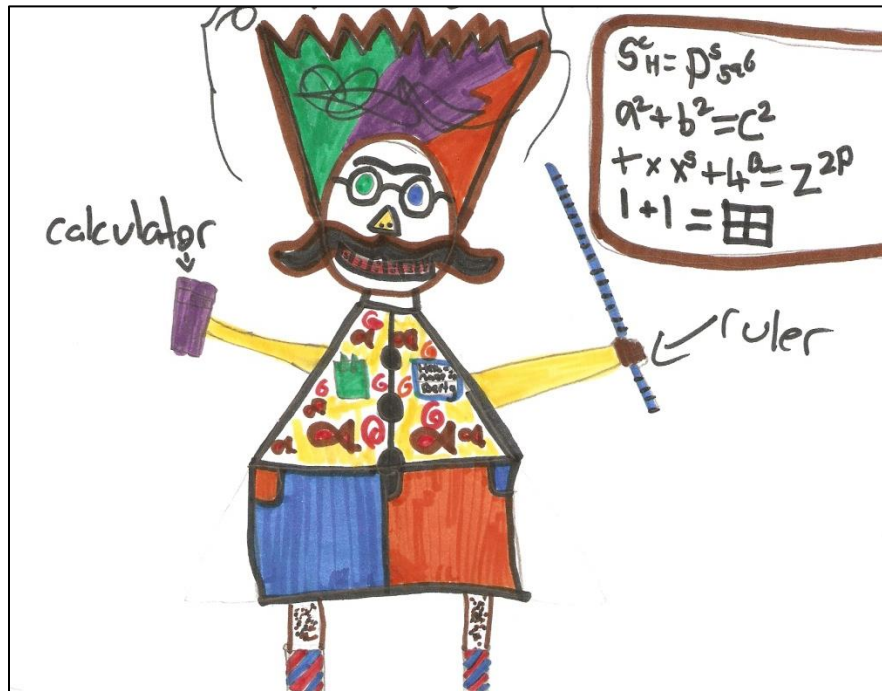
Drawing #7: 'Stereotypical 'nerd'' (by D50, Grade 8 girl)



Drawing #8: 'Happy Einstein-like character' (by D59, Grade 8 girl)



Drawing #9: ‘Wacky character’ (by D60, Grade 8 boy)



Drawing #10: 'Wizard' (by D66, Grade 8 girl)



Appendix G: Interview Protocol for Parents

Semi-Structured Interview Protocol for Parents/Guardians

Project: Ph.D. Thesis – Societal views of mathematics and mathematicians and their impact on children

Date:

Time:

Location:

Interviewer: Jennifer Hall

Participant:

Child's Grade/Sex:

Email Address:

Phone Number:

[Greet the participant(s) and thank him/her/them for participating. Give a brief description of the study and interview process, including recording. Ensure confidentiality and anonymity of responses. Review, sign, and date the consent form.]

Questions:

Experiences with Mathematics as a Student

- 1) Please describe your background with mathematics as a student.
- 2) What was your most memorable mathematics experience as a student?

Experiences with Mathematics as an Adult

- 3) What is your current career? Do you use mathematics in your career? If so, how?
- 4) Do you use mathematics outside of your career? If so, how?

Views of Mathematics and Mathematicians

- 5) If an alien came to Earth and it didn't know what mathematics was, how would you explain to the alien what mathematics is?
- 6) How do you feel mathematics is portrayed in the popular media? Why do you say this?
- 7) How would you describe mathematicians?
- 8) Where in the popular media (e.g., movies, TV shows) have you seen mathematicians?
- 9) How would you describe these mathematicians?
- 10) Have you ever met a mathematician? If so, what was that person like?

Experiences with Mathematics and Your Child

- 11) How would you describe your child's views of mathematics?

- Do you feel that they like mathematics?
- Do you feel that they are skilled in mathematics?

12) Do you interact with your child and mathematics at home (e.g., helping with homework, playing math-related games)? If so, how?

13) How would you feel if your child became a mathematician?

Overall Views

14) How do you currently feel about mathematics?

15) Overall, what or who do you think has had the biggest impact on how you view mathematics?

[Ask the participant(s) for any further questions or comments. Thank participant(s) for participating in the interview.]

Appendix H: Interview Protocol for Teachers

Semi-Structured Interview Protocol for Teachers

Project: Ph.D. Thesis – Societal views of mathematics and mathematicians and their impact on children

Date:

Time:

Location:

Interviewer: Jennifer Hall

Participant:

Position:

Email Address:

Phone Number:

[Greet the participant and thank him/her for participating. Give a brief description of the study and interview process, including recording. Ensure confidentiality and anonymity of responses. Review, sign, and date the consent form.]

Questions:

Experiences with Mathematics as a Student

- 1) Please describe your background with mathematics as a student.
- 2) What was your most memorable mathematics experience as a student?

Experiences with Mathematics as an Adult

- 3) Please describe your experience teaching mathematics.
- 4) What was your most memorable experience teaching mathematics?
- 5) Please describe a typical mathematics lesson in your class.
- 6) How would you react if a student said to you, 'I hate math! When am I ever going to use this stuff?'
- 7) What is your goal in teaching mathematics?
- 8) Do you use mathematics outside of your teaching career? If so, how?

Views of Mathematics and Mathematicians

- 9) If an alien came to Earth and it didn't know what mathematics was, how would you explain to the alien what mathematics is?
- 10) How do you feel mathematics is portrayed in the popular media? Why do you say this?
- 11) How would you describe mathematicians?

12) Where in the popular media (e.g., movies, TV shows) have you seen mathematicians?

13) How would you describe these mathematicians?

14) Have you ever met a mathematician? If so, what was that person like?

Overall Views

15) How do you currently feel about mathematics?

16) Overall, what or who do you think has had the biggest impact on how you view mathematics?

[Ask the participant for any further questions or comments. Thank him/her for participating in the interview.]

Appendix I: Letter of Invitation for School District Directors



Université d'Ottawa
Faculté d'éducation
University of Ottawa
Faculty of Education

[Name of Director]
School District Name
City, Ontario

Dear [Name of Director],

As a Ph.D. candidate working with Dr. Christine Suurtamm in the Faculty of Education at the University of Ottawa, I am conducting a study entitled 'Societal views of mathematics and mathematicians and their impact on children'. Many people have negative views of mathematics, and media tend to perpetuate these views. However, it is unclear how children's views of mathematics are formed, so that is the focus of my study. Learning how children's views are developed may provide insight into ways to counteract negative views. This is particularly important as research has shown that negative views are linked to decreased participation and achievement in mathematics. This research will also benefit your school district by opening up a dialogue with elementary students, teachers, and parents about mathematics and mathematicians. Furthermore, through participating, students will gain a first-hand understanding of what it means to do research.

My study is addressing the following research questions:

- What images of mathematics and mathematicians exist in a child's world as portrayed by media and represented by parents' and teachers' views?
- How do elementary students view mathematics and mathematicians?
 - Are there differences between boys' and girls' views?
 - Are there differences between Grade 4 and Grade 8 students' views?
- What is the relationship between elementary students' views of mathematics and mathematicians and a) media portrayals, b) parents' views, and c) teachers' views?

The purpose of this letter is to invite your school district to participate in my research. If your district agrees to participate, I would like to send letters to all elementary school principals in the district, inviting their schools to participate. If a school agrees to participate, information is then given to individual Grade 4 and Grade 8 teachers, who may then contact me if they are interested in participating. A report summarizing my overall findings will be sent to each participating school district and school. Each class that participates will be provided with a mathematics resource book.

Students, parents, and teachers will be invited to participate in the following:

- Grade 4 and 8 students who receive parental permission and who themselves agree to participate will be asked to take part in one or two of the following:
 - **Online questionnaire** about media habits and views of mathematics and mathematicians – This will presumably be done at home and will take students approximately 20 minutes to complete.

☎ 613-562-5804
📠 613-562-5146

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Ottawa ON K1N 6N5 Canada
www.uOttawa.ca



uOttawa

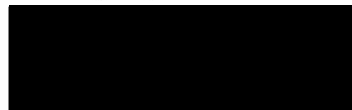
Université d'Ottawa
Faculté d'éducation
University of Ottawa
Faculty of Education

- **Drawing of a mathematician** – Students will be asked to draw a picture of what they think a mathematician looks like. This also will presumably be done at home and will take approximately 30 minutes to complete.
- Grade 4 and 8 teachers who agree to participate will be asked to take part in the following:
 - **Individual interview** – Teachers will be invited to take part in an interview about their views of and experiences with mathematics and mathematicians. The interview will take place outside school hours, and will take approximately one hour to complete.
 - **Distribution of materials** – Teachers will be asked to distribute materials (e.g., information letters, consent forms) to students on my behalf.
- Parents of Grade 4 and 8 students who agree to participate will be asked to take part in the following:
 - **Individual interview** – Parents will be invited to participate in an interview about their views of and experiences with mathematics and mathematicians. The interview will take place outside school hours, and will take approximately one hour to complete.

Participation in each data collection method is optional. For instance, a teacher may decide to participate in an interview, but may not ask her class to participate (or vice-versa). Alternately, a student who decides to participate in the research may decide to only complete the online questionnaire, and his or her parents may or may not decide to participate in the study. In all data collection methods, all participants will be anonymous and schools/school districts will not be identified.

If you have any inquiries about this study, please contact me at [REDACTED]@uottawa.ca. You can also contact my supervisor, Dr. Christine Suurtamm, at [REDACTED]. This research project has received ethics approval from the University of Ottawa Ethics Committee. Any questions concerning the rights of research participants may be addressed to the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5 (613-562-5841 or ethics@uottawa.ca).

Thank you,



Jennifer Hall
Ph.D. candidate, Mathematics Education
University of Ottawa

☎ 613-562-5804
📠 613-562-5146

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Appendix J: Letter of Invitation for Principals



uOttawa

Université d'Ottawa
Faculté d'éducation
University of Ottawa
Faculty of Education

Hello,

As a Ph.D. candidate working with Dr. Christine Suurtamm in the Faculty of Education at the University of Ottawa, I am conducting a study entitled 'Societal views of mathematics and mathematicians and their impact on children'. Many people have negative views of mathematics, and media tend to perpetuate these views. However, it is unclear how children's views of mathematics are formed, so that is the focus of my study. Learning how children's views are developed may provide insight into ways to counteract negative views. This is particularly important as prior research has shown that negative views are linked to decreased participation and achievement in mathematics. This research will also benefit your school by opening up a dialogue with elementary students, teachers, and parents about mathematics and mathematicians. Furthermore, through participating, students will gain a first-hand understanding of what it means to do research.

My study is addressing the following research questions:

- What images of mathematics and mathematicians exist in a child's world as portrayed by media and represented by parents' and teachers' views?
- How do elementary students view mathematics and mathematicians?
 - Are there differences between boys' and girls' views?
 - Are there differences between Grade 4 and Grade 8 students' views?
- What is the relationship between elementary students' views of mathematics and mathematicians and a) media portrayals, b) parents' views, and c) teachers' views?

The purpose of this letter is to seek permission to conduct my research in your school. If you agree for your school to participate, please pass on the enclosed letters to the Grade 4 and Grade 8 teachers in your school. If they are interested, then they can contact me individually. If your school participates, I will send you a report summarizing my findings. Each class that participates will be provided with a mathematics resource book.

Students, parents, and teachers will be invited to participate in the following:

- Grade 4 and 8 students:
 - **Online questionnaire** about media habits and views of mathematics and mathematicians – This will presumably be done at home and will take approximately 20 minutes to complete.
 - **Drawing of a mathematician** – This also will presumably be done at home and will take approximately 30 minutes to complete.
- Grade 4 and 8 teachers:
 - **Individual interview** – Teachers will be invited to take part in an interview about their views of and experiences with mathematics and mathematicians. The interview will take place outside school hours, and will take approximately one hour to complete.

☎ 613-562-5804
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- **Distribute materials** – Teachers will be asked to distribute materials (e.g., information letters, consent forms) to students on my behalf.

- Parents of Grade 4 and 8 students:

- **Individual interview** – Parents will be invited to take part in an interview about their views of and experiences with mathematics and mathematicians. The interview will take place outside school hours, and will take approximately one hour to complete.

Participation in each data collection method is optional. For instance, a teacher may decide to participate in an interview, but may not ask her class to participate (or vice-versa). Alternately, a student who decides to participate in the research may decide to only complete the online questionnaire, and his or her parents may or may not decide to participate in the study. In all data collection methods, all participants will be anonymous and schools/school districts will not be identified.

If you have any inquiries about this study, please contact me at [redacted] [\[redacted\]@uottawa.ca](mailto:[redacted]@uottawa.ca). You can also contact my supervisor, Dr. Christine Suurtamm, at [redacted]. This research project has been approved by [school district name] and has received ethics approval from the University of Ottawa Ethics Committee. Any questions concerning the rights of research participants may be addressed to the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5 (613-562-5841 or ethics@uottawa.ca).

Thank you,

[redacted signature]

Jennifer Hall
Ph.D. candidate, Mathematics Education
University of Ottawa

Appendix K: Letter of Invitation for Teachers



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Hello,

As a Ph.D. candidate working with Dr. Christine Suurtamm in the Faculty of Education at the University of Ottawa, I am conducting a study entitled 'Societal views of mathematics and mathematicians and their impact on children'. Many people have negative views of mathematics, and media tend to perpetuate these views. However, it is unclear how children's views of mathematics are formed, so that is the focus of my study. Learning how children's views are developed may provide insight into ways to counteract negative views. This is particularly important as prior research has shown that negative views are linked to decreased participation and achievement in mathematics. This research will also benefit your class by opening up a dialogue with students and parents about mathematics and mathematicians. Furthermore, through participating, students will gain a first-hand understanding of what it means to do research.

My study is addressing the following research questions:

- What images of mathematics and mathematicians exist in a child's world as portrayed by media and represented by parents' and teachers' views?
- How do elementary schoolchildren view mathematics and mathematicians?
 - Are there differences between boys' and girls' views?
 - Are there differences between Grade 4 and Grade 8 students' views?
- What is the relationship between elementary schoolchildren's views of mathematics and mathematicians and a) media portrayals, b) parents' views, and c) teachers' views?

The purpose of this letter is to seek permission to conduct my research with you and your class. If you agree to participate, your class will be provided with a mathematics resource book.

Students and parents will be invited to participate in the following:

- Students:
 - **Online questionnaire** about media habits and views of mathematics and mathematicians – This will presumably be done at home and will take approximately 20 minutes to complete.
 - **Drawing of a mathematician** – This also will presumably be done at home and will take approximately 30 minutes to complete.
- Parents:
 - **Individual interview** – Parents will be invited to take part in an interview about their views of and experiences with mathematics and mathematicians. The interview will take place outside school hours, and will take approximately one hour to complete.



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Teacher participation takes two forms, and you are welcome to participate in one or both:

- **Individual interview** – You are invited to take part in an interview about your views of and experiences with mathematics and mathematicians. The interview will take place outside school hours, and will take approximately one hour to complete.
- **Distribute materials** – Your participation would involve passing out information letters and consent forms about the research to students in your class. Students (and/or their parents) who want to participate will return signed consent forms to you and then you will mail them to me. I will provide you with slips with the website address of the questionnaire and forms for the drawings (with stamped envelopes) so you can pass them out to students who wish to participate. Students who complete drawings will mail them directly to me. I will contact parents directly if they want to participate in interviews.

Participation in each data collection method is optional. For instance, you may decide to participate in a teacher interview, but you may not ask your class to participate (or vice-versa). Alternately, a student who decides to participate in the research may decide to only complete the online questionnaire, and his or her parents may or may not decide to participate in the study. In all data collection methods, all participants will be anonymous and schools/school districts will not be identified.

If you are interested in participating or would like more information about the research, please contact me at [redacted]@uottawa.ca. You can also contact my supervisor, Dr. Christine Suurtamm, at [redacted] 0 [redacted] [redacted].

[redacted] This research project has been approved by [school district name] and has received ethics approval from the University of Ottawa Ethics Committee. Any questions concerning the rights of research participants may be addressed to the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5 (613-562-5841 or ethics@uottawa.ca).

Thank you very much in advance for your consideration.

Sincerely,

[redacted signature]

Jennifer Hall
Ph.D. candidate, Mathematics Education
University of Ottawa

☎ 613-562-5804
📠 613-562-5146

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Appendix L: Slip with Online Questionnaire Website Address

Mathematics Education Research Project
University of Ottawa

Thank you for volunteering to participate in an online questionnaire about your media habits and your views of mathematics and mathematicians.

The questionnaire is located at:



If you have any questions, please contact Jennifer Hall, the researcher of this study, at



Appendix M: Student Information Sheet and Consent Form for Focus Group Interviews



Information for Elementary Students



Purpose of the research

- To learn about elementary students' views of math and mathematicians
- To learn how students' views may be impacted by parents, teachers, and the media

The researcher

- The researcher is Jennifer Hall, a Ph.D. student in Math Education at the University of Ottawa.
- Jennifer is supervised by Dr. Christine Suurtamm.

Your role as a participant

- You will participate in a focus group interview with three to four other students from your grade.
- You will be shown examples of math and mathematicians from TV shows and asked to share your opinion about them.
- The focus group interview should take about 30 minutes to complete and it will be videotaped.

Why will the focus group interview be videotaped? How will the videotape be used?

- The interview is videotaped so Jennifer can record what is said and who is saying it. She will type up notes about the interview and then study them.
- The videotape will not be shown to anyone except for Jennifer and Dr. Suurtamm, and it will be stored in a locked cabinet so nobody else can see it.



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Your rights as a participant

When you participate in research, your rights will be respected.

You have the right to:



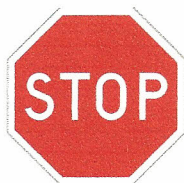
Have your say

Children and young people should be involved in research that focuses on their lives, experiences, and opinions.



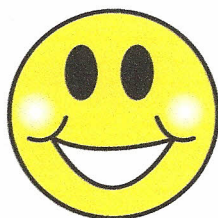
Be informed

Before you participate in the research, you will be fully informed about the project and what your participation will involve.



Stop participating

If you want to stop participating in the focus group or if you want to skip a question, that is okay.



Be treated well

You will be treated with respect during all parts of the research. Hopefully you will enjoy the experience and learn from it.



Privacy

You will not be identified in any papers or presentations about the research. A fake name will be used if Jennifer quotes you in any papers and presentations.



Share your opinion

If you have a problem with something in the research, you can talk to or email Jennifer about it. You can also email or call Dr. Suurtamm.

This page is adapted from Moore, T., McArthur, M., & Noble-Carr, D. (2008). Little voices and big ideas: Lessons learned from children about research. *International Journal of Qualitative Methods*, 7(2), 77-91.



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Informed Consent for Elementary Student Participants

- ☐ I have read the information sheet.
- ☐ I understand the purpose of this study and what is required of me, and I agree to participate in a focus group interview.
- ☐ If I have questions about the study, I know that I can ask Jennifer Hall or her supervisor, Dr. Christine Suurtamm.

Jennifer Hall

[REDACTED] [ca](#)

Dr. Christine Suurtamm

[REDACTED] [ca](#)

Participant's signature:

Date:

Researcher's signature:

Date:

Appendix N: Information Sheet and Consent Form for Parent Interviews



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Information for Parents/Guardians

Primary Researcher

Jennifer Hall
Ph.D. Candidate
Faculty of Education
[redacted]@uOttawa.ca

Supervisor

Dr. Christine Suurtamm
Associate Professor
Faculty of Education
[redacted]@uOttawa.ca

Description of Project

As a doctoral candidate in the Faculty of Education at the University of Ottawa, I am conducting a study entitled 'Societal views of mathematics and mathematicians and their impact on children'. The purpose of my study is to investigate elementary schoolchildren's views of mathematics and mathematicians, and how these views may be impacted by children's media, parents/guardians, and teachers, in order to better understand the complex interplay between outside sources and children's views. I am inviting you to participate in my research study as you are a parent/guardian of a child in Grade 4 or Grade 8.

If you agree to participate, you will take part in an interview about your experiences with mathematics and mathematicians, both as a student and as an adult, as well as your interactions with your child and mathematics. This single interview should take approximately one hour to complete and will be conducted in April of 2011 at a mutually acceptable time and location. The interview will be audio-taped to gather information and allow for transcription.

Your participation in this study is entirely voluntary and you may refuse to answer any question(s) or may withdraw at any time without penalty. If you choose to withdraw, all data gathered until the time of withdrawal will be destroyed. Any information you share will remain strictly confidential. If quoted, you will be assigned a pseudonym, and any identifying details will be removed.

Potential benefits of this study include providing insight into children's views of mathematics and mathematicians, and how these views are impacted by outside sources such as media and key adults in their lives. On a personal level, this study may be beneficial to you as it will provide you with the opportunity to reflect upon and share your mathematics experiences in a confidential, non-threatening environment. Reflecting upon your own experiences and those with your child may also be beneficial to your future interactions with your child and mathematics.

This study has very few potential inconveniences or harms associated with it, but may potentially cause you to reflect on mathematics experiences that were

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613-562-5146

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unpleasant or upsetting. If this occurs, you may skip such a question or take a break from interviewing before continuing. The likelihood of this occurring is very low.

The results of this study will be used in Jennifer Hall's Ph.D. thesis and further publications and presentations. Hard copies of the data will be stored in a locked filing cabinet in the Pi Lab at the University of Ottawa, whereas electronic files will be password protected; all data will only be accessible to Jennifer Hall and Dr. Christine Suurtamm. The data will be destroyed five years after the completion of Jennifer Hall's Ph.D. thesis.

If you have any inquiries about this study, please contact Jennifer Hall or Dr. Christine Suurtamm at the contact information provided above. If you have any inquiries regarding the ethical conduct of this study, please contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5, (613) 562-5841, or ethics@uottawa.ca.

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Informed Consent for Participants

I have read the above information. I understand the purpose of this study and what is required of me, and I agree to participate. I have been assured that my participation is voluntary and that my identity will remain confidential. I am aware that I am free to withdraw from the study at any time without any negative consequences.

I am aware that any inquiries about the research study should be addressed to the Primary Researcher, Jennifer Hall ([REDACTED]), or her Supervisor, Dr. Christine Suurtamm ([REDACTED]).

I am aware that if I have any concerns regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5, (613) 562-5841, or ethics@uottawa.ca.

I am aware that there are two copies of the consent form, one of which is mine to keep.

Participant's signature: _____ Date: _____

Researcher's signature: _____ Date: _____

Appendix O: Thank You Email Sent to Parent and Teacher Interview Participants

Hello,

Thank you for participating in an interview. I enjoyed speaking to you.

As promised, here are some links to neat websites about math and mathematicians. I hope you and your children [students] find them interesting.

(#1-4 are all associated with/created by George Gadanidis, a Math Education prof from UWO.)

1) Joy of X: <http://www.joyofx.com/>

-This site features videos (songs, stories, explanations, etc.) about math and mathematicians. It's both entertaining and educational!

2) Math and Science Performance Festival:

<http://www.edu.uwo.ca/mpc/festival.html>

-This site features videos (songs/dances/cartoons/etc. about math and science) that were submitted to the aforementioned festival, from 2008 to present. I recommend watching 'A World Without Numbers'.

3) Windows Into Elementary Mathematics:

<http://www.fields.utoronto.ca/mathwindows/>

-This website, sponsored by the Fields Institute of the University of Toronto, features videos of mathematicians explaining interesting elementary-level math problems. Lindi Wahl, one of the featured mathematicians, taught me Mathematical Biology (a 3rd-year Applied Math course) at Western, and she's fantastic!

4) Imagine This: <http://publish.edu.uwo.ca/george.gadanidis/imaginethis/>

-This website features some interesting questions to ponder in mathematics, as a way to start meaningful conversations. For instance, if we had to eliminate either 0 or 1 from our number system, which would you choose?

5) Bending and Stretching Classroom Lessons to make Math Inspire:

http://www.nytimes.com/2011/01/18/science/18prof.html?_r=1&ref=science

This New York Times article is about Vi Hart, who calls herself a 'mathemusician'. She creates YouTube videos that link math with art/doodling/music. The videos are amusing and educational, plus they cover a lot of 'big ideas' in mathematics.

Here's the link to her YouTube page: <http://www.youtube.com/user/Vihart>

Here's the link to her website: <http://vihart.com/>

6) Practical Uses of Math And Science (PUMAS): <https://pumas.gsfc.nasa.gov/>

-This website, by NASA, features over 70 examples of math and science in the 'real world'.

7) When Will I Use Math?: <http://www.whenwilliusemath.com/>

-This website provides information about math-related careers, tips for succeeding in math, and other resources.

If you or your children [students] have any questions, feel free to contact me.

Take care,
Jennifer :)

Appendix P: Information Sheet and Consent Form for Teacher Interviews



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Information for Teachers

Primary Researcher

Jennifer Hall
Ph.D. Candidate
Faculty of Education
[redacted] [ca](#)

Supervisor

Dr. Christine Suurtamm
Associate Professor
Faculty of Education
[redacted] [ca](#)

Description of Project

As a doctoral candidate in the Faculty of Education at the University of Ottawa, I am conducting a study entitled 'Societal views of mathematics and mathematicians and their impact on children'. The purpose of my study is to investigate elementary students' views of mathematics and mathematicians, and how these views may be impacted by children's media, parents/guardians, and teachers, in order to better understand the complex interplay between outside sources and children's views. I am inviting you to participate in my research study as you are a Grade 4 or Grade 8 teacher.

If you agree to participate, you will take part in an interview about your experiences with mathematics and mathematicians, both as a student and as an adult, as well as your teaching goals and classroom practices in mathematics. This single interview should take approximately one hour to complete and will be conducted in May of 2011 at a mutually acceptable time and location. The interview will be audio-taped to gather information and allow for transcription.

Your participation in this study is entirely voluntary and you may refuse to answer any question(s) or may withdraw at any time without penalty. If you choose to withdraw, all data gathered until the time of withdrawal will be destroyed. Any information you share will remain strictly confidential. If quoted, you will be assigned a pseudonym, and any identifying details will be removed.

Potential benefits of this study include providing insight into children's views of mathematics and mathematicians, and how these views are impacted by outside sources such as media and key adults in their lives. On a personal level, this study may be beneficial to you as it will provide you with the opportunity to reflect upon and share your mathematics experiences in a confidential, non-threatening environment. Reflecting upon your own experiences and those during your teaching of mathematics may also be beneficial to your teaching practices in mathematics.



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This study has very few potential inconveniences or harms associated with it, but may potentially cause you to reflect on mathematics experiences that were unpleasant or upsetting. If this occurs, you may skip such a question or take a break from interviewing before continuing. The likelihood of this occurring is very low.

The results of this study will be used in Jennifer Hall's Ph.D. thesis and further publications and presentations. Hard copies of the data will be stored in a locked filing cabinet in the Pi Lab at the University of Ottawa, whereas electronic files will be password protected; all data will only be accessible to Jennifer Hall and Dr. Christine Suurtamm. The data will be destroyed five years after the completion of Jennifer Hall's Ph.D. thesis.

If you have any inquiries about this study, please contact Jennifer Hall or Dr. Christine Suurtamm at the contact information provided above. If you have any inquiries regarding the ethical conduct of this study, please contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5, (613) 562-5841, or ethics@uottawa.ca.

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Informed Consent for Participants

I have read the above information. I understand the purpose of this study and what is required of me, and I agree to participate. I have been assured that my participation is voluntary and that my identity will remain confidential. I am aware that I am free to withdraw from the study at any time without any negative consequences.

I am aware that any inquiries about the research study should be addressed to the Primary Researcher, Jennifer Hall [REDACTED] a), or her Supervisor, Dr. Christine Suurtamm [REDACTED] b).

I am aware that if I have any concerns regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5, (613) 562-5841, or ethics@uottawa.ca.

I am aware that there are two copies of the consent form, one of which is mine to keep.

Participant's signature: _____ Date: _____

Researcher's signature: _____ Date: _____

Appendix Q: Television Show Viewing Protocol

TV Show Viewing Protocol

Show:

Episode Name:

Season/Episode Number:

Date Episode Broadcast:

Length of Show:

Summary:

Appendix R: Movie Viewing Protocol

Movie Viewing Protocol

Movie:

Year:

Length of Movie:

Summary:

Appendix S: Video Game Questionnaire

Welcome!

Research Study: Societal Views of Mathematics and Mathematicians and their Impact on Children

Researcher:

Jennifer Hall
Ph.D. Candidate, Mathematics Education, Faculty of Education, University of Ottawa

Supervisor:

Dr. Christine Suurtamm
Associate Professor, Faculty of Education, University of Ottawa

The Study: You are invited to participate in the abovementioned research study conducted by Jennifer Hall. The purpose of the study is to investigate elementary students' views of and experiences with mathematics and mathematicians, and the ways that their views may be impacted by parents' views, teachers' views, and popular media representations.

Part of the study includes an investigation of representations of mathematics and mathematicians in children's media, including video games. A list of top video games played by the students in the study (Grade 4 and 8 students from Ontario) has been compiled based on students' responses to an online questionnaire.

Participation: Your participation in the study would consist of completing a brief questionnaire (which follows this consent form) about your experiences with the 'top' video games and your understandings of the mathematical content therein. The questionnaire should take approximately 10 minutes to complete.

Risks: There are no risks associated with your participation in this study.

Benefits: Your participation in this study will help Jennifer Hall to garner a better understanding of mathematical content in video games played by elementary students.

Confidentiality and Anonymity: Any information you share will remain strictly confidential. The questionnaire data will be used only for Jennifer Hall's thesis and any related publications and presentations, and your confidentiality will be protected. Anonymity will be protected by completing the questionnaire without providing any personally-identifying information. Please note that, since the survey is hosted through the American company SurveyMonkey, the data could be subject to the U.S. Patriot Act, which allows American authorities access to it.

Conservation of Data: The questionnaire data collected will be stored on a password-protected server in the mathematics education lab at the University of Ottawa; on this server, the data pertaining to this project are only accessible to Dr. Suurtamm and Jennifer Hall.

Voluntary Participation: You are under no obligation to participate and if you choose to participate, you can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. If you choose to withdraw, your data will be retained in the database, given the anonymous nature of the questionnaire.

Questions: If you have any questions about the study, you may contact Jennifer Hall or her supervisor, Dr. Christine Suurtamm.

Video Games and Mathematics

If you have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5 Tel.: (613) 562-5387 Email: ethics@uottawa.ca

Acceptance: By clicking on the 'Next' button below, you are agreeing to participate in the above research study conducted by Jennifer Hall of the Faculty of Education at the University of Ottawa, whose research is under the supervision of Dr. Christine Suurtamm.

Please print a copy of this consent form for your personal records.

Thank you for your participation!

Video Games and Mathematics

Demographic Information

1. I am a

- ☐ Woman
- ☐ Man

2. Age:

- ☐ Under 18
- ☐ 18-24
- ☐ 25-29
- ☐ 30-34
- ☐ 35-39
- ☐ Over 39

Video Games and Mathematics

Mathematical Background

On this page, I am asking for information about your post-secondary education and occupation so that I can better understand your background with mathematics.

3. What post-secondary education have you completed? Please list any diplomas or degrees completed, as well as the field of study (e.g., B.Sc., Chemistry).

4. What is your current occupation?

Video Games and Mathematics

Experience with the 'Top' Video Games

Based on the Grade 4 and Grade 8 student participants' responses to an online questionnaire, a list of their top choices of video games has been compiled.

These games are:

- Call of Duty: Black Ops
- Call of Duty: Modern Warfare
- Call of Duty: Modern Warfare 2
- Lego Batman
- Mario Kart
- NHL 11
- Super Mario Bros.

In the following pages, you will be asked about your familiarity in playing each game. If you have never played a certain game, you will be skipped ahead to the questions about the next game. If you have experience playing the game, you will then be asked further questions about the mathematical content and skills related to the game.

Mathematical Content: Mathematics that you see in the game itself, such as numbers, graphs, and tables.

Mathematical Skills: Mathematics-related skills that you need to play the game, such as logic, calculation capabilities, and the ability to read or analyze graphs or tables.

Video Games and Mathematics

Experience with Call of Duty: Black Ops

5. How often have you played Call of Duty: Black Ops?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in Call of Duty: Black Ops

6. Do you see any mathematical content (e.g., numbers, graphs) in Call of Duty: Black Ops? If so, please describe.

7. Do you use any mathematical skills (e.g., logic, calculations) when you play Call of Duty: Black Ops? If so, please describe.

Video Games and Mathematics

Experience with Call of Duty: Modern Warfare

8. How often have you played Call of Duty: Modern Warfare?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in Call of Duty: Modern Warfare

9. Do you see any mathematical content (e.g., numbers, graphs) in Call of Duty: Modern Warfare? If so, please describe.

10. Do you use any mathematical skills (e.g., logic, calculations) when you play Call of Duty: Modern Warfare? If so, please describe.

Experience with Call of Duty: Modern Warfare 2

11. How often have you played Call of Duty: Modern Warfare 2?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in Call of Duty: Modern Warfare 2

12. Do you see any mathematical content (e.g., numbers, graphs) in Call of Duty: Modern Warfare 2? If so, please describe.

13. Do you use any mathematical skills (e.g., logic, calculations) when you play Call of Duty: Modern Warfare 2? If so, please describe.

Experience with Lego Batman

14. How often have you played Lego Batman?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in Lego Batman

15. Do you see any mathematical content (e.g., numbers, graphs) in Lego Batman? If so, please describe.

16. Do you use any mathematical skills (e.g., logic, calculations) when you play Lego Batman? If so, please describe.

Experience with Mario Kart

17. How often have you played Mario Kart?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in Mario Kart

18. Do you see any mathematical content (e.g., numbers, graphs) in Mario Kart? If so, please describe.

19. Do you use any mathematical skills (e.g., logic, calculations) when you play Mario Kart? If so, please describe.

Experience with NHL 11

20. How often have you played NHL 11?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in NHL 11

21. Do you see any mathematical content (e.g., numbers, graphs) in NHL 11? If so, please describe.

22. Do you use any mathematical skills (e.g., logic, calculations) when you play NHL 11? If so, please describe.

Video Games and Mathematics

Experience with Super Mario Bros.

23. How often have you played Super Mario Bros.?

- ☐ Never
- ☐ Rarely (a few times in total)
- ☐ Sometimes (a few times a month)
- ☐ Often (a few times a week)

Video Games and Mathematics

Math in Super Mario Bros.

24. Do you see any mathematical content (e.g., numbers, graphs) in Super Mario Bros.? If so, please describe.

25. Do you use any mathematical skills (e.g., logic, calculations) when you play Super Mario Bros.? If so, please describe.

Video Games and Mathematics

Thank you!

Thank you very much for completing the questionnaire. I appreciate your assistance with my research project.

If you are willing to allow me to watch you play any of the games listed in this questionnaire, please email me at [REDACTED] and we can set up a time to meet.

Thank you!

Appendix T: Video Game Observation Protocol

Video Game Observation Protocol

Participant:

Gender/Age:

Post-Secondary Education:

Occupation:

Game:

Platform:

Experience with Game (years, frequency):

Observations (game content, skills, etc.):

Appendix U: Reading Protocol

Reading Protocol

Book Title:

Author:

Number in Series:

Year:

Number of Pages:

Summary: