AMSI CHOOSEMATHS RESEARCH

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Maths Anxiety:

Students, Pre- and In-Service Teachers

in brief

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

Inge Koch

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Inge Koch

Australian Mathematical Sciences Institute

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Executive Summary

The under-representation of young women in advanced mathematics courses in school, in university mathematics degree programs and in mathematics-related careers in many western countries is of concern for economic and gender-equity reasons. Effective strategies for increasing engagement and participation of girls and young women in mathematics and STEM require an understanding of the forces and factors contributing to the current disengagement. Potential causes include maths anxiety and low confidence in one's mathematical abilities.

The partnership between the Australian Mathematical Sciences Institute and the BHP Foundation, which began in 2015, is aiming to increase participation of girls and young women across Science, Technology, Engineering and Mathematics (STEM) through the Choose Maths project in a multilevel approach.

Maths anxiety, which starts in early primary school, has been shown to be an impediment to achievement, and female primary teachers with maths anxiety are likely 'causes' affecting behaviour and attitudes especially of female primary students. Though no evidence exists of a gender gap in mathematical ability, gender disparity in mathematics performance is evident from early primary school, and the gender gap in self-confidence and maths anxiety develop around the same time and are accompanied by a decrease in positive attitudes and engagement in mathematics of girls.

This report reviews and examines likely causes of the lower interest, participation and achievement of girls and young women in mathematics: maths anxiety and lower confidence in the mathematical abilities of female students and primary teachers. The report includes approaches that have been employed in addressing maths anxiety in students and pre-service teachers. The main findings are:

- Maths anxiety affects brain activity, and results in a 'performance deficit' which can lead to achievements below actual abilities (Section 2);
- Girls are more maths anxious and less confident in their mathematical ability than boys although there is no evidence of a gender difference in mathematical ability (Section 4.3);
- Maths anxiety in 15-year old students has increased from 2003 to 2012 among all students and the gender gap has widened over time (Section 3.4);

- Environmental non-genetic factors contribute more to the development of maths anxiety than genetic risk factors (Section 3.1);
- Teachers are one of the most influential factors impacting on student achievements (Section 3.5);
- Higher levels of maths anxiety in teachers are related to lower mathematics achievements of their students (Section 3.5);
- Teachers with more knowledge of mathematics are more confident and less anxious in their teaching practices and better able to encourage mathematical learning (Section 6);
- Pre-service teachers require solid knowledge of mathematics, good teaching practices and methods for reducing maths anxiety (Section 5.4).

An analysis of survey data from primary teachers in Australia's Choose Maths schools shows evidence of maths anxiety and perceived inadequate pre-service training among primary teachers, as well as evidence that change in improving teachers' mathematical skill base and reducing their maths anxiety is possible through suitable intervention.

The findings from the literature and the Choose Maths data analysis are of concern and demonstrate the need for urgent action on teacher education and on reduction of maths anxiety in pre-service and in-service teachers and their students.

Contents of the full report

Conclusion and Recommendations

Maths anxiety is known to start early in primary school and to affect girls more than boys. It increases with age through primary and most of secondary school and then remains constant. Maths anxiety of 15-year old boys and girls has increased since around 2000 and the gender gap has widened during those years.

The maths anxiety of pre-service teachers typically increases when they become in-service teachers. Further, negative attitudes of maths anxious teachers have a strong influence on same-gender students, and with a very high percentage of female primary teacher -- over 90% in Australian primary schools -- teachers have a powerful impact on young female students, including reinforcing traditional gender stereotypes.

Maths anxiety has been shown to be an impediment to achievement. Its two components, fear and avoidance, affect individuals, their beliefs and performance in different ways:

- Fear due to maths anxiety shifts activities in the brain away from the regions that are involved in mathematical reasoning. This reduces the available working memory resources and results in a 'performance deficit', that is, individuals are performing below their mathematical ability levels.
- Low self-concept of one's own mathematical ability has a strong effect on increasing maths anxiety. Avoidance combined with low levels of confidence negatively impact on an individual's effort to learning and doing mathematics with natural consequences on performance.
- Maths anxiety of teachers can cause stereotype threat in students, and endorsing those stereotypes leads to lower achievements, which in turn affects the individual's confidence and increases maths anxiety.
- Maths anxiety, lack of confidence and inadequate preparation during the mathematics education of teachers can lead to poor teaching practices which then contribute more to maths anxiety of students than the actual content of the subject.

Findings about teachers' impact on students' achievements are of concern and demonstrate the urgent need for action on the side of teacher educators and governments to provide:

- Pre-service teachers with a solid knowledge of mathematics, good teaching practices on mathematics teaching and strategies on how to influence student learning; and

- Current and future teachers with adequate access to methods for reducing their own and their students' maths anxiety and increasing their self-confidence.

Support for teachers in these areas needs to be available for in-service teachers and needs to include access to more mathematical knowledge through professional development or appropriate further qualifications. These avenues of support also need to extend to out-of-field mathematics teachers in secondary schools.

Reducing maths anxiety in pre-service, in-service and out-of-field teachers and in female students will have the potential of increasing students' confidence in their abilities, their interest and hence also their enjoyment and engagement with mathematics.

The higher incidence and higher level of maths anxiety and the lower confidence of girls could be major causes leading to the under-representation of girls and women in senior school mathematics and beyond. More research is required to establish the validity of this hypothesis and to inform practical approaches and strategies.

Although at present there are no known interventions which prevent the onset of maths anxiety, recent research on twins and maths anxiety found that non-genetic environmental factors contribute more to maths anxiety than genetic risk factors. These results are promising in that maths anxiety can be effectively addressed from its onset in the early years of primary school.

Gender differences in mathematical confidence and maths anxiety are much larger than the gender gap in interest or achievement of primary school students, demonstrating a need for interventions which increase girls' confidence. Such interventions should start early and be repeated in order to create a positive and lasting effect on confidence, attitude, interest, achievement and career decisions. Such interventions should include:

- A focus on positive role models which includes addressing and disconfirming of stereotype threats;
- Efforts on building and improving confidence and, simultaneously, decreasing maths anxiety;
- A focus in teaching on emphasising aptitude, engagement, and building of confidence instead of achievement and performance; and
- A focus on teaching with a growth mindset framework, directing students' reappraisal in positive directions and teaching students the power of learning from mistakes and adopting a 'failure-as-enhancing' mindset.

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