‘I want to help others’: Why female A-Level mathematics students reject undergraduate mathematics

Ems Lord

University of Cambridge

Although university mathematics departments are increasingly maximising the potential of tracking undergraduate applications, there is a dearth of data regarding A-Level mathematics students who choose not to apply to those institutions. This pilot case study focused on a mixed group of Y13 (17- and 18-year-old) A-Level mathematics students (*N*=18) attending an urban secondary school. The study was conducted after the closing date for their university applications. Using mind maps, the students were asked to share their reasons for continuing their studies to undergraduate level, as well as their choice of course and institution. The findings indicated several gender differences in their decision-making, including the perceived connection between their university course and their desire to help others. The possible implications of these findings are considered for their potential to inform future, larger-scale studies of interest to both schools and university outreach departments.

Keywords: gender; education, A Level; degree choices; mathematics

Introduction

The low proportion of female applicants for mathematics degree programmes has been well documented. Nevertheless, encouraging all students to continue their mathematical studies at university-level addresses social justice concerns as well as ensuring a steady stream of STEM-trained students and future employees. Considering the situation at international level, the Office for Economic Cooperation and Development (OECD, 2012, p. 14) report a statistically significant gender difference in most countries favouring males planning a career in engineering or computing. In the UK, its figures indicate that more than six times as many males than females are contemplating a STEM-related career (OECD, 2012, p. 114). Also, focusing on those female students who do choose to study mathematics at undergraduate level, McWhinnie and Fox (2013) report an alarming decrease in the numbers continuing their academic careers as researchers or professors; just over 40% of mathematics undergraduates are female yet only 6% of professors are female.

Universities have responded to this phenomenon in a multitude of ways. Recent initiatives include hosting London Mathematical Society-funded females-only events for schools and raising the profile of female mathematicians within university departments, such as the work of the Emmy Noether Society at the University of Cambridge and the Mirzakhani Society at the University of Oxford. However, data collection tends to focus on those students who attend recruitment events or apply for a study place. We need to find alternative ways to engage with students who do not make such contacts. By visiting their schools and exploring their decision-making processes with the students themselves, we can deepen our understanding about their reasons for not choosing to continue their mathematical studies despite studying A-

Level mathematics. This pilot study focused on a cohort of Y13 students which had already submitted its university applications. This paper explores the following research questions:

> RQ1: *What, if any, are the gender differences in the selection of undergraduate courses by A-Level mathematics students?*
> RQ2: *What, if any, are the gender differences in the choice of undergraduate institution by A-Level mathematics students?*

The study

This pilot study was conducted after the Y13 students had submitted their university applications. It consisted of a single case study with a Y13 A-Level mathematics cohort attending a secondary school based in a urban setting. Adopting a case study approach offered the opportunity to design a qualitative study which explored the reasons behind the decision-making processes of the students. Yin (2002, p. 13) defines a case study as "a contemporary phenomenon within its real-life context, especially when the boundaries between a phenomenon and context are not clear and the researcher has little control over the phenomenon and context."

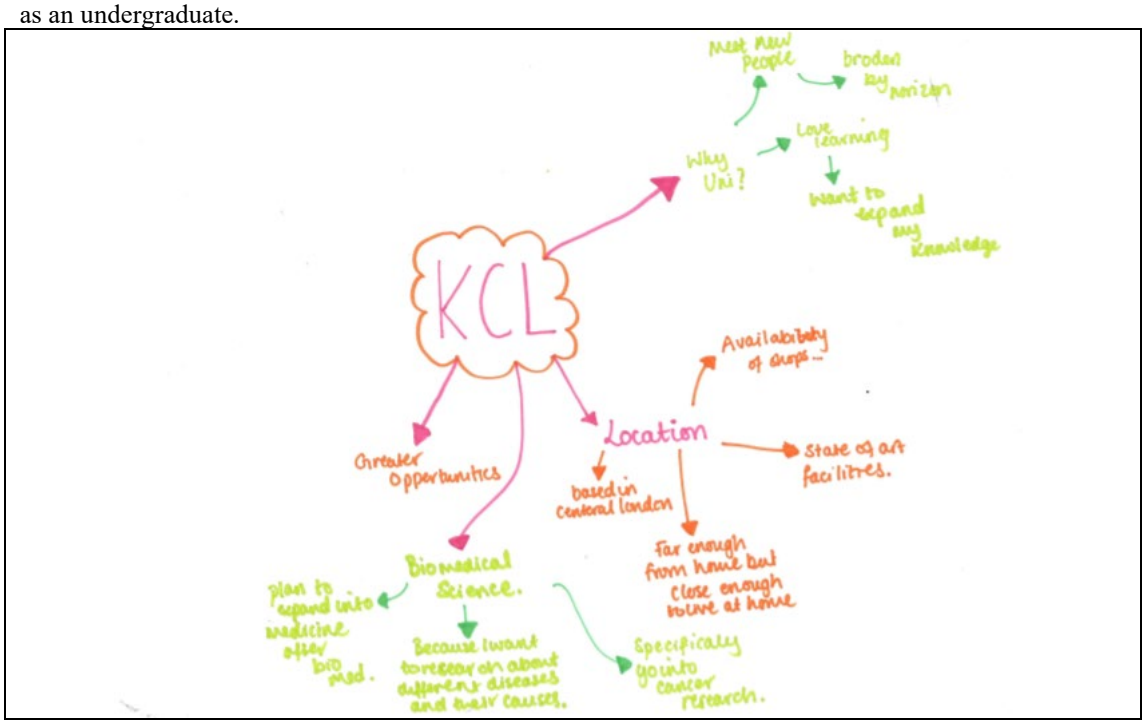
In this study, the school's mathematics department was fully staffed by teachers who had studied mathematics to at least undergraduate level. Those teachers appeared keen to further develop mathematics within their school by offering extra-curricular events and outreach activities, including Master Classes for their feeder schools, and organising residential events for their GCSE students. They offered their students both A-Level Mathematics and A-Level Further Mathematics. Their Y13 A-Level mathematics group consisted of 19 students, 13 males and six females. Although the students were informed that the pilot study was addressing their university choices, they were not alerted to the gender aspect of the study in case that knowledge influenced their responses. The students were reassured that their data would remain anonymous, that their participation was entirely voluntary and that they could withdraw at any time. The procedures adhered to the BERA (2018) ethical guidelines. It should be noted that one of the females was planning a gap year prior to attending university; although she participated in the data collection, her data was excluded from the analysis because she had neither selected a course nor an institution at that point.

Data collection

During one of their timetabled A-Level mathematics sessions, each student was asked to complete a mind map exploring their reasoning behind their choice of undergraduate course, institution and their overall reasons for wishing to continue their studies (Figure 1). Their teachers had previously confirmed that the students were familiar with drawing mind maps from their earlier GCSE studies. Although qualitative data collection often relies on observations, interviews and the scrutiny of existing documents, using mind maps offered a much more creative way to collect the required data in a manner which it was hoped would appeal to the students. The maps offered a "visual snapshot of experience from which to ground theory within data" (Wheeldon & Faubert, 2009, p. 79). The students were encouraged to use colour on their maps and to make them as detailed as possible. Although the literature revealed that previous studies have analysed mind maps in different ways, the approach known

as *concept counting*, which would involve identifying the various concepts within a mind map and recording their frequency (Turns, Atman & Adams, 2000), appeared to be the most suitable for addressing the research questions.

Figure 1: A female A-Level mathematics student's mind map for applying to study biomedical science as an undergraduate.



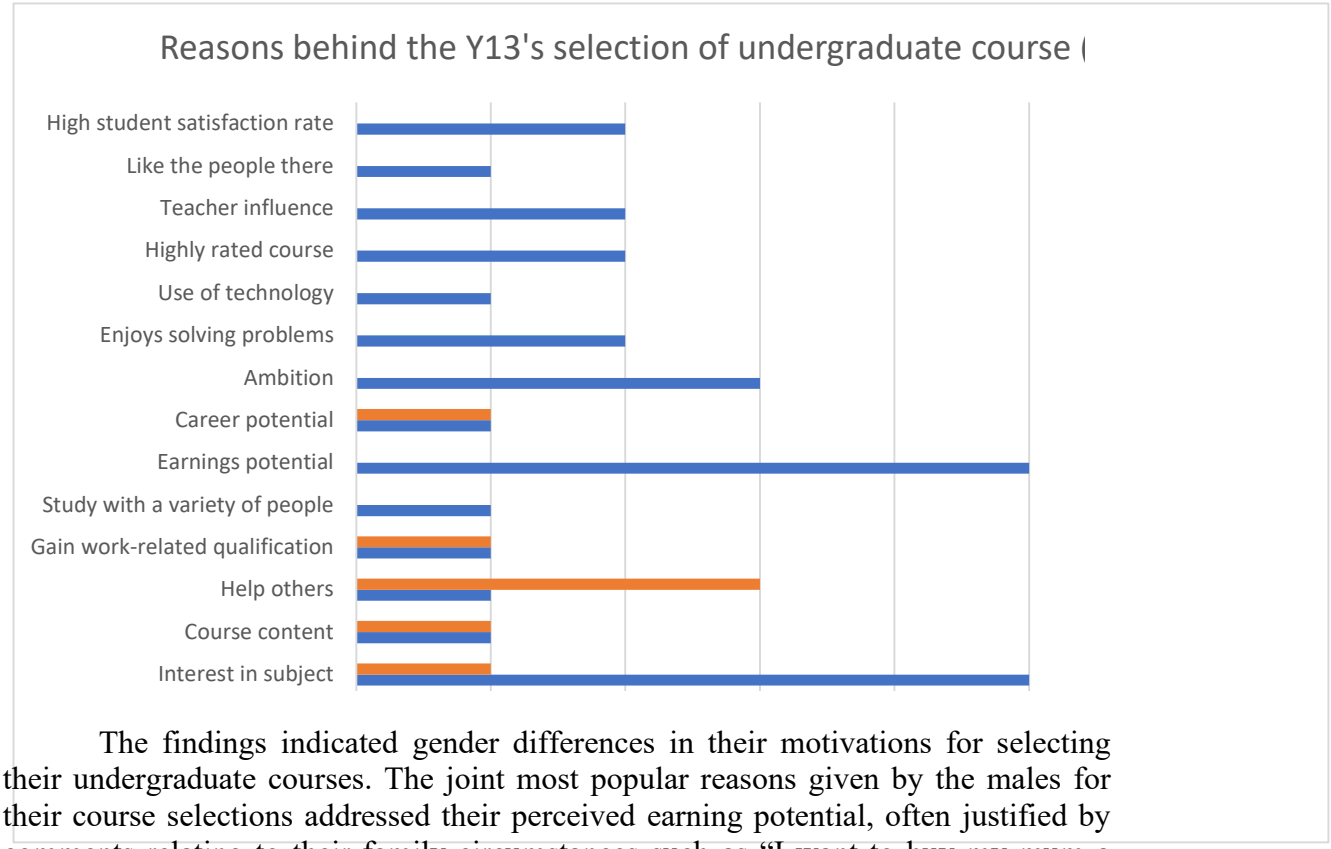
Findings and discussion

RQ1: What, if any, are the gender differences in the selection of undergraduate course by A-Level mathematics students?

Before considering the reasons behind their selection of undergraduate courses, it is interesting to compare their actual course choices by gender. We might infer a possible gender difference in those choices, even though each of the 18 students was studying A-Level mathematics, each of the five females chose to study medical-related courses (nursing, medicine, optometry or biomedical science) whereas only two of the 13 males had chosen similarly medical-related courses (neuroscience and medicine). The remaining 11 males had chosen to study either mathematics, chemistry, economics, accounting or engineering.

Moving on to consider the reasons behind the selection of their undergraduate courses, the analysis resulted in the identification of 14 themes (Figure 2). Altogether, there were 41 different references in their mind maps to those 14 themes (30 by males, 11 by females).

Figure 2: Reasons behind the Y13's selection of undergraduate course (*N*=18)



The findings indicated gender differences in their motivations for selecting their undergraduate courses. The joint most popular reasons given by the males for their course selections addressed their perceived earning potential, often justified by comments relating to their family circumstances such as "I want to buy my mum a house."

Figure 3: A female A-Level mathematics student's mind map for applying to study optometry as an undergraduate.

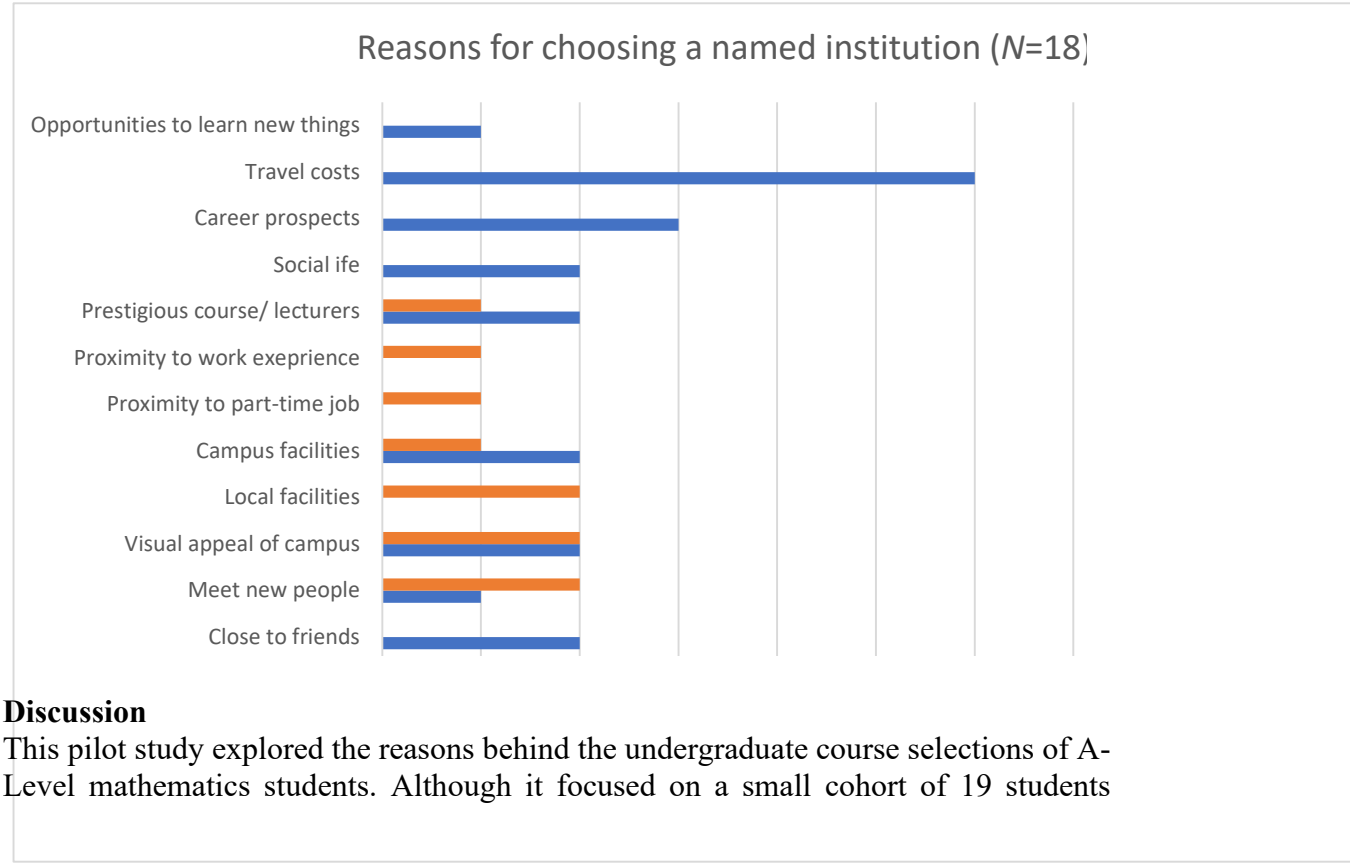
In contrast, the most important reason given by the females was the perceived opportunities to help the wider community through their choice of course. "I want to learn more about some of the world's worst diseases and maybe even find a cure myself," explained an applicant for study biomedical science. Another had applied for a nursing course because she wanted to develop, "The ability to help children who need help, to support them."

RQ2: What, if any, are the gender differences in the choice of undergraduate institution by A-Level mathematics students?

For the second research question, the analysis revealed 15 themes addressing the Y13's reasons to apply to study at university-level (Figure 4). Altogether, there were 55 different references to those 15 themes (38 by males, 17 by females). Proximity to family and friends appeared to be a key motivator behind choosing a campus for both genders and the proportion of both genders wishing to stay near home was similar. Several comments noted the advantages of studying close to home, including "It's familiar and comfortable," "It's far enough from home but close enough to live at home" and "I can see my mum every day." Another suggested that, "My dad will still give me lunch money."

Not all the students wanted to be close to home. A female who had opted to study outside of her home city, explained that she had chosen an institute within a short travelling distance from home so she could "pop back easily." In contrast, another female was adamant that she wanted to be as far away from her urban environment as possible to escape the "chaos." One of the males was strongly resistant to travelling away from his home to attend an Oxbridge setting, "I can't be ****ed travelling for a dead university."

Figure 4: Reasons for choosing a named institution (*N*=18).



Discussion

This pilot study explored the reasons behind the undergraduate course selections of A-Level mathematics students. Although it focused on a small cohort of 19 students

within a single school, and great care should be taken to avoid over-generalising the findings, the results indicated possible foci for future, larger-scale research studies and the benefits of adopting a qualitative research design which enabled the study to uncover the motivations behind the decision-making of A-Level mathematics students who do not apply to study mathematics at undergraduate level.

The findings indicated possible gender differences in the reasoning behind their selection of undergraduate courses, the females choosing medicine-related courses which reflected their stated desire to 'help others.' It would be interesting to investigate whether this trend was consistent across different types of schools and settings. If helping others is shown to a key motivator for female A-Level mathematics selecting their undergraduate course, then mathematics faculties might benefit from adapting their current approach to schools. For example, future outreach work could highlight the contributions of female mathematicians towards tracking disease pandemics and using their data in ways to reduce the likelihood and impact of future incidents. By increasingly stressing the ways in which studying mathematics enables students, especially female students, to achieve their vision of helping others, mathematics faculties might strengthen their efforts to address the gender imbalance among their undergraduates and academics.

The importance of maintaining close contact with families and studying within a familiar environment were major concerns for A-Level mathematics students of both genders. By recognising their importance, and highlighting ways that they could be overcome, university mathematics faculties might encourage more students to consider applying to institutions much further away from home than they might initially consider. Moreover, institutions situated away from urban areas might benefit from reviewing the effectiveness of their communications regarding the range of their facilities and the opportunities within their local areas if they are to tempt urban students to venture further afield when considering their UCAS applications. Moreover, this study was conducted in an urban setting and future studies might compare course selection for students taking A Level mathematics in urban areas, where universities are within easy reach, and those in rural areas who would have to move away from home regardless of choice.

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