PERSONAL BELIEFS AND GENDER GAPS IN MATHEMATICS

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In this paper we report data, gathered in Madrid, Spain, from two groups aged 20-39: one group comprised pedestrians stopped in the City streets, the other consisted of university students, specifically prospective primary school teachers [PPST]. It was found that the PPST were generally more negative than members of the general public about mathematics and its importance. Overall, there was relatively little evidence of gender stereotyping, However, when found, the traditional male stereotype prevailed.

INTRODUCTION

The current study builds on previous work in which the views of members of the public, in Australia and Spain, were sought about studying mathematics and its relevance to career suitability for males and females. The results of the earlier study (Forgasz, Leder, & Gómez-Chacón, 2012) showed that the traditional male stereotype was still prevalent, that is, higher proportions of participants responded that "males" were more suited to studies in mathematics and/or related careers than "females". However, gender stereotyping was less pronounced among the Spaniards. The between country differences suggest that factors in the social milieu shape individuals' beliefs and, therefore, that the social context cannot be divorced from research on affective factors.

Aims

To explore in greater depth which social factors seem significant contributors to views about mathematics and the still apparent gendering of mathematics as a male domain in Spain, the views of two groups were examined: members of the general public (aged 20-39) who were stopped in the streets of Madrid, and Prospective Primary School Teachers (PPST), also in the 20-39 age group. We were particularly interested in the views of the PPST group, given that one of the key influences in children's educational lives is the teaching they receive at Primary School. The opinions or views of their teachers are likely to affect how the students learn mathematics and, as a consequence, may shape or reinforce the students' views of mathematics and gendered views about mathematics.

Background context

Findings from two studies – PISA 2012 and Teacher Education and Development Study [TEDS-M] (Tatto et al., 2012) – contextualise the Spanish setting.

For Spanish students, the scores on the PISA mathematical literacy tests have remained stable between 2003 (481) and 2012 (484) (Thomson, de Bortoli, &

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Buckley, 2013). (In 2012 the OECD average was 494.) Boys, on average, consistently scored higher than girls on the tests: 9 points higher than girls in 2003, and 16 points higher in 2012 – one of the largest increases in the gender gap in mathematics performance among countries with data for both 2003 and 2012.

Attitudinal data gathered as part of the PISA 2012 tests (OECD, 2013) revealed differences in the responses of boys and girls – with respect to enjoyment of mathematics (girls lower than boys), worry about poor grades in mathematics (girls higher than boys), getting nervous when doing mathematics problems (girls higher than boys), believing that they are not good at mathematics (girls higher than boys).

The Teacher Education and Development Study, or TEDS-M (Tatto et al., 2012) results for Spain provide strong evidence of the benefits of pre-service teacher preparation programs at colleges and universities. Ways to improve pre-service teachers' mathematical knowledge for teaching – mathematics content knowledge and mathematics pedagogical knowledge – were identified. When teachers design learning opportunities, reflect on instructional situations, and act or react in the mathematics classroom, motivational and affective aspects of learning and instruction also need to be considered.

Theoretical models informing the study

Many of the early explanatory models for gender differences in the outcomes of mathematics learning (Eccles, 1985; Leder, 1992) and more recent research findings (Baker & Jones, 1993; Halpern et al., 2007) have included societal influences (access to education, laws, and the media) and the views of significant others (parents, teachers, and peers) among the contributing factors. The items developed for the survey used in the present study are consistent with these social milieu elements – see Forgasz et al. (2012).

THE STUDY

Samples and methods

The two samples surveyed in the present study were: group 1 – pedestrians (N = 393), and group 2 – prospective primary school teachers (N = 272).

For the pedestrian survey, participants were drawn from nine sites in the northwest, south, and central areas of Madrid. Data collection was conducted one day a week for a two month period; a morning of approximately three hours was spent at each location. The prospective primary school teacher [PPST] survey was conducted on-line in class at university. Data were collected from students at two universities.

The instrument

The instrument used for data collection was described in Leder and Forgasz (2010). It was translated into Spanish; 14 of the original items were retained (see Table 1 Q2-Q15). An additional question was added for the PPST only: Q1 – "Can you do mathematics? The 15 items represent two dimensions: personal beliefs (Q2-Q5 and Q10), and gender-stereotyped beliefs (Q6-Q9, Q11-Q15). The age and gender of participants were also recorded. As well as the readily codeable (quantitative) responses (e.g., "yes", "no", "don't know", "boys", "girls", "the same"), respondents were encouraged to provide explanations for their answers. [NB. The qualitative comments were manually recorded for the pedestrian sample.]

Analyses

For the quantitative data, frequency distributions of the responses to the items were examined and Pearson chi-square (χ^2) tests were conducted to identify differences in the responses of the participants from the two groups; effect sizes (φ) for statistically significant differences were also calculated.

For the qualitative data, the open-ended responses were closely examined and categorised; a grounded approach was adopted. The emerging themes were: attitudes towards mathematics and its learning; beliefs about personal mathematical abilities; descriptions of the process of learning mathematics; epistemology and views about the nature of mathematics; and values of mathematics education.

RESULTS AND DISCUSSION

A summary of the quantitative differences between the two groups on Q2-Q15 is found in Table 1 (which also includes response options).

As seen in Table 1, five of the 14 items were found to be statistically significantly different by group: Q2, Q3, Q5, Q7, and Q10. Four of these (Q2, Q3, Q5, and Q10) relate to personal beliefs; the fifth (Q7) is a gender-stereotyped belief. The results are reported under the two main headings: personal beliefs, and gender-stereotyped beliefs.

Question	Response options	Pedestrians	PPST	χ^2, p-level, φ
Q2 When you were at school, did you like mathematics?	Yes	289 (73.7%)	68 (25%)	155.6
	No	100 (25.5%)	202 (74.3%)	p< .001
	Average	3 (0.8%)	2 (0.7%)	φ=0.48
Q3 Were you good at mathematics?	Yes	279 (71%)	57 (21%)	175.6
	No	92 (23.4%)	202 (74.3%)	p< .001
	Average	22 (5.6%)	12 (4.4%)	φ=0.51
Q4 Has the teaching of	Yes	122 (31%)	95 (34.9%)	ns

Question	Response options	Pedestrians	PPST	χ^2, p-level, φ
mathematics changed since you were at school?	No	135 (34.4%)	80 (29.4%)	
	Don't know	136 (34.6%)	97 (35.7%)	
Q5 Should students study mathematics when it is no longer compulsory?	Yes	222 (56.6%)	70 (25.7%)	71.7
	No	108 (27.6%)	156 (57.4%)	p< .001
	Don't know	61 (15.6%)	43 (15.8%)	φ=0.3
Q6 Who is better at mathematics, girls or boys?	Girls	53 (13.5%)	35 (12.9%)	ns
	Boys	47 (12%)	22 (11.8%)	
	Same	268 (68.2%)	185 (68%)	
	Don't know	25 (6.4%)	20 (7.4%)	
Q7 Do you think this has changed over time?	Yes	107 (27.4%)	151 (55.5%)	66.5
	No	221 (56.5%)	73 (26.8%)	p< .001
	Don't know	59 (15.1%)	46 (16.9%)	φ=0.32
Q8 Who do parents believe are better at mathematics, girls or boys?	Girls	31 (7.9%)	16 (5.9%)	ns
	Boys	42 (10.7%)	29 (10.7%)	
	Same	177 (45.3%)	115 (42.3%)	
	Don't know	141 (36.1%)	111 (40.8%)	
Q9 Who do teachers believe are better at mathematics, girls or boys?	Girls	42 (10.7%)	29 (10.7%)	ns
	Boys	51 (13%)	28 (10.3%)	
	Same	222 (56.8%)	160 (58.8%)	
	Don't know	76 (19.4%)	54 (19.9%)	
Q10 Do you think that studying mathematics is important for getting a job?	Yes	223 (56.9%)	67 (24.6%)	82.3
	No	101 (25.8%)	159 (58.5%)	p< .001
	Don't know	66 (16.8%)	44 (16.2%)	φ=0.35
Q11 Is it more important for girls or boys to study mathematics?	Girls	5 (1.3%)	4 (1.5%)	ns
	Boys	5 (1.3%)	4 (1.5%)	
	Same	352 (90%)	245 (90.1%)	
	Don't know	29 (7.4%)	19 (7%)	
Q12 Who are better at using calculators, girls or boys?	Girls	20 (5.1%)	14 (5.1%)	ns
	Boys	39 (9.9%)	27 (9.9%)	
	Same	290 (73.8%)	199 (73.2%)	
	Don't know	44 (11.2%)	31 (11.4%)	
Q13 Who are better at using computers, girls or boys?	Girls	3 (0.8%)	2 (0.7%)	ns
	Boys	123 (31.3%)	82 (30.1%)	
	Same	241 (61.3%)	169 (62.1%)	
	Don't know	26 (6.6%)	18 (6.6%)	

Question	Response options	Pedestrians	PPST	χ^2, p-level, φ
Q14 Who are more suited to being scientists, girls or boys?	Girls	33 (8.4%)	14 (5.1%)	ns
	Boys	18 (4.6%)	12 (4.4%)	
	Same	311 (79.1%)	222 (81.6%)	
	Don't know	31 (7.9%)	22 (8.1%)	
Q15 Who are more suited to working in the computer industry, girls or boys?	Girls	5 (1.3%)	1 (0.4%)	ns
	Boys	67 (17.1%)	47 (17.3%)	
	Same	295 (75.3%)	207 (76.1%)	
	Don't know	25 (6.4%)	15 (5.5%)	

Table 1: Frequency distributions and chi-square results (by group) for survey items

Personal beliefs

The four items (Q2, Q3, Q5, and Q10) that were statistically significantly different revealed the following between group differences:

- Q2: an appreciation for and enjoyment of mathematics when they were at school ('like': 73.7% Ped [pedestrian group], 25% PPST; $p<.001$, $\varphi= .48$)
- Q3: beliefs concerning whether they were good at mathematics (good: 71% Ped, 21% PPST; $p<.001$, $\varphi= .51$);
- Q5: beliefs about whether students should continue learning mathematics when it is no longer compulsory ('yes': 56.9% Ped, 25.7% PPST; $p<.001$, $\varphi= .32$); and
- Q10: beliefs concerning whether studying mathematics was important for getting a job ('yes': 56.9% Ped, 24.6% PPST; $p<.001$, $\varphi=.35$)

The data in Table 1 reveal that the majority of PPST did not like mathematics (Q2), and that they did not consider themselves to be good at mathematics (Q3). When the PPST were asked the additional question, 'Can you do mathematics?' (Q1), 46.3% indicated that they could not. This is a sobering finding because these are future primary teachers who will have to teach and encourage pupils to learn mathematics.

We examined some of the explanations that participants provided for their responses to the four items (Q2, Q3, Q7, and Q10) that were statistically significant different by group. We focus on examples from the PPST sample because this group is of particular interest. As well, there were much lower proportions of positive responses from this group.

Q2: "When you were at school, did you like mathematics?"

Only one-quarter of the PPST indicated that they liked mathematics. Three major themes emerged in their answers: attitudes (e.g., "Mathematics is boring"), teacher influence (e.g., "I was not very good at math, I think that I did not have a good

teacher", and beliefs about personal mathematical competence and knowledge (e.g., "It seems complicated and difficult to understand"; and "It doesn't interest me and it doesn't seem useful in real life.").

Q3: "When you were at school, were you good at mathematics?"

Whether the PPST considered themselves good or not at mathematics (and the majority did not) was often explained in terms of getting good or bad grades in this subject. Another theme was related to the view of mathematics as "a group of rules or steps to follow". A third perspective was of mathematics being linked to negative emotions, often associated with the teacher.

Q5: "Should students study mathematics when it is no longer compulsory?"

The majority of the PPST group considered that the further study of mathematics beyond the time it is compulsory, should be a personal decision and would depend on whether the individual wanted to study it or not. For many PPST participants the discipline of mathematics seemed completely isolated from the real world. They did not see the need for using mathematics in everyday life. Those who thought that mathematics should continue to be studied talked in terms of only those parts which could help them become useful members of society. The more theoretical or abstract parts, they claimed, should only be taught to those students who were planning to pursue careers in which these concepts would be necessary.

Q10: "Is studying mathematics important for getting a job?"

Surprisingly, many participants from the PPST group did not consider mathematics to be important for getting a job or, as shown in their responses to Q5, that it should not be studied when it is no longer compulsory. Typical examples of the responses of the PPST group to question Q10 reflected a belief that only basic knowledge is necessary for daily life and mathematics was disconnected from the real world (e.g., "It depends on the level of mathematics. Obviously everyone needs to know how to add and subtract and everything. But why on earth would a baker need to work out the cubic root of an imaginary number.").

Gender-stereotyped beliefs

There were no statistically significant differences for eight of the items tapping gender-stereotyped views (Q6, Q8, Q9, Q11-Q15). The vast majority of respondents in both groups believed that it was equally important for girls and boys to study mathematics (Q11). Among the low percentages of respondents who held gender stereotyped views, there was little difference in the two groups' response frequencies about males' and females' mathematical capability (Q6); perceptions of parents' (Q8) and teachers' (Q9) beliefs about boys' and girls' mathematical proficiency; about calculator use (Q12); and suitability to being scientists (Q14). However, the

traditional male stereotype was evident – higher proportions responded "males" than "females" – with respect to views about computer competency (Q13) and suitability for working in the computer industry (Q15).

The only statistically significant difference between the two groups was found for Q7. A higher proportion of PPST (55.5%) than pedestrians (27.4%) believed that there has been a change over time in whether boys or girls were better at mathematics. Two factors stood out in the explanations for the beliefs of the PPST group. The first was the role of females in society. For example, one PPST wrote:

> previously women did not study and instead dedicated themselves to looking after children and domestic chores, and were therefore outside the education system. Sometimes they were not able to access schooling and when they did they received a very different education to the boys, one that focused more on tasks related to running a household.

The second factor related to gender equality in the education law, which has been a decisive factor for women to access education.

CONCLUSIONS

Surprisingly, substantial differences were found in the personal beliefs about mathematics and its importance between the pedestrian group and the PPST group. Disappointingly, the PPST group was more negative than the general public about mathematics, about their competence in mathematics, and about the importance of mathematics, intrinsically, and for jobs. Further research to understand the longer-term implications of the PPST's views on student learning of mathematics, educational aspirations, and gender-stereotyped attitudes and beliefs is needed.

There was little evidence overall that either group held strong gender-stereotyped views about mathematics or related careers. The one exception was regarding males' and females' competence with computers and suitability to work in the computer industry, with both groups holding more strongly to the traditional male stereotype.

Further research is also need to explore in depth the relationships between views such as those identified in this study and Spanish students' relatively low PISA performance and the growing gender gap in mathematics achievement between 2003 and 2012.

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