NON-BINARY PEOPLE'S VIEWS OF GENDER AND MATHEMATICS

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A considerable corpus of research exists about people's views of gender and mathematics. As this research is nearly always reported by binary participant groups (e.g., women/men), there is a gap in the research about the views of people with non-binary genders. We conducted a study in Canada and Australia about the general public's views of gender and mathematics. Here, we report on the findings specific to the non-binary participants in the study (n = 7). Participants generally were quite gender-egalitarian in their responses, demonstrated sound understanding of gender as a social construct, and avoided the use of "sex" language and binary language. We conclude by discussing considerations for conducting research with non-binary participants.

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A great deal of research has been conducted about people's views of gender and mathematics, the vast majority of which has been undertaken with students, teachers, and parents (e.g., Denner, Laursen, Dickson, & Hartl, 2018; Moè, 2018; Nürnberger, Nerb, Schmitz, Keller, & Sütterlin, 2016). Although parents and teachers certainly play a substantial role in students' developing conceptions of gender and mathematics, it is also important to understand the broader context in which these conceptions form. Therefore, investigating the general public's views of mathematics provides crucial information about other views to which students are exposed.

There is a paucity of research about the general public's views of mathematics, and even less regarding the general public's views of gender and mathematics. One notable study about the latter topic was conducted by Forgasz and Leder in Australia, working with international collaborators in Canada, South Korea, Spain, and the United Kingdom (e.g., Hall, 2018; Forgasz, Leder, & Gómez-Chacón, 2012; Forgasz, Leder, & Tan, 2014). Participants were asked about their views of gender and mathematics, as well as related topics (e.g., science). All of the gender-related questions used in this study were worded in a binary manner (e.g., "Who are better at mathematics, girls or boys?"), and participants' genders were assumed, based on appearance, by interviewers.

Although the findings of this study are informative, we were concerned about the binary wording of the questions, as well as the gender attributions (Ryle, 2019) made by the interviewers. Therefore, we adapted Forgasz and Leder's instrument so that the questions were written in a non-binary manner, and participants were explicitly asked to identify their genders. We trialled this instrument in Canada and Australia with approximately 400 members of the general public.

Here, we report on findings specific to a participant group that is vastly under-represented in research: non-binary people. In studies regarding people's views of gender and mathematics of which we are aware, findings are presented by binary participant groups (e.g., girls/boys). Such groupings are indicative of binary conceptions of gender and therefore marginalize an entire gendered participant group and overlook their views and experiences.

Theoretical Perspectives

Working from a feminist and social constructivist stance, we view gender as a performative social construct that occurs on a spectrum, rather than in a binary (Butler, 1999; Ho & Mussap, 2019). Specifically, we conceive of gender as the "behavioral, social, and psychological characteristics"

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(Pryzgoda & Chrisler, 2000, p. 554) of women, men, and non-binary individuals. The broader category of non-binary genders comprises several variants, such as pangender and genderqueer. Here, for simplicity and to reflect our participants' terminology, we use the term "non-binary" to refer to participants with genders outside the woman/man binary.

Since gender is a social construction, what is considered appropriate for each gender is subject to the specificities of time, place, and culture. Mathematics is a field that was historically and continues to be conceptualized as masculine in Western culture (Ernest, 1998; Leyva, 2017). Hence, exploring views of gender and mathematics remains a worthy research goal.

Research Design

The study was conducted in two large, comparable cities: one in Canada and one in Australia. People in four 'matched' public places (e.g., shopping mall in each city) were approached and asked to orally complete a brief questionnaire about their views of gender and mathematics. In the following sections, we describe the data collection instrument, participants, and analysis methods.

Data Collection Instrument

Our data collection involved the replication of some questions from the questionnaire used in the aforementioned study led by Forgasz and Leder, but we altered the gender-related questions to make them non-binary. For instance, instead of asking "Is it more important for girls or boys to study mathematics?", we asked "For which gender is it most important to study mathematics?" The purpose of changing the wording was twofold: 1) We did not want to provide binary gender options and 2) We wanted to make the wording sufficiently open-ended so that participants would use their own wording in their responses. As such, we were able to analyze the linguistic choices that the participants made in their responses, as we will later discuss.

The questionnaire had three sections. In the first section, participants provided demographic information (e.g., gender, age). Participants' genders were not assumed based on appearance; rather, participants were asked, "What is your gender?" In the second section, participants were asked five questions about their views of gender and mathematics (e.g., ability, importance) and prompted to explain their responses. In the third section, participants were asked three questions about their views of gender and related constructs (e.g., sex) and again prompted to explain their responses. Finally, participants were given the chance to provide any additional comments about gender and mathematics. Here, we report on findings from the second section of the questionnaire.

Participants

In total, 405 adult participants took part in the study: 195 from Australia and 210 from Canada. Due to the participants' inconsistent use of gender terminology (e.g., woman, man, genderqueer) and sex terminology (e.g., female, male), responses to the gender demographic question were combined into the following categories: women/females/etc., men/males/etc., and non-binary. Examples of 'etc.' responses were "girl" for the first category and "bloke" for the second category. Information about the participants is shown in Table 1, with percentages applying to columns.

Table 1: Australian and Canadian Participants, by Gender Group

Gender Group	Australian Participants	Canadian Participants
Women/Females/etc.	88 (45.1%)	109 (51.9%)
Men/Males/etc.	105 (53.8%)	96 (45.7%)
Non-Binary	2 (1.0%)	5 (2.4%)

There was a higher proportion of non-binary participants in Canada than in Australia. In total, seven (1.7%) of the participants across the sample were non-binary. This percentage is slightly higher than estimates (less than 1%) from larger questionnaires conducted with the general public in Australia

and Canada (Australian Bureau of Statistics, 2018; Waite & Denier, 2019). Additional details about the non-binary participants are shown in Table 2.

Table 2: Demographic Information about Non-Binary Participants

Participant	Gender Response	Age Category	Language(s) Spoken at Home	Highest Level of Education Completed
AusNB1	"genderqueer… non-binary"	18–39	English	High school
AusNB2	"non-binary"	18–39	English	College*
CanNB1	"non-binary"	40–59	French	College
CanNB2	"other or third"	18–39	English	High school
CanNB3	"non-binary"	18–39	English	High school
CanNB4	"non-binary"	18–39	English	Undergraduate
CanNB5	"non-binary"	18–39	English/French	Undergraduate

**Note: In Australia and Canada, college is a post-secondary institution that typically offers career-focused programs.*

Data Analysis

The participants' responses to the open-ended questions were analyzed using emergent coding (Creswell, 2014). That is, all responses to a question (from the entire dataset) were read multiple times to get a sense of the data. Then, codes were created and applied to the responses. Participants' responses were also allocated a "sex/gender language" code (SGL code; e.g., sex, gender, mixed) and a "binary/non-binary language" code (BNBL code; e.g., binary, non-binary, no indication). For instance, if a participant responded, "It's equally important for boys and girls to study math," the response would be coded with a "gender" SGL code and a "binary" BNBL code. In contrast, a response of "Males, females, and people of mixed genders can do math equally well" would be given a "sex" SGL code and a "non-binary" BNBL code. Due to the small number of non-binary participants, only descriptive statistics (e.g., counts) could be calculated.

Findings

In the following sections, we provide details about the non-binary participants' views on gender and mathematics, based on their responses to five open-ended questions on these topics. Unless otherwise mentioned, no SGL or BNBL was used in the vast majority of responses.

Relationship Between Mathematics Ability and Gender

Participants were asked whether they believed that mathematics ability was related to gender, and, encouragingly, most (n = 5) did not. Participants cited that individual variability precluded this kind of relationship, as characterized by a comment that any observed ability difference "is due to socialization and it's not actually due to their innate abilities" (CanNB5). Of the participants with other viewpoints, one argued that there was "a very strong emphasis in males, especially to perform in mathematics" (CanNB2) and the other explained that "girls are better at maths because they…are raised to have more patience, are not expected to just be good at things automatically" (AusNB1). Interestingly, these participants also justified their positions using arguments about social practices, rather than inherent differences.

Change Over Time in this Relationship

Next, participants were asked if they believed that there had been a change over time in the relationship between mathematics ability and gender. Most (n = 5) expressed a belief that there had been a change over time, but that this change related to outcomes rather than actual ability. Participants noted that there has been increased opportunity in recent times for people with marginalized genders to access mathematics. AusNB1 explained that "education and employment in maths and sciences hasn't been accessible to women and people of other genders historically until very recently." The remaining participants indicated that they did not think there had been a change

over time but did not elaborate on their reasoning. In terms of the use of SGL, the bimodal responses (*n = 3* for each category) were gender language or no indication of SGL.

Perceptions of Parents' Views of this Relationship

Participants were asked if they believed that parents thought that mathematics ability was related to gender. The responses to this question were bimodal (*n = 3* for each category): that it depended on the parents or that parents favoured boys. For example, CanNB1 suggested that parents' views depended on their cultural backgrounds, whereas AusNB1 argued that "obviously parents have gendered expectations of the vocations that their children will choose and I think they probably are more likely to expect boys to become engineers." While responding, some participants referenced their own parents' views, while other participants answered generally.

Perceptions of Teachers' Views of this Relationship

Participants were also asked if they believed that teachers thought that mathematics ability was related to gender. There was little consistency in the responses: three participants said that such views depended on the teacher, one thought that teachers favoured boys, one thought that teachers viewed all children equally, and two provided unclear responses. Some participants responded generally, while others extrapolated from their own experiences. For example, AusNB2 reported, "I just feel like they would always put the people that were males ahead of the class or think that they would do better" and shared a story of a teacher thinking that they cheated on a test because they earned 100%, while no boys did (AusNB2 identified as a girl at this point).

Gender and the Importance of Studying Mathematics

In the final question, participants were asked, "For which gender is it most important to study mathematics?" The modal response (*n = 5*) was that it was important for people of all genders to study mathematics. For instance, CanNB2 stated, "I believe all of them are equally important. I don't think that professions should be limited by gender." The other two participants 1) provided an unclear response and 2) stated that it was more important for women to study mathematics. While responding, four participants used non-binary language while one used binary language.

Concluding Remarks

In this report, we described the findings pertaining to the non-binary participants in our study of the general public's views of gender and mathematics. Generally, these participants held gender-egalitarian views and mixed perceptions of others' views (i.e., teachers, parents). With regards to language use, use of any SGL or BNBL by the participants was limited. However, when used, sex language was rare, and only one instance of binary language occurred. Although we cannot know for certain, it is reasonable to assume that as a result of their personal experiences exploring gender, these participants are more knowledgeable and understanding that gender is social construct. Indeed, non-binary people tend to use gender-related language that is more sophisticated than that used in general society, and they are more likely to use gender language and non-binary language than are people with binary genders (Hall & Jao, 2018a, 2018b; Matsuno & Budge, 2017).

Pervasive binary perspectives and structures of gender in society continue to marginalize non-binary people. We, in the mathematics education community, are not immune to such marginalizing practices. In the vast majority of mathematics education studies that include gender (either as a focus or simply as one of many demographic "variables"), researchers strictly involve binary gender groups. We hope that our study may serve as an example of a way to frame research, and collect and analyze data in a more inclusive way. In so doing, we hope to encourage other researchers to reflect on their own practices. It is only with our ongoing collective efforts that all members of our society will be included and represented in research.

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