

Chapter 10

Gendered? Gender-Neutral? Views of Gender and Mathematics Held by the Canadian General Public

Jennifer Hall

Abstract By investigating the general public's views, we can better understand the cultural milieu in which mathematics teaching and learning take place. In this study, part of an international research project, I investigated the Canadian general public's views of gender and mathematics. Using a brief survey, people on the street and in public spaces in four demographically diverse locations in the Canadian province of Ontario were asked their views on the topic. The findings suggest reasons to be both cautiously optimistic and concerned. While the most common response to the questions examined typically was to see no gender difference, more participants held a gendered view (typically privileging boys) than a gender-neutral view. Interestingly, no age group-related differences occurred in response patterns, but gender-related differences in response patterns were evident.

Keywords Mathematics education • Gender • General public • Beliefs/views

Introduction

Investigating the general public's views about mathematics is essential in order to garner an understanding of the social milieu in which mathematics teaching and learning occur. Unfortunately, as argued by Leder and Forgasz (2010), “attempts to measure directly the general public's views about mathematics, its teaching and its impact on careers are rare” (p. 329). While several studies exist regarding people's views of mathematics, these studies are often conducted with select populations,

J. Hall (✉)
Monash University,
Room 406, Building 6, Clayton Campus, 29 Ancora Imparo Way, Clayton, VIC 3800,
Australia
e-mail: jennifer.hall@monash.edu

such as elementary, secondary and tertiary students (e.g. Hall, 2013; Mendick, Epstein, & Moreau, 2007; Morge, 2006; Towers, Takeuchi, Hall, & Martin, 2015). Only in a few known studies have researchers investigated this topic with the general public, defined as “ordinary people, especially all the people who are not members of a particular organization or who do not have any special type of knowledge” (The general public, 2016). For example, researchers in the United Kingdom (Lim, 1999; Lim & Ernest, 1999, 2000) explored the general public’s images of and opinions about mathematics, in a project involving approximately 550 participants ages 17 and above. Overall, the most negative views of mathematics were found in the youngest group of participants (17–20 years of age) and in university students who were not mathematics majors. Encouragingly, the majority of participants disagreed with the stereotype that mathematics is a male domain. However, the majority of the participants also agreed that mathematics is a difficult subject, only for a select few. Lim and Ernest concluded that the adults’ views were primarily influenced by their school mathematics experiences. More recent research (Lucas & Fugitt, 2009), conducted with more than 1,300 participants in the rural Midwestern United States, explored the general public’s views of mathematics education. The study’s participants tended to hold traditional views, criticizing today’s practices as lacking emphasis on “the basics” and being too focused on technology. Overall, mathematics was seen by the participants as being very important to success in postsecondary education, future careers and everyday life.

Due to concerns about a lack of research in this domain, Leder and Forgasz initiated research in Australia that investigated the general public’s views of mathematics, with a particular focus on gender and mathematics (reported in such publications as Forgasz & Leder, 2011; Forgasz, Leder, & Gómez-Chacón, 2012; Forgasz, Leder, & Tan, 2014; and Leder & Forgasz, 2010, 2011). Using a brief survey, initially conducted on the street and later via Facebook, Leder and Forgasz gathered data from both Australian and international participants. In order to expand the research internationally, a team of researchers was assembled to collect street-level data in a variety of countries. Specifically, street-level data were collected in Australia, Canada, South Korea, Spain and the United Kingdom.¹ The total number of street-level participants in each country is shown in Table 10.1.

Table 10.1 Number of street-level participants in each participating country

Country	Number of participants
Australia	799
Canada	204
South Korea	318
Spain	636
United Kingdom	61

¹These are the countries in which volunteers agreed to collect data.

In this chapter, I discuss findings from my analysis of the street-level data collected in Canada as part of this large international research project.

Context

The data collection for the Canadian sample took place in the province of Ontario, which is located in Central Canada and contains nearly 40% of the country's population (Statistics Canada, 2015a). In Canada, education falls under the purview of individual provinces and territories (i.e. no national curriculum exists). Ontario's mathematics curriculum (Ontario Ministry of Education, 2005a, 2005b, 2007) addresses a wide variety of mathematical topics in each grade level, and emphasis is placed on diversity in both teaching practices and assessment types. The use of mathematical tools is encouraged, both in class and on large-scale provincial assessments 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" (2005a, p. 3).

Ontario students are required to participate in large-scale provincial assessments of mathematics in Grades 3, 6 and 9. These assessments are created and conducted by the Education Quality and Accountability Office (EQAO). The EQAO assessments involve a variety of question types and address the provincial curriculum. My analysis (Hall, 2012) of five years of EQAO data showed that no statistically significant gender differences existed at any grade level in terms of mathematics achievement. In contrast, as demonstrated by my analysis of data from the questionnaires that accompany the assessments, gender differences existed with regard to affective factors. Namely, across all grade levels and across the five years of data examined, a statistically significantly higher percentage of boys, compared to girls, reported liking mathematics and being good at it.

In Ontario, students are required to take three mathematics courses during high school, between Grade 9 and Grade 12 (Ontario Ministry of Education, 2016). At the Grade 12 level, when most students have completed their required mathematics courses, boys have a higher proportion of mathematics courses in their timetables than girls do (Hall, 2012). Additionally, boys are the majority of students in five of the six Grade 12 mathematics courses offered (Hall, 2012). These gender differences persist at the university level, where women are the minority in mathematical fields from the bachelor's to doctoral degree level. Notably, the proportion of women in mathematical fields of study at the bachelor's and master's degree levels has been declining since the early 1990s (Statistics Canada, 2010a, 2010b, 2015b, 2015c).

Theoretical Framework

This study was guided by a social constructivist and feminist epistemological stance, in which gender is viewed as being socially constructed, as well as historically and culturally situated. As suggested by Simon (1995), "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” (p. 115). This learning process applies to learning mathematics itself, learning ideas about mathematics (e.g. stereotypes about mathematics and mathematicians) and learning about gender. My views are consistent 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). In this definition, the roles that the broader society and culture play in policing behaviours presumed to be “gender-appropriate” are highlighted, which is particularly relevant in mathematics, a field historically viewed as a male domain.

In alignment with scholars such as Butler (1990, 1999) and Fausto-Sterling (2000), I view both gender and sex as performative social constructions that fall on a spectrum, rather than into binary categories. That said, I support the lead researchers’ decision to offer “boys” and “girls” as responses and “men” and “women” as coding categories – both in terms of a pragmatic decision and in terms of reflecting current society, in which binaried representations and categorizations are the norm. Gender tends to be a particularly salient aspect of schooling (e.g. grouping students by gender, girls’ and boys’ teams). While there have been some recent shifts in societal perceptions of gender, our world is still very much gender binaried in most settings. Thus, by having binary categories in the gender-related questions on the survey and analysing the data by binary groups (i.e. men and women), I am reflecting the current cultural milieu in which the participants live. I recognize, however, that in so doing, I may be excluding and/or misrepresenting those individuals whose gender identities do not align with binary categories.

Methodology

As this research is part of a larger, international project instigated by Helen Forgasz and Gilah Leder of Australia, the data collection instrument and methods of data collection followed the guidance of the principal investigators. In the subsequent sections, I begin by describing the data collection instrument and process of data collection. Then, I provide demographic information about the study’s participants. I conclude by discussing the methods by which the data were analysed.

Data Collection Instrument

Data were collected using a survey, designed by Forgasz and Leder, comprised of 14 questions. Of the 14 questions, two addressed the participant’s school mathematics experiences (i.e. liking mathematics and perceiving themselves as good at mathematics), three addressed mathematics education generally and the remaining

nine questions focused on gender and mathematics (or related fields). The three “general” mathematics education questions addressed (1) whether participants thought the teaching of mathematics had changed since they were in school, (2) whether participants thought students should study mathematics when it was no longer compulsory and (3) whether participants thought studying mathematics was important for getting a job.

The nine gender-focused questions addressed the participants’ views of who was better in mathematics, girls or boys – both their own stance and their perceptions of teachers’ and parents’ views. Participants were also asked to reflect on whether there had been a change over time in terms of who was better at mathematics, girls or boys, and whether it was more important for girls or boys to study mathematics. The other gender-focused questions addressed the participants’ views of boys’ and girls’ suitability for jobs in mathematics-related fields (science and the computer industry) and abilities with mathematical tools (computers and calculators). All of the gender-focused questions were worded with “girls or boys” at the end of the question (e.g. “Who do teachers believe are better at mathematics, girls or boys?”). Note that this ordering disrupts the commonly used ordering of “boys and/or girls”, which unconsciously privileges boys. In the reporting of findings from this study, I consciously use varied orders when discussing gendered groups, as, like Thorne (1993) in her landmark book, *Gender Play: Girls and Boys in School*, I want “both genders to be fully in view” (p. 8).

In addition to the 14 topical survey questions, demographic information about the participant’s gender, age (under 20, 20 to 39, 40 to 59 and 60 and older) and home language (English or another language) was collected. Participants had to be at least 18 years of age (i.e. adults under Canadian law) to take part in the study. In addition to responding to the provided questions, participants were offered the chance at the end of the survey to provide further comments.

Data Collection

Data were collected in the Canadian province of Ontario between December of 2012 and August of 2013. Four locations were selected based on their varied demographic make-up, herein referred to by the pseudonyms of Rochester, Thomasville, Upton and Smithburg. To increase the ease of following the findings, I have created pseudonyms that begin with the same letter as each location’s demographic classification (e.g. Rochester = rural). Information about each location is shown in Table 10.2.

Table 10.2 Demographic information about the data collection sites

	Rochester	Thomasville	Smithburg	Upton
Classification	Rural	Town	Suburban	Urban
Part of Ontario	Southwestern	Central	Eastern	Eastern
Population	3,000	25,000	110,000	900,000

Data collection took place in grocery stores in Rochester and Smithburg, in a community centre in Thomasville and on a downtown street in Upton. In each location, permission to conduct the research was obtained from the appropriate individuals (e.g. store managers), in addition to the Research Ethics Board permission granted by the Australian and Canadian universities associated with the research. In Thomasville, the initial data collection site, I collected the data by myself, which resulted in an inefficient process (seven hours to complete approximately 50 surveys). That is, while I was speaking to a participant, many other potential participants went by. Thus, for the other three sites, I was assisted by a friend or family member in order to make the data collection process more efficient; in each instance, the requisite number of surveys [~50, the minimum number deemed acceptable for chi-square analyses, as per Muijs' (2004) recommendations] was collected in two hours. We are all young women, so it could be construed that having a woman asking questions about gender and mathematics (a field that has historically been dominated by men) may bias the participants' responses. However, Schaeffer, Dykema and Maynard's (2010) findings from their review of several studies indicated that gender-related effects of the interviewer on the participants' responses are typically minimal or nonexistent. Indeed, when collecting data, we did not feel as though the participants "held back" or otherwise altered their responses because they were being interviewed by a woman about gender and mathematics (e.g. explicitly sexist comments, in boys'/men's favour, were provided).

In each location, data collection occurred on the weekend or on a public holiday, in an attempt to maximize the number and diversity of passersby. Passersby who appeared to be in a hurry, who had small children with them and/or who were wearing headphones were not approached, after initial rejections from these populations and/or difficulty when conducting the survey (in the case of participants with small children). In each instance, the interviewer would approach a passerby, introduce herself and ask if the person would be willing to take part in a brief survey. Participants were then asked if they agreed to be audiotaped; if not, answers were recorded on a hard copy of the survey. In nearly all cases, participants agreed to be audiotaped, particularly upon learning that the purpose of audiotaping was to assist in the quality of data collected and subsequently analysed. Participants were also assured by the fact that I would be the only person to access the audio tapes. Prior to being asked the gender-related questions, participants were informed that, although the questions were worded in a binary manner (i.e. girls or boys), they were welcome to answer as they wished (e.g. "They are equal"). If participants inquired further about the research project, a handout was provided with more information, including a description of the larger project and contact information for the lead researchers, Forgasz and Leder. The majority of participants did not receive a handout.

Participants

In total, 204 people participated in this research project: 52 from Rochester, 53 from Thomasville, 50 from Smithburg and 49 from Upton. In most cases, participants took part in the interviews individually. The exceptions occurred in cases such as a

Table 10.3 Participants in each location, by age group

	Age group			
	Under 20	20–39	40–59	60 and older
Rochester	7.7%	28.8%	25.0%	38.5%
Thomasville	0.0%	49.1%	20.8%	30.2%
Smithburg	0.0%	26.0%	40.0%	34.0%
Upton	0.0%	67.3%	18.4%	14.3%
All participants	1.5%	43.1%	26.0%	29.4%

couple or parents with an adult child agreeing to participate. In total, 17 pairs and two trios completed the interviews, resulting in 40 of the 203 participants (19.6%) completing the survey in a nonindividual situation. In these cases, I attempted to alter the order in which the participants responded, to get a better sense of each participant's individual views, particularly if I noticed a trend of the second respondent simply agreeing with the first respondent's answers, rather than voicing a unique opinion and/or explanation.

In each location, more women than men took part, although the participants were more gender-balanced in Upton and Smithburg (55.1% and 52.0% women, respectively) than in Rochester and Thomasville (67.3% and 62.3% women, respectively). Overall, 59.3% of the participants were women.

Interesting variations in age distribution occurred across the data collection sites, as depicted in Table 10.3 (Percentages apply to each row).

Understandably, few participants in the “under 20” (i.e. 18–19 years of age) age group were involved in the study. Besides the small age range, we may have missed approaching potential participants due to our perceptions of their age: If we thought that a passerby appeared younger than 18 years of age, we would not approach her/him. The high proportion of participants aged 20–39 in Thomasville may be explained by the number of families with children who use the community centre (the data collection site), while the high proportion of participants aged 20–39 in Upton may be explained by the proximity of the street (the data collection site) to postsecondary institutions and neighbourhoods where many young adults live.

With regard to linguistic diversity, great variations occurred across the locations, reflecting their demographic characteristics. In Rochester, a rural town of 3,000 people with very little ethnic diversity, only 4 of the 52 participants (7.7%) reported speaking a language other than English at home. In contrast, in Thomasville, a larger and rapidly expanding town (current population of 24,000 people; the population has doubled in the past five years) located within commuting distance of a large, diverse city, 11 of the 53 participants (20.8%) reported speaking a non-English language at home. Notably, in these two locations, both of which are located in Central/Southwestern Ontario, a wide variety of languages (e.g. German, Tagalog) was reported. In contrast, most of the participants in Upton and Smithburg who reported speaking a non-English language at home spoke French. In Upton, 14 of the 49 participants (28.6%) reported speaking a language other than English at home, compared to 33 of the 50 participants (66.0%) in Smithburg. These findings are not surprising, given that both centres are located in Eastern Ontario (Smithburg is east of Upton), and the primarily French-speaking province of Quebec is located east of Ontario.

Data Analysis

Using the audio or written recordings, the participants' responses to the questions were coded using categories (e.g. "boys", "girls", "same", "don't know" and "depends" for the gender-focused questions) provided by the lead researchers, in order to allow for international comparisons. These data were analysed using descriptive statistics (e.g. counts, percentages). Due to the low number of "don't know" and "depends" responses, these categories were combined into a single "unsure/ambivalent" category.

Chi-square tests for independence were performed in order to determine if there were statistically significant differences (at the $\alpha = 0.05$ level) in the ways that participants' responses were distributed by gender and age group across the response categories. Since there were only three participants in the "under 20" age category, this category was combined with the "20–39" age category, thus resulting in an "18–39" age category. This combined category was used in the chi-square analyses by age group. Hence, the age group categories used in the analysis were "18–39", "40–59" and "60 or older".

If participants provided further explanation for their responses, these comments were transcribed and analysed using emergent coding. That is, the responses for each question were examined through multiple readings to obtain a sense of the data, and then categories were created and used to code the responses.

Findings

For the purposes of this chapter, I focus on the two questions about the participants' school experiences, in order to provide a clearer profile of those who took part in the research, and the five questions that specifically related to gender and mathematics (as opposed to mathematics education in general, electronic tools or related careers, such as being a scientist). Findings are presented for each selected question in the following sections.

Q2: When you were at school, did you like learning mathematics?

Just over half of the participants (54.4%) reported that they enjoyed learning mathematics while they were in school, compared to 33.3% who reported disliking mathematics. Only 12.3% of the respondents reported feeling ambivalent toward mathematics. Unsurprisingly, the explanations provided for positive or negative feelings toward mathematics often related to how strong or weak the participants felt that they were in mathematics. Other reasons provided for liking

Table 10.4 Response distribution by gender for Q2

Group	Like	Dislike	Ambivalent
Men	68.7%	21.7%	9.6%
Women	44.6%	41.3%	14.0%

mathematics included finding the subject interesting and “real world” applicable, as well as appreciating the logic, order and “black and white” nature (i.e. only one right answer) of mathematics. One participant (P41, Upton, man, 18–39) outlined his fascination with finding mathematics in the real world thusly: “I found them [mathematical concepts] amazing and loved that they weren’t just made up but also noticeable in nature”. Participants who disliked mathematics described it as being boring, reported having poor teachers and labelled themselves as “language people”. One participant (P38, Rochester, woman, 18–39) expressed her distaste by simply exclaiming, “Math is dumb!” Those who reported being ambivalent toward mathematics often provided an explanation that related to different feelings for different types of mathematics. For example, one participant (P10, Thomasville, woman, 60 or older) stated, “I enjoyed geometry and stuff, but I didn’t enjoy algebra”.

Chi-square analyses of the responses to this question revealed statistically significant differences in the response distributions by gender ($\chi^2 = 11.708, p = 0.003$) but not by age group ($\chi^2 = 2.117, p = 0.714$). In Table 10.4, the spread of the responses by the gender of the participants is shown.

As shown in Table 10.4, the men who participated in the study reported holding far more positive views of mathematics than did the women who participated in the study. More than two-thirds of men reported liking mathematics as students, compared to less than half of the women. While similar percentages of women and men reported feeling ambivalent, nearly twice as many women as men reported disliking mathematics as students. Such findings are not surprising, given the wealth of literature (e.g. Hall, 2012; Lupart, Cannon, & Telfer, 2004) reporting gender differences in boys’/men’s favour with regard to feelings toward mathematics.

Q3: Were you good at mathematics?

As discussed, reports of liking mathematics were often linked to reports of being good at mathematics. Consequently, it follows that a similar proportion of participants (52.9%) reported being good at mathematics. However, participants who felt they were average or not good at mathematics were more evenly distributed (20.1% and 27.0%, respectively) than the “dislike” or “ambivalent” responses to the prior question. Explanations for being good at mathematics primarily related to school grades, although a few participants provided other evidence, such as working in a mathematics-focused field, being in gifted classes and understanding mathematics quickly.

Table 10.5 Response distribution by gender for Q3

Group	Strong	Weak	Average
Men	69.9%	13.3%	16.9%
Women	41.3%	36.4%	22.3%

Chi-square analyses of the responses to this question again revealed statistically significant differences in the response distributions by gender ($\chi^2 = 18.063$, $p < 0.001$) but not by age group ($\chi^2 = 4.837$, $p = 0.304$). Given the links between liking mathematics and perceiving oneself to be good at mathematics, this finding is not surprising. In Table 10.5, the spread of the responses by the gender of the participants is shown.

As shown in Table 10.5, the vast majority (nearly 70%) of the men in the study felt that they had been strong mathematics students. The remaining men were distributed fairly evenly between “weak” and “average”, with the fewest number of respondents reporting that they were weak students. This distribution was in stark contrast to the responses from women: Nearly as many women reported being weak students as being strong students (approximately two-fifths in both cases). While these claims were often substantiated by reports of poor mathematics marks or placement in “low” streams (e.g. “basic”, “workplace”) of mathematics classes, it is possible that the men in the study may have over-reported their abilities in the subject area. Reports of boys’ and men’s overconfidence in mathematics are plentiful in the extant literature (e.g. Bench, Lench, Liew, Miner, & Flores, 2015; Dahlbom, Jakobsson, Jakobsson, & Kotsadam, 2011; Sadker & Sadker, 1994).

Q6: Who are better at mathematics, girls or boys?

Encouragingly, the most common response (37.3%) was that there were no gender differences in mathematics ability. However, this response was only slightly more common than believing that boys are better at mathematics (31.9%). Although a substantial proportion of participants reported that girls are better at mathematics (20.6%), these responses were only two-thirds the number of those who selected boys. In total, over half of the participants held some sort of gendered stance for this question. Few participants (10.3%) reported holding an unsure or ambivalent stance on this topic.

Participants who claimed that there were no gender differences tended to provide an explanation relating to the notion of everyone being equally capable at mathematics. For instance, one participant argued, “Men and women are equal and have the same brain power” (P51, Thomasville, woman, 18–39). Explanations for girls’ mathematical superiority often related to girls being stronger students overall, whereas explanations for boys’ mathematical superiority tended to relate to innate ability (“mathematical nature”). An example of a comment about the latter is: “I think men have more of a capacity to take that in – math – They’re probably better

than females” (P2, Smithburg, man, 60 or older). Related, the stereotypical notion of girls being better at language arts and boys being better at mathematics was discussed.

Chi-square analyses of the responses to this question revealed no statistically significant differences in the response distributions by gender ($\chi^2 = 3.037, p = 0.386$) or age group ($\chi^2 = 11.402, p = 0.077$). Thus, regardless of gender or age group, substantial proportions (approximately 20–40%) of the respondents reported (a) a gender-neutral view, (b) a view of girls as superior or (c) a view of boys as superior, compared to very few participants with an unsure or ambivalent viewpoint.

Q7: Do you think this has changed over time?

Participants’ views were quite mixed (40.2% agreed and 44.6% disagreed), which may perhaps be indicative of different interpretations of the question. Less than one-sixth (15.2%) of the participants reported being unsure or ambivalent about this question. Of the participants who either agreed or disagreed, some participants’ explanations appeared to indicate that they thought the question referred to ability, whereas others’ explanations indicated understanding the question as referring to achievement. In the former cases, participants would explain that girls and boys have always been equally capable of doing mathematics but that societal factors may have held girls back (e.g. sexist teachers, stereotypes). For example, one participant posited that:

It’s not a problem about whether or not boys are better at math than girls; it’s a problem of whether or not boys are *encouraged* to be better at math than girls. So, I hesitate to say that, yeah, it has changed. I think what has changed is the perception. Definitely, it’s okay now for girls to be good at math and sciences, whereas perhaps 30 years ago, back when I was in high school, it wasn’t necessarily perceived that way. If you were a girl and good in math or sciences, you were some kind of grind² and you weren’t going to get yourself a husband. [Laughter] (P16, Upton, man, 40-59, emphasis in original)

In the case of achievement differences, participants stated that boys used to do better at mathematics but that girls now do equally as well (or, in some cases, better), since they have more opportunities. Participants’ discussions often related to the greater proportion of women enrolled in higher education now, compared to in the past: “Girls are encouraged to take math more than they used to just because of the job situation and they’re allowed to go on to university, so they get to take math more” (P37, Smithburg, woman, 40–59).

Chi-square analyses of the responses to this question revealed no statistically significant differences in the response distributions by gender ($\chi^2 = 1.384, p = 0.709$) or age group ($\chi^2 = 9.962, p = 0.126$). Thus, the responses for these subgroups were distributed similarly across the response categories, with large proportions of

²According to Urban Dictionary (www.urbandictionary.com), the term “grind” is slang typically used to refer to a group of lesbians.

respondents (approximately 40% in each case) selecting “agree” or “disagree”. As discussed, these mixed views are arguably more related to different interpretations of the question (ability vs. achievement) than differences in views.

Q8: Who do parents believe are better at mathematics, girls or boys?

While the participants’ views of parents’ beliefs about gender and mathematics were quite mixed, the most common response was to purport that parents believe that boys are better than girls at mathematics (30.9%). These participants argued that parents held these views because they believed the stereotypes about gender and mathematics. Nearly as many participants (27.9%) argued that parents held gender-neutral views of their children and mathematics. As with the previous question, the least common gendered view was that parents believed that girls were better at mathematics (21.1%). Again similar to the previous question, one-fifth (20.1%) of the participants reported being unsure or ambivalent about this question. These participants often explained that they either did not have children or that their children were adults.

Such personal “evidence” was often provided, like the following elaboration on an “unsure” response: “My family is all girls, so there was no comparison group” (P44, Upton, woman, 18–39). This comment implies that if there had been boys in the participant’s family, she would have been able to answer the question about parents’ views in general. This type of extrapolation, from a specific personal example (e.g. family, experience in school) to the entire population, was commonly seen for the explanations for the answers to many of the questions in this study, indicating flawed logic (i.e. anecdotal evidence presented as scientific evidence) on the part of many participants. Across all the questions in the survey, very few participants referred to having read/heard about the topic from a broader, more scientific source, such as a news broadcast or article. Paulos (1988) argues that such reasoning is indicative of innumeracy, as “innumerate people characteristically have a strong tendency to personalize – to be misled by their own experiences” (p. 6).

Chi-square analyses of the responses to this question revealed statistically significant differences in the response distributions by gender ($\chi^2 = 11.778, p = 0.008$) but not by age group ($\chi^2 = 1.330, p = 0.970$). In Table 10.6, the spread of the responses by the gender of the participants is shown.

As evidenced by the data in Table 10.6, approximately the same proportion of men felt that parents held gendered views in favour of girls or in favour of boys. This is a very different distribution from the responses from women, where nearly

Table 10.6 Response distribution by gender for Q8

Group	Girls	Boys	Same	Unsure or ambivalent
Men	30.1%	34.9%	18.1%	16.9%
Women	14.9%	28.1%	34.7%	22.3%

twice as many felt that parents held gendered views in boys' favour compared to girls' favour. Notably, for both women and men, more people selected a gendered view in boys' favour rather than girls' favour. Another interesting comparison occurs for the "same" responses: More than one-third of women participants thought that parents held gender-neutral views, whereas less than one-fifth of men participants reported this stance.

Q9: Who do teachers believe are better at mathematics, girls or boys?

In contrast to perceptions of parents, the most common perception of teachers was that they held gender-neutral views of their students and mathematics (33.8%). Participants explained that teachers would have more knowledge about this topic than the "average person", plus they would have exposure to many children doing mathematics, so would form a less biased view than parents (who, the participants argued, may base their opinions solely on their own children – which, as mentioned, was indeed the case for some of the participants in the study). As one participant (P46, Smithburg, man, 40–59) suggested, "Teachers don't pick a side... They're neutral... They're always looking to help somebody who's struggling". Perceptions of teachers holding gendered views were fairly equally distributed: 18.6% of participants reported boys, compared to 20.1% reporting girls. Explanations provided were similar to those discussed with regard to being better at mathematics in general, such as arguments about boys' "natural" abilities with mathematics and girls' preferences for language arts. A large proportion of the participants (27.5%) reported being unsure about teachers' feelings. These participants typically explained that they had no contact with teachers at the present time, either because they did not have school-aged children or because they did not know any teachers personally. Such responses are again indicative of participants extrapolating their personal experiences to make a general claim.

Chi-square analyses of the responses to this question revealed no statistically significant differences in the response distributions by gender ($\chi^2 = 1.427, p = 0.699$) or age group ($\chi^2 = 7.352, p = 0.290$). Hence, the most common perception, regardless of gender or age group, was to believe that teachers hold gender-neutral views of children's mathematics abilities. However, substantial proportions argued that teachers held gendered views, with responses fairly evenly distributed between "girls" and "boys" responses (approximately 20% for each category).

Q11: Is it more important for girls or boys to study mathematics?

Of all the questions regarding gender and mathematics, this question had the most consistency in the participants' responses: 94.6% of the participants argued that it was equally important for boys and girls to study mathematics, an encouraging

finding. In fact, many participants were incredulous that the survey would even include such a question. Only 2.5% of participants reported a gendered stance (0.5% for girls; 2.0% for boys). Additionally, only 3.0% reported being unsure or ambivalent toward this question. The overwhelmingly most common explanation provided was that everyone needs to know mathematics – for school, everyday life and future occupations. Some participants also discussed how mathematics was helpful to thinking in a more general sense: “Studying and learning math helps develop thinking and reasoning processes that contribute to the overall ability to make decisions” (P52, Townsville, woman, 20–39).

Chi-square analyses of the responses to this question revealed no statistically significant differences in the response distributions by gender ($\chi^2 = 2.311$, $p = 0.510$) or age group ($\chi^2 = 5.741$, $p = 0.453$). Thus, the vast majority of respondents argued that it was equally important for girls and boys to study mathematics, a heartening finding.

Conclusions

The findings from my analysis of data from over 200 participants from the Canadian province of Ontario suggest that gendered views of mathematics (and of others’ views of mathematics) tend to be the norm. Although “no difference” was typically the modal category for the questions examined, the combination of “girls” and “boys” categories (i.e. the gendered responses) was almost always a higher proportion. The only question for which the majority of participants reported holding a gender-neutral view (rather than a gendered view) addressed the importance of studying mathematics, for girls and boys. For the questions regarding superiority in mathematics, more participants held a gendered view (i.e. selecting either boys or girls as their response) than a gender-neutral view. In most cases involving gendered views, more participants selected boys than girls, indicating a more favourable view of boys and mathematics. This finding suggests that gender stereotypes regarding mathematics persist, even in a very gender-equitable society like Ontario, wherein equity is inscribed in the mathematics curriculum.

Similar outcomes occurred in a study in the United Kingdom, where Lim and Ernest (1999) found that 20% of their participants subscribed to the stereotype that mathematics is a male domain. Additionally, in the responses to this questionnaire by Canadian Facebook participants (35 participants, of whom 62.9% were women, which is a similar gender distribution to my sample) in this international gender and mathematics study (Forgasz et al., 2014), response patterns emerged that were similar to those found with my street-level sample. The modal response for the Facebook participants was to report a gender-neutral view of girls’ and boys’ mathematics abilities, but of the gendered responses, more participants selected “boys”. For the questions about parents and teachers, the Facebook responses had the same modal categories (“boys” and “same”, respectively) as the street-level sample, although the Facebook sample had a far lower proportion of

the participants who reported holding gender-neutral perceptions of parents' views (12.5%, compared to 27.9% in the street-level sample) and who selected "girls" as the response for their perception of teachers' views (8.3%, compared to 20.1% in the street-level sample). Encouragingly, the vast majority of participants in both the Facebook (91.7%) and street-level (94.6%) Canadian samples purported that it was equally important for boys and girls to study mathematics.

When considering the findings by the gender of the participants, statistically significant differences in response distribution only occurred for one of the gender-focused questions, regarding the participants' perceptions of parents' views. In this instance, women participants tended to hold gender-neutral perceptions of parents' views, while men participants tended to think that parents held gendered views (approximately balanced between "boys" and "girls" responses). However, when considering gendered views, twice as many women claimed that parents favoured boys compared to those who thought that parents favoured girls when considering mathematics ability. While it is encouraging that, for the other gender-related questions (general views of ability, views of changes over time, perceptions of teachers' views and the importance of studying mathematics), men and women responded in similar ways, the general response patterns were still troubling, as discussed above. Slightly different patterns were found with Lim and Ernest's (1999) participants, where the men tended to believe that men are better at mathematics while women tended to hold a gender-neutral view of women's and men's abilities. However, it is important to note that these participants were discussing views of adults, while my participants were discussing views of children, which may have altered the response patterns.

Notably, there were no statistically significant differences in response distribution by age group for any of the gender-related questions examined. This was a somewhat surprising finding, given my assumption (and hope) that subsequent generations would become progressively more gender-neutral in their views. However, this assumption/hope is not necessarily supported by research: General research about gendered views provides conflicting results, with some studies supporting my assumption, while others challenge it (Leder & Forgasz, 2011). Varied patterns of age-related views have also been found in studies about gender and mathematics. For instance, in Lim and Ernest's (1999) research, the youngest (17–20 years old) and oldest (50 and older) participants tended to hold less gender-egalitarian views than those in the middle age groups. In an early report (Leder & Forgasz, 2010) on the Australian portion of the large international research project of which my research was a part (i.e. the street-level data), none of the seven questions examined (two questions about the participant's experiences with school mathematics and five questions about gender and mathematics) had any statistically significant differences in response distribution by age group. However, with a larger Australian sample (689, compared to 203 in the early report), including respondents from Facebook, age-related differences in response patterns were found to be present for several questions. Leder and Forgasz (2011) compared "younger" (under 40) and "older" (40 and over) participants' responses, which is a different strategy than I employed when making age-based comparisons.

Nonetheless, of the same questions examined, age-related differences were found with regard to the response distributions for the general question about gendered abilities, the question regarding perceptions of teachers' views and the question regarding perceptions of parents' views but not for the question regarding the importance of studying mathematics. Leder and Forgasz (2011) found that, while the younger participants believed that "parents and teachers were more likely to be more egalitarian, they themselves hold more strongly than those in the older group to the traditional gender-stereotyped view that boys are more suited to and more successful in mathematics than girls" (p. 453), a troubling finding.

The findings from this Canadian research project, while somewhat encouraging, should also raise concerns for those involved in mathematics education. Since the majority of the adults surveyed tended to hold gendered views (with more of these gendered views favourable toward boys than girls), these messages are ostensibly being disseminated to young people, particularly by their parents. Additionally, even in a volunteer-based study like this, which arguably leads to positively skewed results, one-third of the respondents – particularly women – reported disliking mathematics and not doing well in mathematics as students. It is very likely that such negative views and experiences may impact the mathematical interactions that these adults have with children in their lives. In another research project (Hall, 2013), I found that children's views of mathematics are indeed impacted by their parents' views of the subject matter, a finding that is supported by prior research (e.g. Jacobs & Bleeker, 2004; Tiedemann, 2000). Thus, targeting parents' understandings of gender and mathematics, by both the educational system and the media (in which mathematics education researchers can play a key role, in both cases), in both cases, should be a focus. More generally, parents, teachers and – particularly in today's technology-focused world – media all play key socializing roles in children's lives (Arnon, Shamai, & Ilatov, 2008; Roberts & Foehr, 2004), so it is important that mathematics educators strive to target the messages that are being disseminated to children about gender and mathematics so that all children are exposed to positive, gender-neutral messages that encourage positive relationships with mathematics and participation at non-mandatory levels of study.

Looking Ahead

As elaborated earlier, I do not view gender as a binary construct. However, I adhered to the lead researchers' decision to offer binaried options for response and coding categories, for pragmatic reasons, and to reflect a society that continues to be very binaried, particularly in school settings. During data collection, only one participant (representing less than 0.5% of the sample) challenged the "girls or boys" wording of the questions. This participant (P16, Upton, man, 40–59) argued that "I think it's a more nuanced – Your survey seems to be binary, and I think it's a lot more nuanced than that". He suggested that the survey's wording should be changed to better reflect this complexity. During the interview, I agreed with this participant that "it"

(meaning gender) is indeed not a binary and that it is more nuanced than the “girls or boys” options suggest. However, at the time, I was not sure how a survey of the general public on such a topic could be constructed without including binary options as prompts.

Since completing this project, I have spent time pondering what a non-binary “gender and mathematics” survey written for the general public might look like. Guidance is provided by GLTBQIA organizations for wording “gender” questions (i.e. questions about the participant’s gender identity) on surveys (e.g. Kellerman 2016; Miller & Weingarten, 2005), but, to my knowledge, no suggestions exist – particularly within mathematics education – regarding writing survey questions *about* gender. After discussing this topic with a colleague, we have come up with ideas for a parallel survey to the one used in the research reported here. In this proposed survey, all of the questions will be reworded to allow participants complete freedom (without any priming) in their responses regarding gender and mathematics. None of the questions will be worded in such a way that binary categories (i.e. “girls” and “boys”) will be mentioned. For instance, rather than asking “Who are better at mathematics, girls or boys?”, we would ask “Do you think that there are any gender differences in mathematics ability? Please explain”. Using the latter wording, participants would have the freedom to address the same topic in a less-guided manner. Certainly, rewording some of the questions is challenging, but we think, with some creativity, parallels can be found for all the survey’s existing questions.

We believe that conducting such a survey has great potential for shifting the manner in which “gender issues” research in mathematics education is conducted, moving away from the rarely questioned binaries and other issues that are seen in most research of this type. Indeed, analyses of general education publications (Glasser & Smith, 2008) and mathematics education publications (Damarin & Erchick, 2010) highlight common issues: a lack of operational definitions for “sex” and “gender” provided by researchers and the problematic use of these (and related) terms interchangeably. As I have discussed elsewhere (Hall, 2014), I have become particularly cognizant of these issues and strive to write in a manner that aligns with my views about gender (e.g. avoiding “sex” language). Thus, in this reconceptualised survey, we will particularly focus on the language choices provided by the participants in the absence of any examples of “gender” language. Due to the revised wording of the questions, we anticipate that much richer data will be collected, as not only will gendered views be shared, similar to those attained in the current version of the survey, but we will also gain insight into the general public’s use of gendered language when discussing mathematics. Our hope is that this proposed research project will instigate a shift and provide a challenge to the manner in which much “gender issues” research is conducted in mathematics education. While the way forward is uncharted territory, it is also an exciting prospect for a field with a long history.

Acknowledgements I gratefully acknowledge the opportunity provided to me by Helen Forgasz and Gilah Leder in being part of this international research project. I would also like to thank Heather Rogers, Stéphanie Chiasson and Michelle Kania for their assistance with data collection.

This chapter builds on a paper presented at the 38th Conference of the International Group for the Psychology of Mathematics Education (PME 38) and the 36th Conference of the North American Chapter of the Psychology of Mathematics Education (PME-NA 36).

References

- Arnon, S., Shamai, S., & Ilatov, Z. (2008). Socialization agents and activities of young adolescents. *Adolescence*, *43*(170), 373–397.
- Bench, S. W., Lench, H. C., Liew, J., Miner, K., & Flores, S. A. (2015). Gender gaps in overestimation of math performance. *Sex Roles*, *72*(11–12), 536–546. doi:[10.1007/s11199-015-0486-9](https://doi.org/10.1007/s11199-015-0486-9).
- Butler, J. (1990). *Gender trouble: Feminism and the subversion of identity*. New York, NY: Routledge.
- Butler, J. (1999). Subjects of sex/gender/desire. In S. During (Ed.), *The cultural studies reader* (2nd ed., pp. 340–358). London, England: Routledge.
- Dahlbom, L., Jakobsson, A., Jakobsson, N., & Kotsadam, A. (2011). Gender and overconfidence: Are girls really overconfident? *Applied Economics Letters*, *18*(4), 325–327. doi:[10.1080/13504851003670668](https://doi.org/10.1080/13504851003670668).
- Damarin, S. K., & Erchick, D. B. (2010). Toward clarifying the meanings of gender in mathematics education research. *Journal for Research in Mathematics Education*, *41*(4), 310–323. Retrieved from <http://www.nctm.org/publications/journal-for-research-in-mathematics-education/>
- Fausto-Sterling, A. (2000). *Sexing the body: Gender politics and the construction of sexuality*. New York, NY: Basic Books.
- Forgasz, H., Leder, G., & Gómez-Chacón, I. M. (2012). Young pedestrians' gendering of mathematics: Australia and Spain. In J. Dindyal, L. P. Cheng, & S. F. Ng (Eds.), *Mathematics education: Expanding horizons: Proceedings of the 35th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 298–305). Singapore: MERGA.
- Forgasz, H., Leder, G., & Tan, H. (2014). Public views on the gendering of mathematics and related careers: International comparisons. *Educational Studies in Mathematics*, *87*(3), 369–388. doi:[10.1007/s10649-014-9550-6](https://doi.org/10.1007/s10649-014-9550-6).
- Forgasz, H. J., & Leder, G. C. (2011). Mathematics, computers in mathematics, and gender: Public perceptions in context. *PNA*, *6*(1), 29–39. Retrieved from <http://www.pna.es/index2Eng.html>
- Glasser, H. M., & Smith, J. P., III. (2008). On the vague meaning of “gender” in education research: The problem, its sources, and recommendations for practice. *Educational Researcher*, *37*(6), 343–350. doi:[10.3102/0013189x08323718](https://doi.org/10.3102/0013189x08323718).
- Hall, J. (2012). Gender issues in mathematics: An Ontario perspective. *Journal of Teaching and Learning*, *8*(1), 59–72. Retrieved from <http://ojs.uwindsor.ca/ojs/ledy/index.php/JTL>
- Hall, J. (2013). *Societal views of and experiences with mathematics and mathematicians and their influence on elementary students* (Unpublished doctoral dissertation). University of Ottawa, Ottawa, Canada.
- Hall, J. (2014). Unpacking “gender issues” research. *Philosophy of Mathematics Education Journal*, *28*, Article 5. Available at <http://people.exeter.ac.uk/PErnest/pome28/index.html>
- Jacobs, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development*, *2004*(106), 5–21. doi:[10.1002/cd.113](https://doi.org/10.1002/cd.113).
- Kellerman, S. (2016). *How you can make the gender question on an application more inclusive*. Retrieved from <http://itspronouncedmetrosexual.com/2012/06/how-can-i-make-the-gender-question-on-an-application-form-more-inclusive/>
- Leder, G. C., & Forgasz, H. J. (2010). I liked it till Pythagoras: The public's views of mathematics. In L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education: Proceedings of the 33rd Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 328–335). Fremantle, Australia: MERGA.

- Leder, G. C., & Forgasz, H. J. (2011). The public's views on gender and the learning of mathematics: Does age matter? In J. Clark, B. Kissane, J. Mousley, T. Spencer, & S. Thornton (Eds.), *Mathematics: Traditions and new practices: Proceedings of the AAMT-MERGA Conference* (pp. 446–454). Adelaide, Australia: MERGA.
- Lim, C. S. (1999). Using metaphor analysis to explore adults' images of mathematics. *Philosophy of Mathematics Education Journal*, 12, Article 9. Retrieved from <http://socialsciences.exeter.ac.uk/education/research/centres/stem/publications/pmej/pome12/default.htm>
- Lim, C. S., & Ernest, P. (1999). Public images of mathematics. *Philosophy of Mathematics Education Journal*, 11, Article 6. Retrieved from <http://socialsciences.exeter.ac.uk/education/research/centres/stem/publications/pmej/pome11/art6.htm>
- Lim, C. S., & Ernest, P. (2000). A survey of public images of mathematics. *Research in Mathematics Education*, 2(1), 193–206. doi:10.1080/14794800008520076.
- Lucas, D. M., & Fugitt, J. (2009). The perceptions of math and math education in Midville, Illinois. *The Rural Educator*, 31(1), 38–54. Retrieved from <http://www.nrea.net/index.cfm?pid=7925>
- Lupart, J. L., Cannon, E., & Telfer, J.-A. (2004). Gender differences in adolescent academic achievement, interests, values, and life-role expectations. *High Ability Studies*, 15(1), 25–42. doi:10.1080/1359813042000225320.
- Mendick, H., Epstein, D., & Moreau, M.-P. (2007). *Mathematical images and identities: Education, entertainment, social justice*. Swindon, England: Economic and Social Research Council.
- Miller, & Weingarten. (2005). *Creating GLBTQIA-inclusive forms: Suggestions for policy and implementation*. Retrieved from <http://www.glv.org.au/files/CreatingGLBTQIAForms.pdf>
- Morge, S. P. (2006). *College students' beliefs about mathematics, gender, and popular media* (Unpublished doctoral dissertation). University of Indiana, Bloomington, IN.
- Muijs, D. (2004). *Doing quantitative research in education with SPSS*. London, England: SAGE.
- Ontario Ministry of Education. (2005a). *The Ontario curriculum grades 1–8: Mathematics (Revised)*. Toronto, Canada: Queen's Printer for Ontario.
- Ontario Ministry of Education. (2005b). *The Ontario curriculum grades 9 and 10: Mathematics (Revised)*. Toronto, Canada: Queen's Printer for Ontario.
- Ontario Ministry of Education. (2007). *The Ontario curriculum grades 11 and 12: Mathematics (Revised)*. Toronto, Canada: Queen's Printer for Ontario.
- Ontario Ministry of Education. (2016). *What do you need to graduate?* Retrieved from <http://www.edu.gov.on.ca/extra/eng/ppm/graduate.html>
- Paulos, J. A. (1988). *Innumeracy: Mathematical illiteracy and its consequences*. New York, NY: Vintage Books.
- Roberts, D. F., & Foehr, U. G. (2004). *Kids and media in America*. Cambridge, England: Cambridge University Press.
- Sadker, M., & Sadker, D. (1994). *Failing at fairness: How our schools cheat girls*. New York, NY: Touchstone.
- Schaeffer, N. C., Dykema, J., & Maynard, D. W. (2010). Interviewers and interviewing. In P. V. Marsden & J. D. Wright (Eds.), *Handbook of survey research* (2nd ed., pp. 437–470). Bingley, England: Emerald Group.
- Simon, M. (1995). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education*, 26(2), 114–145. doi:10.2307/749205.
- Statistics Canada. (2010a). *Table 477-0013 – University enrolments, by registration status, program level, Classification of Instructional Programs, Primary Grouping (CIP_PG) and sex, annual (number)*, CANSIM (database). Retrieved from <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4770013&&pattern=&stByVal=1&p1=1&p2=-1&tabMod e=dataTable&csid=>
- Statistics Canada. (2010b). *Table 477-0014 – University degrees, diplomas and certificates granted, by program level, Classification of Instructional Programs, Primary Grouping (CIP_PG) and sex, annual (number)*, CANSIM (database). Retrieved from <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4770014&&pattern=&stByVal=1&p1=1&p2=-1&tabMod e=dataTable&csid=>

- Statistics Canada. (2015a). *Table 051-0001 – Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (persons unless otherwise noted)*, CANSIM (database). Retrieved from <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0510001&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=>
- Statistics Canada. (2015b). *Table 477-0029 – Postsecondary enrolments, by program type, credential type, Classification of Instructional Programs, Primary Grouping (CIP_PG), registration status and sex, annual (number)*, CANSIM (database). Retrieved from <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4770029&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=>
- Statistics Canada. (2015c). *Table 477-0030 - Postsecondary graduates, by program type, credential type, Classification of Instructional Programs, Primary Grouping (CIP_PG) and sex, annual (number)*, CANSIM (database). Retrieved from <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4770030&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=>
- The general public. (2016). *Cambridge dictionary*. Retrieved from <http://dictionary.cambridge.org/dictionary/english/general-public>
- Thorne, B. (1993). *Gender play: Girls and boys in school*. New Brunswick, NJ: Rutgers University Press.
- Tiedemann, J. (2000). Parents' gender stereotypes and teachers' beliefs as predictors of children's concept of their mathematical ability in elementary school. *Journal of Educational Psychology*, 92(1), 144–151. doi:10.1037/0022-0663.92.1.144.
- Towers, J., Takeuchi, M., Hall, J., & Martin, L. C. (2015). Exploring the culture of school mathematics through students' images of mathematics. In T. G. Bartell, K. N. Bieda, R. T. Putnam, K. Bradfield, & H. Dominguez (Eds.), *Proceedings of the 37th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 570–573). East Lansing, MI: Michigan State University.