ATTITUDES AND META-COGNITIVE ASPECTS OF LEARNING MATHEMATICS: AN ANALYSIS BY GENDER

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ABSTRACT

Gender differences in mathematics achievement favouring boys are more often found on harder, problem solving tasks than routine questions and are more often found with older students than younger students. To examine the possible implication of factors hypothesised to be related to problem solving ability, information was gathered from 14 classes of students in Years 7 to 10. Girls consistently displayed greater meta-cognitive knowledge. Younger girls gave greater importance than boys to learning styles that are related to the teacher, effort and memorising, but by Year 10 the boys had come to value these just as much as the girls. Only on confidence and, to a lesser extent, enjoyment did the sex differences consistently favour boys.

INTRODUCTION

Early in the study of gender differences in mathematics achievement, the observation was made that gender differences in favour of boys were more pronounced on hard "higher order" tasks than on routine, generally computational, tasks (Fennema, 1980). Despite the many changes that have since been made to increase girl's interest in mathematics, their perception of its importance and their participation at school, this phenomenon continues (Leder, 1985; Marshall, 1984). The Australian Mathematics Competition provides a striking example as girls have been consistently under-represented amongst high achievers in this competition (Atkins and O'Halloran, 1978; Edwards, 1984). In 1990, over 90% of secondary schools in Australia and approximately one in every three Australian secondary students entered this competition, with girls and boys entering in nearly equal numbers. Yet, despite serious attempts to eliminate sex-bias from the

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questions, girls made up only 23% of the top group and only 3 of the 27 medal winners ("Sex bias does not compute", The Australian, 30/10/90, page 3).

Because these consistent and persistent gender differences in performance are associated with mathematical problem solving and also tend to increase with age, it is of interest to examine the changes over the secondary years in various factors which are hypothesised to contribute to problem solving performance (see, for example, Schoenfeld 1985): knowledge of mathematical content (both quantity and quality) and appropriate problem solving strategies, attitudes to mathematics and beliefs about how it is done, meta-cognitive factors and aspects of control and affective factors. In this paper, data is presented which shows how some of these factors develop in girls and boys in Years 7 to 10.

METHOD

Sample

Data was collected from students at a State secondary school in a suburban lower-middle class area of Melbourne, Australia. All students in Years 7 to 10 (average ages 12 to 16) are taught the same course in mixed-ability classes. The 14 tested classes were volunteered by their teachers, 3 men and 4 women. The numbers of students supplying largely complete data is given in Table 1. (The actual numbers of students responding to each item is often a little lower because of omissions and absences at the time of testing.)

Measurements were made of student achievement, attitudes, meta-cognitive knowledge and preferred learning styles, especially those that might relate to rote learning or learning with understanding. Below each variable is listed, with the notation subsequently used and an outline of the measurement procedure.

Table 1: Number of students and classes in sample.

	Year 7	Year8	Year9	Year 10	
No. of classes	4	3	1	6	
No. of boys	23	25	9	55	No of
girls	35	42	13	61	

Achievement Measures

MM - Maths mark: This was the overall mark assigned for each student by his or her teacher and includes some test marks, some assignment work and some recognition of effort and completion of tasks.

PS - Problem solving mark: This score was obtained by administering during class time one of two 50 minute tests. Years 7 and 8 were given the test described by Bourke and Stacey (1988) whilst Years 9 and 10 had a non-routine problem solving test developed by the author as part of a larger study. This test consists of six questions requiring a range of problem solving and mathematical skills.

Attitude measures

These scales each consisted of 6 or 8 Likert items. Reliability coefficients for the scales was calculated using an unrelated sample of 131 secondary students.

ENJ - Enjoyment of mathematics lessons: The scale was developed by Bourke (1984). (Cronbach alpha 0.84).

USE - Perceived usefulness of Mathematics in everyday life[2] : Scale developed by Bourke (1984) (Cronbach alpha 0.81)

CONF - Confidence to succeed in maths - This scale was adapted from the scale used by Fennema and Sherman (1978) (alpha 0.86)

UND - Importance attached to understanding: This scale (alpha 0.75) was developed by author and included items such as " I learn best when I understand the reasons" and "It is a waste of time when the teacher explains why a formula works".

NAT - Appreciation of nature of mathematics: Scale developed by author (Cronbach alpha 0.76) consisting of 8 items, relating to the utility and intrinsic interest of mathematics.

Meta-cognitive measures

Three free-response items measured students' meta-cognitive awareness of their knowledge, and of mathematical processes and strategies.

[2] Perceived usefulness of mathematics to get a job was also initially measured. However, almost all students strongly agreed Maths is useful for employment. The testing followed the Government sponsored television campaign "Maths multiplies your choices" at the end of 1989.

MIST - To assess awareness of mathematical knowledge, students were asked to list 4 different mistakes which they commonly make. These were scored by counting the number of structurally different items.

STUCK - There are two crucial decision points in solving mathematical problems where an overall meta-cognitive understanding seems particularly important- when you are stuck on a problem and when you need to check what you have done. Students were asked to write down the advice they would give to a friend in these two circumstances. The resulting measures (STUCK and CHECK) were obtained by rating students answers as follows:

0 no sensible response

1 responses which amount to asking someone else (e.g. ask your teacher, look up the answer in the back of the book)

2 simply repeat the question

3 responses showing some student initiative (e.g. re-read your notes, try a similar example, work backwards etc)

4 more than one of the responses earning 3 above.

CHECK- as for STUCK

Preferred Learning Styles

In order to identify differences between rote learners and students who try to understand, students had to rate a variety of ways of learning maths as a most (or least) important way to learn maths or neither, scoring -1 for a least, 0 for neutral and +1 for most.

ACT- Perceived importance of Activity methods (4 items: making models, measuring, doing activities, using materials)

TEA - Perceived importance of teacher and work related methods (4 items: listening to teacher explain, memorising the rules, copying how the book does it, watching the teacher do examples)

DO - One item " Doing a lot of examples of each type".

HEART - One item :learning it off by heart".

MEM - Two items: A most important reason why students do not do well in maths is that "they do not get enough practice"/"there is too much to remember".

RESULTS

Space does not permit the inclusion of detailed numerical results. The sex differences found are summarised below in Table 2. All variables were found to correlate with MM and PS in the predicted directions although some of the correlations were small (0.1). CONF had the highest correlation, around 0.5 for each year level.

Table 2: Differences between scores of girls and boys.

	Year 7	Year 8	Year 9	Year 10
PS	-	-	-	-
MM	G*	-	-	G*
NAT	-	-	B	-
USE	G*	G	G	-
CONF	B	B	B	B
UND	-	G*	-	-
ENJ	B	-	B*	B
STUCK	G*	G	G	G**
CHECK	G	G	G	G**
MIST	G**	G	G	G*
ACT	-	-	-	-
MEM	-	G	G*	-
TEA	G*	G	-	-
DO	G*[3]	G	-	-
HEART	-	-	-	-

CODE:

blank (-) scores for girls and boys very close (sig. level of diff >30%)

G - girls score higher than boys B - Boys score higher than girls

[3] More boys chose this as a least important way of learning maths. Girls were more often neutral.

* difference significant at 5% level	** diff. significant at 1% level

Differences in means for achievement and attitudes (PS, MM, ENJ, USE, CONF, UND, NAT) were tested for significance with a t-test at each year level. For meta-cognitive knowledge and preferred learning styles, the scores were small integers (max range -4 to +4), so that Chi-squared tests on the proportions of responses with each score were applied to test for significant differences.

DISCUSSION OF RESULTS

Neither achievement measure shows a difference in favour of the boys at this school, even though this may have been expected for the problem solving test, particularly at Years 9 and 10. (Previous research with the Year 7 and 8 test when used in primary school had not found a difference in favour of boys (Bourke and Stacey, 1988)). The reasons for this are unclear, although it may be associated with the fact that the test is administered in class time by the classroom teacher, without any element of competition. Alternatively, this may support the observation of Annice et al (1988) of the Australian Mathematics Competition that sex differences were greater in routine word problems than in non-routine problem solving, such as has been tested here. This needs further investigation.

The attitude measures show the consistently greater confidence of boys, as is generally reported in the literature, and a tendency for boys to enjoy lessons more than girls (although all means were reasonably close to neutral - neither like nor dislike). The generally higher ratings for everyday usefulness of mathematics by girls were unexpected, and as commented earlier, our impression was that almost all students expressed a strong belief that mathematics is useful for employment. This is a very positive result because perceived usefulness of mathematics is often found to be a strong predictor of student choice to continue with mathematics (Fennema and Sherman, 1978).

On the meta-cognitive measures (STUCK, CHECK and MIST), the girls uniformly gave more suggestions than the boys, which certainly indicates no lack of meta-cognitive awareness of mathematical processes. There was less difference on UND, which attempted to measure importance placed on understanding the reasons behind mathematical principles, rather than learning by rote.

Several differences in preferred learning style were noted. Perhaps surprisingly, boys did not place greater value on activity methods (making models, measuring things etc) than did girls. In fact, few students valued these methods - they were the items most often negatively rated. A similar pattern from Years 7 to 10 was shared by the measures related to work-related, teacher-centred methods and memorising. The younger girls gave greater importance than the boys to teacher and work related methods (MEM, TEA, DO). By Year 10, the values placed on these by the boys had risen to the same level as that of the girls. This pattern may merely reflect differences in maturation or it may point to an earlier predisposition of girls to rote learning (despite their agreement with the propositions of importance of understanding). The connection with problem solving ability is unclear from this analysis.

Two further analyses by gender of this data are warranted: firstly the data for high achievers will be analysed separately as these are where the greater problem solving differences are often found and secondly a study is being made of those students who show marked inconsistencies between their school maths mark and their results on the problem solving test.

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