I liked it till Pythagoras: The Public's Views of Mathematics[26]

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Gender differences in mathematics learning have attracted sustained attention in Australia and internationally. Over time, female participation in academic fields and careers long considered male domains has improved. Yet recent mathematics achievement data reveal that gender gaps favouring males appear to have re-opened. In our study we explored the Victorian general public's views on gender issues and school mathematics. In general, boys were considered to be better at mathematics than girls, that is, vestiges of the male mathematics stereotype persist.

Prologue

> The new focus on nature seems to be encouraging parents to indulge in sex differences even more avidly.... From girls' preschool ballet lessons and makeovers to boys' peewee football... the more we parents hear about hardwiring and biological programming, the less we bother tempering our pink and blue fantasies. (Freeman-Greene, 2009, p.11)

Twenty years have passed since the Victorian (Australia) state government conducted a state-wide media campaign, Maths Multiplies Your Choices, to encourage parents to think more broadly about their daughters' careers. Success in mathematics, it was emphasized, often serves as a critical filter to career and employment opportunities. Sex segregation of the labour market, while common, should not be viewed as inevitable. The success of the campaign was measured both directly – many schools subsequently reported an increase in girls' enrolments in mathematics subjects once they were no longer compulsory – and indirectly. A market research company was employed to explore parents' attitudes to their daughters' education and career before and after the campaign (McAnalley, 1991). Since then, in Victoria, there has been no concerted attempt to measure the general public's views about mathematics learning and the role of mathematics in determining males' and females' career options. In this paper we focus directly on this topic.

Providing a Context

Gender Differences in Mathematics Achievement

Publication of student achievement data from large scale testings seems to ensure that gender differences in mathematics learning continue to attract sustained attention from both the research and broader communities, in Australia and internationally. For example, performance data from the National Assessment Program for Literacy and Numeracy tests [NAPLAN] introduced Australia-wide in 2008, and results for Australian students in the two most recent Trends in International Mathematics and Science Study [TIMSS] tests, illustrate that small but identifiable gender differences in mathematics achievement persist.

NAPLAN results for students at all relevant grade levels are shown in Table 1. These results are given considerable media prominence on their release, for "each year, over one million students nationally sit the NAPLAN tests, providing students, parents, teachers,

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schools and school systems with important information about the literacy and numeracy achievements of students" (NAPLAN 2009, p. 2). Media reports of performance, including gender differences, often contain simplified summaries of complex data (Forgasz, Leder, & Taylor, 2007). This is not altogether surprising, given reporters' time and space constraints. That such media accounts often shape and sway public opinion, including views on gender issues, is well documented (e.g., Barnett, 2007; Jacobs & Eccles, 1985).

Table 1
2008-2009 NAPLAN Mean Scores for Grades 3, 5, 7, and 9 - Mathematics

Year	2008		2009	
Grade level	M	F	M	F
3	400.6	393.1	397.5	390.2
5	481.6	469.9	492.6	480.6
7	552.3	537.3	549.1	538.0
9	586.5	577.6	592.4	585.6

The most striking feature of the data in Table 1 is undoubtedly the large overlap in the performance of males and females. However, it is also apparent that males consistently outperform females. Similarly, despite much overlap in the performance of females and males on the TIMSS tests, small gender differences in mathematics achievement persist. For the TIMSS 2003 testing, mean scores for males in grade 3 were 3 points higher than those of females; in 2007 they were 6 points higher. Corresponding data for the grade 8 sample were: 12 and 15 points higher for males than for females for the TIMSS 2003 and TIMSS 2007 testings respectively (Thomson, Wernert, Underwood, & Nicholas, 2008).

Possible Explanations

Multiple explanations have been put forward for the continuing gender differences in mathematics achievement. After a detailed review of relevant literature, Halpern et al. (2007) concluded that reasons for the overlap and differences in the performance of males and females were multifaceted, and not able to be explained by a single factor and that "[e]arly experience, biological constraints, educational policy, and cultural context" (Halpern et al., 2007, p. 41) could all play a part. Geist and King (2008) also referred to pervasive societal beliefs about gender linked capabilities and their impact:

> Many assumptions are made about differing abilities of girls and boys when it comes to mathematics. While on the 2005 NAEP girls lag only about 3 points behind boys, this is only a recent phenomenon. In the 1970's, girls actually outperformed boys in all but the 12th grade test.... assumptions about differing levels of ability pervade not just the classroom, but home. (pp. 43-44)

In their detailed model of achievement motivation, and implicitly of academic success, Wigfield and Eccles (2000) highlighted the influence on students' learning and behaviours not only of learner-related variables but also of the overall context in which learning occurs, that is the attitudes, actual and perceived, of critical "others" in students' homes and at school, and societal expectations more generally.

Societal Expectations - Public Views about Mathematics

Attempts to measure directly the general public's views about mathematics, its teaching and its impact on careers are rare. As noted above, this was last done in Victoria some 20 years ago. (The cumbersome process to obtain approvals for this study, summarised later in the paper, may help explain the scarcity of such research.) A decade ago Sam and Ernest (1998, p. 7) noted that, "there are relatively few systematic studies conducted on the subject of myths and images of mathematics. We need an answer to the question: What are the general public's images and opinions of mathematics?" Responses to two items framed their subsequent discussion on this topic. Lucas and Fugitt (2007) similarly argued that the public's views on mathematics and mathematics education were rarely sought. Yet, they found that people (Mid-West USA residents) responding to their 10-item survey were generally interested in, and often well informed about, the way mathematics was taught in schools. The respondents generally believed that a good mathematics education offered young people a better and successful future; schools failed to offer effective mathematics education because too much emphasis was placed on technology and not enough on the basics; teachers often exerted too much pressure and criticism to the detriment of their students' attitudes to mathematics; and teachers should make learning mathematics more enjoyable. Issues such as these were also explored in the study reported in this paper.

The Study

Aims

The study's overall aim is expressed concisely in the excerpt, provided below, of the "explanatory statement" needed to be prepared as part of the ethics approval process[27]. As required, a copy of this statement was given to participants.

> We have stopped you in the street to invite you to be a participant in our research study. ...We are conducting this research, which has been funded by [our] University, to determine the views of the general public about girls and boys and the learning of mathematics. We believe that it is as important to know the views of the public as well as knowing what government and educational authorities believe.

To set the scene for our survey, in our first question we asked participants whether they had seen the recent TV advertising campaign *You Can do Maths,* an Australian Association of Mathematics Teachers [AAMT] initiative that "encourages all young people and their families to appreciate the important role mathematics plays in many careers and everyday life" (youcandomaths, 2008)[28]. Although few respondents (13%) remembered seeing the material, and a further 3% were unsure, the item proved a productive starting point.

Method

Data were gathered at a number of heavy foot-traffic sites in the metropolitan area of Melbourne (two main sites), in a large regional centre, and in a rural city. One morning or

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[27] In addition to obtaining overall ethics approval, separate requests needed to be made to the councils involved. One council, claiming that they were "already over committed with Charities", refused our request. While more helpful, others stipulated the precise sites for our data collection, required proof of public liability insurance cover by our "employer", insisted we have a copy of the approval letter with us during data collection, and asked for an assurance that we would collect and bin any paper work handed out if subsequently dropped on the footpath. A startling range of council officers handled our request: "Manager of Animal Administration Compliance and Response"; "Manager – Traffic and Local Laws"; "Director Community Relations"; "Director Corporate Services"; and "Director of Major Projects".

[28] Winners of a competition to write further scripts for the campaign were announced at about the time we conducted our survey (see e.g., http://www.youcandomaths.com.au/press-release-nurse.php)

afternoon (about four hours) was spent at each location. Our goal was to have 50 completed surveys at each site, a minimum number considered adequate for data to be analysed using chi-square tests (Muijs, 2004).

Sample

The public survey sample thus comprised diverse groups located in different parts of the state. The overall sample size was 203: 95 males and 108 females. Of these, 35 were under 20, 90 were aged between 20 and 39, 45 between 40 and 59, and 33 over 60.

The Instruments

To ensure maximum cooperation from those we stopped in the street, we limited our survey to 15 questions. In addition, however, we asked details about age (under 20, between 20 and 39, between 40 and 59, and over 60), and noted whether the respondents were male or female. Further, as well as the readily code-able responses such as "yes", "no", "don't know", "boys", "girls", "the same", respondents were encouraged to elaborate and explain the reason for their answer; the comments were manually recorded by those administering the public survey. To comply with MERGA paper space constraints, we limit our discussion to items which focused on mathematics, omit those concerned with computers, and list the survey items only as part of the presentation of the results. Selected but representative explanations given by interviewees for their answers are also provided.

Results

When you were at school did you like learning mathematics?

More (129: 63.5%) indicated they had liked mathematics than those who had not (67: 33.0%). The rest (7: 3.4%) were ambivalent. Chi-square tests revealed no statistically significant difference by respondent age or gender (though proportionately more males than females stated they had liked mathematics, ($\chi^2 = 5.099$, df = 2, $p<.08$)). Comments included:

> In the early years, yes. Later things went horribly wrong. I had a disastrous teacher.
>
> Yes, I liked mathematics. I had good teachers. This is crucial. I was lucky.
>
> I liked it till Pythagoras and letters meant numbers.
>
> I liked it till year 10.
>
> NO! I hated it.

Were you good at mathematics?

Again more respondents (124: 61.1%) claimed that they had been good at mathematics than those who did not (54: 26.6%). Approximately one quarter (24: 11.8%) considered they had been average. Chi-square tests revealed statistically significant differences by respondent gender: more males than females indicated that they had been good students. ($\chi^2 = 9.442$, $p<.05$, df = 3. Effect size (φ) =.22), but not by age. Explanations included:

> I was good at Primary school but I went down in high school.
>
> I'm much better since I left school.
>
> I learnt enough to manage at work.

I was a champion at tables but no good once we got to Pythagoras.

Has the teaching of mathematics changed since you were at school?

Almost half (98: 48.3%) thought mathematics had changed since they had been at school; fewer (84: 41.4%) said they did not know. The rest (21: 10.3%) thought there had been no changes. Some believed the changes had been for the better:

It's easier now. Teachers explain a lot more.

It's better now. In the past you had to learn the work. Now you can ask questions.

There is more use of computers – I hope that's better. But enough time should be spent on mathematics.

Others were more critical:

I imagine that things have changed. For example, now there are electronics and scientific calculators. It's bad. Students don't know how things happen. They just punch in a formula and that's it.

Mathematics is too computerized now.

Probably things have changed. But people don't seem to be able to do much without calculators. My daughter is lazy now with computers.

Chi-square tests revealed statistically significant differences in responses to this question by age ($\chi^2 = 51.514$, $p<.001$, df = 6. Effect size (φ) =.50), but not by gender. Those in the older two age groups, that is, those aged 40 and over were more likely to say that mathematics teaching had changed; those in the younger two age groups that they did not know.

Should students study mathematics when it is no longer compulsory?

Almost two-thirds (129: 63.5%) of the respondents agreed that students should continue with the study of mathematics, fewer (52: 25.6%) disagreed, and the rest (22: 10.8%) had no clear opinion about this. Chi-square tests revealed no statistically significant differences by respondent gender or age. Again, the additional comments were informative:

No, not if the choice is between language or mathematics.

No, everyone uses calculators at work.

Absolutely. It opens up a lot of career paths and shuts doors if you don't.

Depends on their interests and what they want to do.

Who is better at mathematics, girls or boys?

Just under half (88: 43.3%) of the respondents thought boys and girls were equally good at mathematics; 17% were unsure. Of the remainder more than half thought boys were better (53: 26.1%); fewer believed girls were better (26: 12.8%). Reasons given included:

Boys are always better at mathematics. Girls are good at English.

Boys are better. They like to figure things out.

Girls are better. They can multi-task.

Girls are better in junior school and boys are better in senior school.

Depends on the individual, on their interest. Whichever one spends more time.

Chi-square tests revealed no statistically significant differences in responses to this question by respondent gender or age.

Do you think this has changed over time?

Many respondents (82: 40.4%) thought there had been no change over time.

> No, still boys. They are engineered towards mathematics – it's a society thing.

> Boys still – it's cultural.

Almost as many (73: 36.0%) were uncertain or ambivalent.

> I don't know - I have a son. Boys used to be more competitive but now it seems to be girls.

> In Primary school, girls are better. But when they grow up - men are good at mathematics, more so than girls.

The remainder (48: 23.6%) considered that this (whether boys or girls were better) had changed.

> Yes. I think it used to be boys. Women now seem more interested in getting educated and going to university.

> Girls. Expectations for girls have lifted. They are taking up more mathematics subjects.

> Girls now are better. Maybe it is because girls study more, are disciplined and so now achieve the same as boys.

There were no statistically significant differences in responses by gender or age.

Who do parents believe is better at mathematics, girls or boys?

Few (27: 13.3%) thought that parents considered girls to be better. More than double (59: 29.1%) thought parents assumed boys would be better. Similar proportions thought parents believed boys and girls to be the same (65: 32.0%) or stated that they did not know or that it depended on other factors (52: 25.6%). Chi-square tests revealed no statistically significant differences in responses to this question by respondent gender or age.

> My parents think boys. But girls and boys are the same I think.

> It's changing. It used to be boys.

> No difference. Mum goes on about equality.

> Girls. I have three daughters. It's a silly question.

Who do teachers believe is better at mathematics, girls or boys?

There were few differences assigned by respondents to the beliefs of parents and teachers. The majority stated either that they did not know (68: 33.5%) or that teachers would expect no differences (63: 31.0%). More (44: 21.7%) nominated boys than girls (28: 13.8%) as being better. Differences in responses by gender or age were not statistically significant.

> Boys in my time.

> Girls of course, because it's easier to teach and explain to females.

> I hope no difference. Teachers are supposed to be impartial.

> If you ask my wife she would say boys.

Do you think studying mathematics is important for getting a job?

A clear majority (150: 73.9%) answered in the affirmative.

> It's one of the criteria they, that is employers, look at.
>
> It's essential. We all need basic knowledge of numbers.
>
> All jobs have some element of maths.
>
> It's a necessary skill everyone needs. Maths is involved in everything even if people don't realise it.

About the same number disagreed (28: 13.8%) or did not know or were ambivalent (25: 12.4%). Their responses included:

> No, it is not vital for all jobs.
>
> Depends on the job – yes if it is relevant. But mathematics teaches logic.

There were no statistically significant differences in responses by gender or age.

Is it more important for girls or boys to study mathematics?

Almost all the respondents (188: 92.6%) considered that it was equally important for boys and girls to study mathematics. Of the remainder, more (9: 4.4%) considered the subject to be more important for boys, very few (3: 1.5%) nominated girls and an equally small number (3: 1.5%) had no clear opinion. There were few elaborated answers. Most of those interviewed felt they had clarified their beliefs in answering previous items.

Chi-square tests revealed statistically significant differences in answers to this question by gender, with proportionately more females stating it was equally important and more males nominating boys ($\chi^2 = 10.563$, $p<.05$, $df = 4$. Effect size (φ) =.23), but not by age.

Discussion

The emphasis in our survey was on school mathematics – a subject on which the participants were certainly prepared to reflect. Most, and proportionally more males than females, had apparently liked mathematics at school and thought they had been good, or at least average, in the subject. Older participants were more likely to believe that mathematics teaching had changed since their time at school; younger respondents said that they did not know. From the comments reproduced, and others not listed in the paper, there appeared to be greater concern that technology use had a negative rather than a positive effect on mathematics learning. Participants in Lucas and Fugitt's (2007) study expressed similar fears about the influence of technology on mathematics teaching and learning. The public's beliefs captured in that project about the value of mathematics for future living and careers was mirrored in our study, as was the importance attributed to teachers, who were often mentioned as reasons for having liked or disliked mathematics at school.

Answers to items with a specific focus on boys' and girls' learning of mathematics revealed that many, both males and females, rejected the view that gender is a factor influencing mathematics performance. Nevertheless, there was still a substantial proportion of those surveyed who continued to think that boys were better than girls at mathematics, or were thought to be better, by their parents and teachers. Thus vestiges persist in contemporary society in Victoria, and presumably more widely, with respect to gender stereotyping about mathematics learning and the outcomes of that learning.

Clearly, the design of our study does not allow a direct causal effect to be drawn between the views of the public gathered in this study and the small but persistent gender differences in performance reported in large scale tests of mathematics achievement such as those described earlier in the paper. However, the opinions gathered should not be set aside or trivialised, unless of course, assumptions are made that they do not affect, however subtly, the career aspirations and developing views about mathematics of young people as they grow up in their homes, learn in their schools, mix with their peers, and are exposed to the perspectives and media portrayals of the wider societies in which they live.

The findings strongly suggest the ongoing need to explore, more intensively and extensively, the views of all 'critical others' in the lives of students, including the general public, who may influence their future educational and career directions.

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