First and Final Year Undergraduate Students' Perceptions of University Mathematics Departments

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In many countries, concerns have been raised regarding the lack of participation of students in mathematics at the university level due to a dearth of skilled professionals to meet the needs of an increasingly technological, and thus mathematical, world. In this paper, we report on a study in which we are comparing first and final year undergraduate students' experiences in mathematics departments. We focus on students' conceptions of the supports and challenges that they experience in mathematics departments, using a multimodal data collection method, photovoice. We will share findings from this ongoing research project focusing on comparisons between first and final year students' perceptions of their learning environment. The knowledge that will be gained from this research is crucial in understanding students' lived experiences and thus making suggestions to address university mathematics pipeline issues.

Keywords: Undergraduate Mathematics, Lived Experience, Learning Environment, Pipeline Issues, Photovoice

Declining numbers of undergraduate students graduating in mathematics impact innovation in a world that is "becoming increasingly technological and significantly more mathematical" (Australian Academy of Science [AAS], 2016, p. 37). In Australia, a very small proportion (0.4%) of students enrolling in tertiary education plan to pursue degrees in the mathematical sciences (AAS, 2016). Consequently, several government and scientific organizations have stressed the need for increased participation in the mathematical sciences at the tertiary level (AAS, 2016; Australian Mathematical Sciences Institute [AMSI], 2017). Additionally, women remain a minority of students in university programs in the mathematical sciences, and women's proportion of the enrolments has been declining in recent years (AAS, 2016; AMSI, 2017; Johnston, 2015). To address these issues, we report on findings from a study focusing on issues of student experience in mathematics degree programs, via a multimodal methodology, photovoice, combined with individual interviews.

Literature Review

Tertiary mathematics education is an expanding field of research, and experts have suggested that research is needed about students' experiences, as existing research often focuses on the teaching and learning of specific mathematical topics (Coupland, Dunn, Galligan, Oates, & Trenholm, 2016). While there are many studies (e.g., Hernandez-Martinez et al., 2011; Wade, Sonnert, Sadler, & Hazari, 2017) about the transition to university, there is a paucity of research about students' progressions throughout mathematics degree programs. Rather, most studies of mathematics majors (e.g., Piatek-Jiminez, 2015) tend to focus on a particular year level.

Previous researchers have identified issues in the tertiary mathematics pipeline that have contributed to attrition, such as a lack of understanding of career pathways, poor teaching, the demands of course load, and loss of interest in content (Fenwick-Sehl, Fioroni, & Lovric, 2009;

Piatek-Jimenez, 2015). While students of all abilities appear to lose mathematical confidence as they progress through introductory calculus (Ellis, Fosdick, & Rasmussen, 2016), students' self-beliefs warrant further examination (Sheldrake, Mujtaba, & Reiss, 2015).

Gender-specific issues have also been highlighted. Reasons for women's attrition include a lack of support from faculty members, feelings of being invisible or not fitting in, a low proportion of women in the program, and a loss of interest in the subject area (Damarin, 2000; Herzig, 2004; Mastekaasa & Smeby, 2008; Rodd & Bartholomew, 2006). In contrast, protective aspects include social and academic support from friends and family, encouragement from educators, and personal characteristics such as determination and competitiveness (Gill, 2000; Hall, 2010; Robnett, 2013, 2016; Rodd & Bartholomew, 2006).

Theoretical Framework

This study is framed by a feminist and social constructivist epistemological stance (e.g., Butler, 1999; Fosnot, 2005). We view knowledge as a human construction that is gendered and culturally, socially, and historically situated. Furthermore, we view disciplinary knowledge of mathematics, as well as views of mathematics and mathematicians, as socially constructed, gendered, and linked to the specificities of time and place. With regard to the context of the study, we apply this lens to the students' experiences in mathematics degree programs by viewing their learning as "both a process of active individual construction and a process of enculturation into the mathematical practices of the wider society" (Cobb, 1994, p. 13).

Objectives

The current situation in undergraduate mathematics warrants further investigation to better understand the experiences that contribute to students' perseverance in the field. By providing students with an opportunity to discuss their experiences, both supportive and challenging, we hope to develop an understanding of the issues that they face. In so doing, we will inform mathematics faculties and other stakeholders of ways to address students' concerns.

The aims of this project are: (1) to understand the experiences of undergraduate students enrolled in mathematics degree programs, in order to explore how mathematics departments support or challenge them, and (2) to examine how gender may play a role in students' experiences of studying mathematics at the undergraduate level. Our project is guided by the following research questions:

1. What are mathematics majors' experiences of university mathematics departments?
    a. What aspects of the departments do students find supportive?
    b. What aspects of the departments do students find challenging?
    c. How do students' experiences in the mathematics departments influence their career aspirations?
2. Are there differences in experiences by:
    a. Gender?
    b. Year level (first year versus final year)?
    c. Institution?

To address these questions, we will utilise qualitative research methodologies, namely comparative case study and photovoice.

Methodology

The research project is a comparative case study of two Australian universities. Specifically, we are investigating the experiences of first year and final year students, with a focus on gendered aspects of students' experiences. Experiences in the first year of university have been shown to be critical in supporting students, particularly women and gender minorities, to continue in the field (Herzig, 2004; King, Cattlin, & Ward, 2015). The final undergraduate year is the time when students need to finalise decisions about future careers and/or further studies. By having participants from different year levels, genders, and institutions, we will be able to examine how these aspects may influence students' experiences. In the following sections, we provide an overview of the study's methodology, namely comparative case study and photovoice, and discuss the data sources, participants, and analysis methods.

Comparative Case Study

As a case study, our research involves "the study of an issue explored through one or more cases within a bounded system" (Creswell, 2007, p. 73). According to Stake's conception (1995, 2005), our research project is an instrumental case study, as we are focusing on a broader issue of which the case is representative, and a collective case study, as it is an instrumental case study extended to several cases (i.e., multiple case study design). The broader issue is the differential experiences and participation by gender and year level in studying university mathematics, as illustrated by the cases of the first year and final year students at each institution. To investigate this issue, we are using a modified version of photovoice (Wang & Burris, 1997).

Photovoice

Photovoice involves participants taking photographs that are relevant to their lives in order to "promote critical dialogue and knowledge about important community issues through large and small group discussion of photographs" (Wang & Burris, 1997, p. 370), with the goal of reaching policymakers. The participants both create and discuss the data, increasing their autonomy in the research process, as they can "identify, define, and enhance their community according to their own specific concerns and priorities" (Wang & Burris, 1997, p. 374).

The use of photovoice has grown exponentially in the past few years, presumably due to the widespread use of smartphones. Several researchers (e.g., Cook & Quigley, 2013; Wilkinson, Santoro, Major, & Langat, 2012) have used photovoice to learn about post-secondary students' experiences. However, we only know of three examples of photovoice in mathematics education research (Chao, 2012; Harkness & Stallworth, 2013; Tan & Lim, 2010), and these studies were not conducted at the post-secondary level.

We are using a modified version of photovoice that begins with individual semi-structured interviews, focused on each participant's educational pathway into the mathematics degree program, experiences in the program, and career aspirations. Then, per the photovoice process (Wang & Burris, 1997), each participant takes photographs to represent the supportive and challenging aspects of the mathematics department. In focus group interviews, participants discuss the photographs. Photographs can focus and encourage discussion in focus group interviews, as well as provide a different mode in which participants can express themselves (Whitfield & Meyer, 2005). Supported by the interview facilitator, participants discuss themes that they see across the photographs.

Data Sources

We have data from three sources – individual interviews, focus group interviews, and photographs – with the latter two intertwined. The individual interviews are audio-recorded, the focus group interviews are video-recorded, and the photographs are provided electronically to the researchers for further analysis. Multiple data sources allow for triangulation, "a process of using multiple perceptions to clarify meaning… [that] helps to identify different realities" (Stake, 2005, p. 454). Moreover, by comparing the data sources, "various strands of data are braided together to promote a greater understanding of the case" (Baxter & Jack, 2008, p. 554).

Participants

Data are currently being collected from two comparable, prestigious Australian universities (herein referred to as University X and University Y), both of which have large mathematics departments. We will involve 20 participants per institution, 10 first year and 10 final year students. Data collection will be completed by October of 2018 (i.e., the end of the semester). In Table 1, we provide information about the participants to date. These participants have completed individual interviews and are in the midst of undertaking the photovoice process.

Table 1. Participant information.

University X	Women	Men
First year	4	4
Final year	2	0
University Y	**Women**	**Men**
First year	1	2
Final year	2	1

The focus groups will be comprised of five students each (first year or final year students only in each focus group), as this group size is ideal in terms of providing space for all participants to share their photographs and contribute fully to the discussion.

Analysis

The multiple data sources and participant groups necessitate a complex and multi-stage approach to data analysis. The individual interviews are currently being analyzed through a process of emergent coding (Bogdan & Biklen, 2007; Creswell, 2014). Due to the importance placed on the participants' explanations of the photographs, they will be analyzed within the context of the focus group interviews. After the focus group interviews, we will further analyze the photographs using content analysis (Riffe, Lacy, & Fico, 2014), in order to provide additional detail and description that may not be evident in the focus group interview videos.

With regard to the comparative case study methodology, analyses will occur at multiple levels. To begin, thematic analyses of the entire dataset will take place, in order to understand key themes regarding supports and challenges in mathematics departments for all participants. Then, the thematic findings will be further considered with regard to the year level and gender of the participants, to see if there are any trends specific to these groups. Each institution will be considered separately to develop a holistic understanding of each mathematics department.

Results

In the presentation, we will share findings from all aspects of the project – individual interviews, focus group interviews, and photographs – focusing on comparisons by year level. Here, we share initial findings from the individual interviews that have been completed.

The participants have taken many different pathways into the field of mathematics, such as transferring from other programs or working prior to beginning their studies. While most participants were traditional-age undergraduate students (18-22 years old), five participants were mature-aged students. Surprisingly, some participants reported that they have failed mathematics classes in past, and several described themselves as “slow learners” or “not that good at maths.” However, they reported that they persisted due to personal interest in mathematics or because they were close to completing their degree. All participants reported that peers were a major support in their academic success and persistence. Hence, a desire for more social dimensions to their programs was commonly reported, rather than changes to pedagogical/structural elements.

The first year participants have had quite a positive experience. They reported that the faculty members are passionate and helpful, and the tutorials are interactive and focus on collective understanding. While unaccustomed to discussing mathematics in groups, the collaborative style of learning allowed the participants to meet other students and develop a better understanding of the content. The participants attributed any lack of achievement in mathematics to the challenge of transitioning between high school and university, rather than any distinct factors in the mathematics departments. The participants explained that if they had any difficulty adjusting, they have felt supported and encouraged by staff to continue participating in mathematics. Concerns raised by the participants related to the distribution of marks across assessments, the quantity of work to complete, and the level of scaffolding in some classes. Additionally, the participants reported an even gender distribution in their classes and noted that they have not felt that there has been any gender-related differential treatment of students.

The final year participants echoed that they generally feel supported, but that the quality of support varied by faculty member. Students were very attentive to the implicit educational values of staff (i.e., whether the staff care about students and prioritize their teaching) as demonstrated in even minor interactions, such as providing email addresses and noting their availability for support. As with the first year students, the final year students did not report any gender-based discrimination. However, most were acutely aware of stereotypes regarding lower participation/interest of women in mathematics. The final year women participants reported feeling significant internal pressure to justify their own continued participation and felt that any personal failure would contribute to gender inequity. For instance, Participant 2 from University X stated, “Failing at a concept often feels like failing as a girl. Or, as a female in mathematics, I feel very representative of that.” Final year participants also identified issues regarding pedagogy and assessment (e.g., mandatory attendance, informal learning opportunities); in these discussions, the participants demonstrated their understanding of institutional constraints.

Implications

In this paper, we provide an example of the use of photovoice, a novel methodology in mathematics education, particularly at the university level. By sharing our experiences, we may assist colleagues in expanding their methodological repertoires. Photovoice allows participants to express their feelings about their experiences in a democratic, participatory manner. Visual representations allow participants to share their ideas in a mode that may be more accessible, thus providing unique insights into their experiences.

Our findings will inform practice at the participating universities and hopefully increase retention of mathematics majors, thus addressing the National Innovation and Science Agenda aim to boost the number of Australian graduates in science and mathematics as a strategy to build Australian capabilities for innovative economies (Australian Government Department of Industry, Innovation and Science, 2015). An important aspect of meeting this goal is addressing the significant decline in students graduating in mathematics. This study will contribute to a greater understanding of the mathematics pipeline by investigating students’ (especially women and gender minorities’) reasons for remaining in (or leaving) mathematics departments.

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