Who is Really Interested in Mathematics? An Investigation of Lower Secondary Students' Mathematical Role Models

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Declining participation rates in advanced mathematics courses and STEM-related occupations has been an issue in Australia for some time, particularly for females. As students continue to disengage with mathematics and complain about its usefulness, it is important to explore what we can do to stem the tide of departing students. One area worthy of investigation is students' interest in mathematics including whether they are able to name a mathematical role model in their lives. Forty-three students in Years 7 to 9 from three schools were asked to name people they knew who were interested in mathematics. There was a strong bias towards male figures (44 to 17), particularly fathers and male peers.

At a time when there has been an explosion in the amount of data available to inform research and development, there is an increasing need for well-trained mathematicians and statisticians. However, the numbers of students continuing to study advanced levels of mathematics in senior secondary schooling and at the university level are declining (Board of Studies NSW, 2010; Brown, 2009; Forgasz, 2006; Office of the Chief Scientist, 2012). Many students find mathematics boring and frustrating (Brown, Brown, & Bibby, 2008; Murray, 2011) and anxiety and avoidance are persistent and growing issues in mathematics education (Ashcraft & Moore, 2009; Sherman & Wither, 2003). There are potentially rich avenues of research that could provide insight into this situation. This study sought to investigate these issues from the perspective of *interest* in mathematics, with a particular focus on students' perception of other people in their lives who are interested in mathematics. These 'mathematical role models' reveal much about students' backgrounds and their understanding of interest in mathematics and the discipline itself. Exploring the different role models of male and female students might also reveal any gender differences.

Literature Review

Interest has the potential to produce effective and practical results; it has been known to positively affect persistence and effort (Krapp & Lewalter, 2001; Renninger & Hidi, 2002), academic motivation (Harackiewicz & Durik, 2003; Schiefele, 2001) and cognitive performance (Ainley, Hidi, & Berndorff, 2002; Krapp, 2002). Interest is also associated with enjoyment and producing effort that feels effortless (Lipstein & Renninger, 2006). Therefore, improving students' interest in mathematics has the potential to combat many of the negative attitudes and experiences that currently beset the field of mathematics.

Many definitions of interest are available in the literature, but there is common agreement on its chief characteristics. Most contemporary definitions acknowledge that interest is a construct that is composed of factors such as a thirst for knowledge, an emotional or affective response and a strong value or importance placed on the subject (e.g., Hidi & Harackiewicz, 2000; Hidi, Renninger, & Krapp, 2004). Interest is also associated with a conscious decision to engage or re-engage with content (Hidi & Renninger, 2006; Lewis, 1970).

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The chief indicator that mathematics suffers from a lack of interest is the decline in enrolments at a nationwide level in post-compulsory secondary and tertiary mathematics courses, particularly at the advanced levels. Students are clearly not engaging or re-engaging with content as the previous definition of interest would imply. Much has been made of these declining enrolments and how this creates a shortage of appropriately-trained graduates in STEM fields (e.g., Australian Academy of Science, 2006; Office of the Chief Scientist, 2012). This is especially true for the provision of secondary mathematics teachers, which holds ominous implications for the next generation of mathematicians. The *Staff in Australia's Schools* report (SiAS) noted that "fewer teachers of mathematics at Years 7-10 had completed studies at third year or higher (46%) [in 2010] than was the case in 2007 (53%)" (McKenzie, Rowley, Weldon, & Murphy, 2011, p.55).

The lack of sufficiently-trained graduates in STEM fields as well as the secondary teacher shortage means that there is a limited pool of mathematical role models to whom students can look up to and follow. Investigating this supposed lack of role models and who the current role models are will lend some insight into whether this is a viable avenue worthy of further study. There has been limited recent research in this area, particularly in the Australian context.

There are suggestions in the existing literature that such a direction could prove fruitful, especially when examining the issues that girls face in mathematics education. While negative attitudes and experiences need to be addressed across the diversity of Australian secondary students, it has long been recognised that girls hold particular views about themselves as learners of mathematics and of the reasons they attribute to their success in mathematics (Martin, Anderson, Bobis, Way, & Vellar, 2012).

Differences in achievement between boys and girls is disputed in the literature, but it is clear that differences in attitudes, behaviours and participation rates in mathematics do exist. Watt (2007) found that girls are less interested and have less liking for mathematics than boys, and are less likely to choose careers related to mathematics. Girls also tend to feel less confident and express doubts about their performance (Ai, 2002; Leedy, LaLonde & Runk, 2003). Girls are also under-represented in advanced mathematics courses; for example, in 2013 their percentage share of enrolments in the New South Wales Higher School Certificate (HSC) subjects of Extension 1 Mathematics and the higher Extension 2 Mathematics stood at 41% and 36% respectively, when in fact girls represented 51% of students enrolled in the HSC in 2013 (Board of Studies NSW, 2013).

There are many possible reasons for girls' underrepresentation in advanced mathematics courses. Gender stereotyping in favour of boys still exists in the public perception (Leder & Forgasz, 2010). When questioning members of the community at various public sites, Leder and Forgasz found that only 12.8% believed girls were better than boys at mathematics, with 26.1% believing boys were better than girls and the remainder believing they were equal or unsure. There were no statistically significant differences due to the respondent's age or gender. Another example of gender stereotyping was found by Jacobs, Davis-Kean, Bleeker, Eccles and Malanchuk (2005), who noted that parents tended to promote mathematics amongst their male children but did not do the same for their female children.

These findings provide a window into a world where girls are not necessarily encouraged to pursue an interest in mathematics, evidenced by their underrepresentation in senior advanced mathematics courses. While gender stereotyping has been studied in the past, a study of mathematical role models could cast a different perspective on these issues.

With this background in mind, the investigation into mathematical role models needs to include some acknowledgement of the role of gender, in particular whether there are enough female role models to offset society's general stereotypes. It is beyond the purview of this study to establish any gender mediation effects of role models, such as whether a female student can derive the same positive benefit from a male role model as a female one. Instead, this study seeks to provide a base for further research by establishing whether any identifiable or remarkable patterns or trends exist in the field of mathematical role models. If, for example, males dominate the field of role models, this would be the basis for subsequent research on whether this has any detrimental effect for female students of mathematics.

The Study

This investigation of mathematics role models was undertaken as part of a larger study that focuses on interest in mathematics in the lower secondary years. A mixed-methods approach was utilised involving the completion of a written questionnaire, followed by individual interviews for selected students. The purpose of the written questionnaire was to collect information on students' attitudes and measure their level of interest in mathematics, according to their responses to a set of Likert-scale items. Three independent schools in a large metropolitan area took part in the study. All students in Years 7 to 9 completed the written questionnaire, resulting in a total of 1,229 responses. School A was a co-educational school, while School B and School C were a single sex boys' and girls' school respectively.

After the questionnaires had been completed and analysed, 43 students were individually interviewed. Interviewees were selected with the purpose of gaining a broad cross-section of experiences and attitudes. Therefore, as measured by the Likert-scale items in the written questionnaire, students with both high and low levels of interest were selected. To mitigate the possibility of a single class or teacher having an undue influence, students were selected across a range of classes, with a maximum of two students coming from any one class. The final distribution of the interviews is shown in Table 1 below.

Table 1
Student Distribution of Individual Interviews

School	Year	Males interviewed	Females interviewed
A (Co-ed)	7	3	3
	8	3	3
	9	4	
B (Boys)	7	4	
	8	5	
	9	7	
C (Girls)	7		2
	8		4
	9		5
Total		26	17

The unequal number of male and female students, who were interviewed, was a consequence of those who provided permission to be interviewed by the researchers. The interviews explored students' levels of interest in mathematics in relation to their past experiences and current experiences in mathematics classrooms. The results of two particular questions from the interviews form the basis of the data reported in this paper:

1. Can you name someone you know who is really interested in mathematics?
2. How do you know that they are really interested in mathematics?

Student responses to these two questions were transcribed and inductively coded (Thomas, 2006). If students asked for clarification as to who they could name, for example, whether they were to name someone from within the school or whether they could nominate people from outside, the interviewer indicated no preference and the only guidance provided was that the student should name whoever first came to mind. It should also be noted that while the term 'mathematical role model' is used repeatedly in this paper, no such term was used in the interview. Therefore the usage of the term is not meant to indicate any active or formal mentoring relationship between the student and the person named.

Results

Of the 43 students who were interviewed, most students named a single person when asked to name someone they knew who was "really interested in mathematics". Students who responded with general answers such as "friends" were encouraged to be more specific and they typically named a single person thereafter. The responses were coded according to the types of people that students named and are presented in Table 2 in descending order of frequency. In total, 61 people were named by the 43 students.

Table 2
Can you name someone you know who is really interested in mathematics?

Type	No. of Responses	% of Responses	Notes
Father	20	33	Also other male primary carers
Male peer	16	26	Friend in class or year group
Female peer	6	10	Friend in class or year group
Other male relative	5	8	Grandfather, uncle, brother etc.
Mother	4	7	Also other female primary carers
Female teacher	4	7	
Other female relative	3	5	Grandmother, aunt, sister etc.
Male teacher	3	5	

The responses show a strong bias towards male figures, particularly fathers and male peers, indicating that students readily identify males as being interested in mathematics, but are less likely to nominate females. The overall ratio of male to female role models was 44 to 17 (72% male to 28% female). Even considering that boys outnumbered girls amongst those interviewed (26 to 17), it is unclear whether any bias based on the gender of the interviewee should exist. The most obvious conclusion from the data is that there appears to be a shortage of female mathematical role models for this group of students.

Further examining the occurrences of male and female peers provides some interesting details that reinforce the findings in the previous literature regarding gender stereotypes. All of the peers that were named came from the same school as the interviewee. Of the 6 instances where female peers were mentioned as being interested in mathematics, 5 of them came from the girls' school, where a male peer was impossible. Of the 16 instances where a male peer was mentioned, 6 of them came from the boys' school. This means that at the remaining school, which was coeducational with an approximately equal enrolment of boys and girls, male peers mentioned as being interested in mathematics outnumbered female peers by 10 to 1. This striking result shows that even in an environment where mathematics is compulsory and there are equal numbers of boys and girls in attendance, males (as seen by the students) are more commonly perceived to be interested in mathematics than girls. This indicates that some form of gender stereotyping among peers has already begun at the lower secondary level.

Even at the girls' school, despite the contribution of 5 female peers (that could not be offset with male peers) to the pool of mathematical role models, the final gender balance of role models was equal with 6 each, with the male contribution including 4 fathers and 2 other male relatives, while the additional female role model was one mother. It appears that aside from the unique circumstance of having solely female peers, the gender imbalance remains in favour of males even at a single sex girls' school.

The lack of teacher representation was surprising. It may be that students already assumed that the researchers knew their teachers were interested in mathematics and that they should provide a more imaginative or adventurous choice. Those that did mention a teacher often did so after considering the question for some time, perhaps indicating that this response was a last resort.

The dominance of fathers as mathematical role models presents some intriguing implications. Recent research appears to indicate that fathers or male caregivers have a stronger influence on students' future intentions and orientations in relation to mathematics than mothers or female caregivers, who play a more 'protective' role in preventing student disengagement (Martin, Anderson, Bobis, Way, & Vellar, 2012). This study appears to support such a finding, as fathers are commonly viewed as mathematical role models by their children, and may have some influence on their future aspirations. This only serves to further highlight the vital role that fathers play in encouraging their children in their studies of mathematics, especially in response to the gender stereotyping outlined in the literature review.

The second question, "How do you know that they are really interested in mathematics?" revealed respondents' beliefs about interest and the behaviours they associated with someone who was interested in mathematics. The responses to this question were coded and are represented by the categories outlined in Table 3.

In the literature review it was acknowledged that interest is composed of a thirst for knowledge, an emotional or affective response and a strong value or importance placed on the subject (e.g., Hidi & Harackiewicz, 2000; Hidi, Renninger & Krapp, 2004). These categories appear to broadly align with this multi-dimensional understanding of interest, as employment could be associated with value, helping and proficiency with the thirst for knowledge, and enjoyment with affect. The employment category was most strongly associated with parental figures, while the enjoyment category was most often mentioned in relation to peers or teachers. The proficient category was evenly spread across all types of role models.

Table 3
How do you know that they are really interested in mathematics?

Category	No. of Responses	Sample Responses
Employment	21	"He's a computer programmer, so I think he enjoys a lot of formulas."
		"He's an accountant and basically does maths for a living."
Helping	12	"He helps me with my homework and shows me all sorts of stuff."
Proficient	18	"He only lost one mark this year and carries a calculator around."
Enjoyment	21	"She seems really excited teaching it to us."
		"Most of my friends are like 'oh no, maths' but she says 'I enjoy maths, I don't mind going to it.'"

While "helping" is represented least among the four categories, it is of note that of the 12 times the "helping" category appeared, on 10 occasions the named helper was the father. This indicates that there is some truth to the traditional supposition that fathers are more likely to help their children with mathematics homework. The remaining two named helpers were one uncle and one mother, leading to another significant gender imbalance in the overall number of helpers (11 to 1 in favour of males). The helper is a powerful mathematical role model since its name indicates an active relationship between the role model and the student, which may not be the case for the other three categories. To have this important role so strongly identified with males is a further example of the inequity in gender of mathematics role models. It also serves to reinforce the vital role that fathers have in encouraging their children's study of mathematics.

Discussion and Conclusions

These results demonstrated a very clear gender bias towards males in terms of students' examples of people they knew who were interested in mathematics. Fathers and male peers were the dominant role models. Fathers have an even more important role to play because they are often identified as 'helpers', who have a more active relationship as a role model for their children. As parents they must be careful not to overly encourage boys at the expense of girls (Jacobs et al., 2005).

A subsequent study might look to interview the role models themselves, and investigate the nature of their impact on students' interest in mathematics. It is quite conceivable that some of these named role models had little effect on a student's interest, while others could have had a very large influence. Discovering the ways that a role model can positively influence interest in mathematics would provide some much-needed advice for fathers and others in such a position.

Further research in this area would also benefit from a sample that has greater socioeconomic diversity. The three independent schools involved in this study typically attracted students from middle-class families, where one or both parents had completed some form of tertiary education and families had above-average incomes. Many parents held jobs that placed them in the professional class. Gathering data from students of more diverse backgrounds may reveal additional insights that were not possible with the current sample. Examining the mathematical role models of these students would be an intriguing avenue for further study.

While there appears to be a strong bias towards male role models in mathematics, it is still unclear whether this is a significant contributing factor to the underrepresentation of girls in advanced mathematics courses and subsequent STEM-related occupations. It is of course a worthwhile exercise to encourage more equitable representation and more female role models in mathematics regardless of whether such a link exists, but any insight in this area would strengthen the rationale for further investigations regarding role models.

References

Ai, X. (2002). Gender differences in growth in mathematics achievement: three-level longitudinal and multilevel analyses of individual, home, and school influences. *Mathematical Thinking and Learning, 4*(1), 1-22.

Ainley, M. D., Hidi, S., & Berndorff, D. (2002). Interest, learning and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*, 1-17.

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment, 27*(3), 197-205.

Australian Academy of Science (2006). *Mathematics and statistics: Critical skills for Australia's future.* Retrieved 23 February 2014 from http:/www.review.ms.unimelb.edu.au/Report.html

Board of Studies New South Wales (2010). *Media Guides 2001-2010 Higher School Certificate and SChool Certificate.* Retrieved 23 February 2014 from http://www.boardofstudies.nsw.edu.au/bos_stats/

Board of Studies New South Wales (2013). *2013 Media Guide*. Retrieved 23 February 2014 from http://www.boardofstudies.nsw.edu.au/news-media/media-guide-2013

Brown, G. (2009). *Review of education in mathematics, data science and quantitative disciplines.* Report of the Group of Eight Universities. Turner ACT: Group of Eight.

Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": Reasons given by 16 year-olds for not continuing their study of mathematics. *Research in Mathematics Education, 10*(1), 3-18.

Forgasz, H. J. (2006). *Australian Year 12 Mathematics Enrolments: Patterns and Trends - Past and Present.* Melbourne: Australian Mathematical Sciences Institute.

Harackiewicz, J. M., & Durik, A. M. (2003. Task value in the college classroom: Predicting goals, interest, and performance. In M. Niemivirta (Chair), *Advances in achievement goal research: The role of moderators and mediators.* Symposium conducted at the 10th Biannual Meeting of the European Association for Learning and Instruction, Padova, Italy.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for hte 21st century. *Review of Educational Research, 70,* 151-179.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111-127.

Hidi, S., Renninger, K. A., & Krapp, A. (2004). Interest, a motivational variable that combines affective and cognitive functioning. In D. Y. Dai & R. J. Sternberg (Eds.), *Motivation, emotion and cognition: Integrative perspectives on intellectual functioning and development* (pp. 89-114). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Jacobs, J. E., Davis-Kean, P. E., Bleeker, M. M., Eccles, J. S., & Malanchuk, O. (2005). "I can do it but I don't want to." The impact of parents, interests and activities on gender diferences in math. In A. Gallagher & J. Kaufman (Eds.), *Gender difference in mathematics* (pp.246-263). New York: Cambridge University Press.

Krapp, A. (2002). Structural and dynamic aspects of interest development: Theoretical considerations from an ontogenetic perspective. *Learning and Instruction, 12*, 383-409.

Krapp, A., & Lewalter, D. (2001). Development of interests and interest-based motivational orientations: A longitudinal study in vocational school and work settings. In S. Volet & S. Jarvela (Eds.), *Motivation in learning contexts: Theoretical advances and methodological implications* (pp. 201-232). London: Elsevier.

Leder, G. C., & Forgasz, H. J. (2010). I liked it till Pythagoras: The public's view 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.328-325). Fremantle, WA: MERGA

Leedy, M. G., LaLonde, D., & Runk, K. (2003). Gender equity in mathematics: Beliefs of students, parents and teachers. *School Science and Mathematics, 103*(6), 285-292.

Lewis, E. C. (1970). *The Psychology of Counselling*. Iowa: Holt Rhinehart and Winston.

Lipstein, R., & Renninger, K. A. (2006). "Putting things into words": 12-15 year-old students' interest for writing. In P. Boscolo & S. Hidi (Eds.), *Motivation and writing: Research and school practice* (pp. 113-140). New York: Elsevier.

Martin, A. J., Anderson, J., Bobis, J., Way, J., & Vellar, R. (2012). Switching on and switching off in mathematics: An ecological study of future intent and disengagement among middle school students. *Journal of Educational Psychology, 104*(1), 1-18.

McKenzie, P., Rowley, G., Weldon, P., & Murphy, M. (2011). Staff in Australia's schools 2010: Main report on the survey. *Australian Council for Educational Research*. Retrieved 20 November 2013 from http://www.deewr.gov.au/Schooling/Documents/SiASMainReport.pdf

Murray, S. (2011). Declining participation in post-compulsory secondary school mathematics: students' views of and solutions to the problem. *Research in Mathematics Education, 13*(3), 269-285.

Office of the Chief Scientist. (2012). *Mathematics, engineering and science in the national interest.* Canberra: Commonwealth of Australia.

Renninger, K. A., & Hidi, S. (2002). Student interest and achievement: Developmental issues raised by a case study. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 173-195). New York: Academic.

Schiefele, U. (2001). The role of interest in motivation and learning. In J. M. Collis & S. Messick (Eds.), *Intelligence and personality: Bridging the gap in theory and measurement* (pp.163-194). Mahwah, NJ: Lawrence Erlbaum Associates.

Sherman, B. F., & Wither, D. P. (2003). Mathematics anxiety and mathematics achievement. *Mathematics Education Research Journal, 15*(2), 138-150.

Thomas, D. (2006). A general inductive approach for analysing qualitative evaluation data. *American Journal of Evaluation 27*(2), 237-46.

Watt, H. M. G. (2007). A trickle from the pipeline: Why girls underparticipate in maths. *Professional Educator, 6*(3), 36-41.