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ABSTRACT

Gender differences in mathematics learning continue to attract much research attention. Single-sex settings as the preferred option for improving schooling for girls have evoked fierce advocates as well as critics. This case study, undertaken in response to a specific request from a co-educational state school in the outer area of Melbourne, Australia, and with its maximum cooperation, examined both the shorter and longer term effects on students' attitudes and performance in mathematics of the introduction of single-sex mathematics classes at the grade 10 level. Important dimensions of the study included surveying students in as well as out of the program, seeking the reactions of parents to this initiative, and the opportunity to assess the effect of the introduction of such classes at grade 10 instead of at lower grades (7 and 8), where such interventions have more typically been tried. Results include: (1) Both female students and mothers were more favorably inclined towards the single-sex mathematics program than were their male counterparts; (2) Performance levels for males and females were not significantly different throughout the project year; and (3) Anticipated and actual subject choices for grade 11 were no different for males and females; however, anticipated subject choices for grade 12 showed more differences between males and females than past state average statistics. Contains 10 references. (Author/MKR)

SINGLE-SEX MATHEMATICS CLASSES IN A CO-EDUCATIONAL SETTING:

A CASE STUDY

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Gender differences in mathematics learning continue to attract much research attention. Single-sex settings as the preferred option for improving schooling for girls have evoked fierce advocates as well as critics. This case study, undertaken in response to a specific request from a co-educational state school in the outer area of Melbourne, Australia, and with its maximum cooperation, examined both the shorter and longer term effects on students' attitudes and performance in mathematics of the introduction of single-sex mathematics classes at the grade 10 level. Important dimensions of the study included surveying students in as well as out of the program, seeking the reactions of parents to the initiative, and the opportunity to assess the effect of the introduction of such classes at grade 10 instead of at lower grades (7 and 8) where such interventions have more typically been tried.

Background to the study

The impetus for this study came from staff at a co-educational high school in the outer metropolitan area of Melbourne, Australia. They wished to assess the effectiveness of an experimental program they had recently introduced: to deliver mathematics to grade 10 students in single-sex settings. In the previous two years the school had made one single-sex mathematics class available for girls at grade 10 who particularly wished to learn mathematics in such an environment. At the end of 1992 the mathematics staff, with the support of the principal, decided to extend the program, to make **all** grade 10 mathematics classes single-sex, and to determine the impact on the students of this initiative in its first year. At all other grade levels mathematics would continue to be taught in mixed groups. By selecting grade 10 for this intervention it was hoped that more females in particular would elect to continue with the more rigorous mathematics courses which are optional at grades 11 and 12[1].

Previous research

Whether females in single-sex classes are advantaged with respect to mathematics learning continues to attract research attention. Studies comparing mixed and single-sex learning settings have more commonly been conducted with students from single-sex and co-educational schools. Findings have been inconsistent (Gill, 1988). Some schools have tried single-sex settings within co-educational schools. Although some

[1]The academic school year in Australia coincides with the calendar year and in Victoria is divided into four terms.

promising results have been reported from science (Sampson, 1989) and mathematics classes (Rowe, 1988; Schwarz & Rowe, 1990; Wettenhall, 1985), the optimal learning setting for girls in mathematics remains unclear.

In one study, students in grades 7 and 8 were randomly allocated to single-sex or co-educational mathematics classes. No gender differences in achievement were found over the two year monitoring period but there were significantly higher gains in confidence for students in the single-sex classes than in the mixed classes; the most notable gains being found for girls (Rowe, 1988). Grade 9 students' attitudes towards single-sex or mixed classes in mathematics and science were reported by Regan (c1992). Descriptive data revealed that females from single-sex classes believed that students of both sexes benefited from the single-sex learning setting and that they should continue into the next year; males from single-sex settings expressed opposing views equally strongly.

Using a number of affective variables incorporated in models explaining gender differences in mathematics learning outcomes (see Leder, 1992), Forgasz (1993) compared the scores of grade 7 males and females from single-sex and mixed mathematics settings. Gender differences were found for students in co-educational schools irrespective of whether the students were in single-sex or mixed classes. Males from the single-sex setting were found to be more stereotyped about mathematics as a male domain than were males from the mixed settings. The differences in the scores of males from mixed and single-sex settings were greater than between corresponding groups of females. Bornholt, Goodnow and Cooney (1988) investigated factors influencing the achievement self-concepts of students in grades 7 to 10. Males were found to make higher estimates of their mathematics achievements than females, and differences in estimated achievement levels were smaller between males and females in co-educational settings than for males and females in single-sex schools.

Some girls, who have experienced single-sex classes, have expressed concern that this environment can engender a false sense of security (Milligan et al., 1992). Teachers have suggested that gender-stereotyped views can be re-inforced just as easily in single-sex as in co-educational classes (Milligan et al., 1992). According to Gill (1988), teacher perception and teaching style are likely to be as crucial in single-sex girls' classes as in mixed classes to achieve desired ends.

Objectives

The main aim of this paper is to trace the effectiveness in enhancing student appreciation of, and participation in, mathematics of a school initiated program: presenting mathematics in single-sex settings to grade 10 students in an otherwise co-educational school environment. Data gathering included attitudinal as well as performance measures.

Theoretical framework
Four theoretical perspectives used at different times to examine gender differences in mathematics learning were discussed at the 1992 meeting of the *International Organization of Women and Mathematics Education (IOWME)* held in Quebec during the *7th International Congress on Mathematical Education (ICME-7)*. These were the intervention perspective, the segregation perspective, the discipline perspective, and feminist perspectives. These categories are best regarded as overlapping rather than mutually exclusive: positions emphasized through different feminist perspectives are reflected as well in the first three categories. For example, there is commonality between the intervention and feminism of equality perspectives, between the discipline and radical feminism perspectives and between the segregation and feminism of difference perspectives.

Those working within the segregation framework assume that curricula and methods of teaching are typically geared to the needs of males rather than females. A viable method for facilitating the learning of mathematics by females, they argue, is to organize a single-sex learning environment which allows the needs and preferences of females to be catered for more directly. The intervention strategy described in the present study falls within the segregation paradigm.

Methods and techniques
Quantitative and qualitative research techniques were used for data gathering. An overview of the instruments and time line is given in the next section.

Data sources
To date there have been three distinct periods of data gathering: early in the school year, in the middle of term 1; during third term i.e., seven-eight months into the program; and just before the end of the school year. Self-report, paper-and-pencil tests were the primary sources for phases one and three. The second data collection phase relied primarily on interviews. Those interviewed included students currently in the program as well as students at grades 9 and 11. Data were also gathered from parents with children in grade 10.

Self report measures
The diversity of the self-report measures administered can be gauged from the list that follows. Students were asked to complete:

1. A 30 item Likert scale which sought students' views about mathematics. It included statements such as 'My teacher encourages me in maths', 'Maths is of little use in my life'.
2. A 36 item scale which elicited students' attributions for success and failure in mathematics.
3. Students were asked to respond to a number of items on five point scales (5=excellent to 1=weak). Questions asked included: 'How good are you at maths?', 'How good at maths would you like to be?', 'How good at maths does

your teacher believe you are?', and 'How good at maths would your parents like you to be?'

4. A 50 item Likert scale which sought students' perceptions of their mathematics classroom environment. Statements to which students were asked to respond included 'All students in the class use the same textbook', 'Students solve problems by obtaining information from the library'.
5. A Semantic Differential scale was used to describe 'what kind of person you think you are'. Bipolar adjectives included industrious/not hard working, independent/dependent.
6. Various open ended questions, e.g., 'If you could change your mathematics classes, what would you change? Explain why you want these changes', 'Do you like maths? Explain why'.

Interview data

The interviews covered the following main issues:

1. Students' response to their single-sex class.
2. The effect of the single-sex class in relation to learning mathematics.
3. Working with the opposite sex.
4. Students' perceptions of and attitudes to teachers in relation to single-sex classes.
5. Relevance of mathematics for the future.

Follow up questions were asked as appropriate.

Performance data

Teachers were asked to provide a rating of students' performance in mathematics at the beginning, middle, and end of the year. These ratings relied primarily on data obtained through the school's regular assessment program.

Time 1 - end of term 1, i.e., late March

Sample size

The sample size for this part of the study consisted of 82 males and 84 females.

Results

Despite the considerable overlap in the females' and males' responses, a number of interesting differences were identified in the responses of grade 10 students at the beginning of the year when they had been in the single-sex environments for 6-8 weeks. For example,

* More females than males rated themselves average at mathematics (40% and 24% respectively), while more males (30%) than females (11%) rated themselves excellent (see Figure 1),
* More males (35%) than females (20%) indicated that their classmates would probably think they were excellent at mathematics (see Figure 2),

PLACE FIGURES 1 AND 2 ABOUT HERE

* Males were more confident about themselves as learners of mathematics ($t_{158} = 1.76$, $p<.1$),

* Females perceived their teachers as more supportive of them as learners of mathematics than did males (t_{161} = 2.63, p<.05)
* Females were more likely than males to attribute success to environmental factors (t_{158} = -3.059, p<.005), failure to effort (t_{158} = -1.845, p<.07) and ability (t_{159} = -2.196, p<.05),
* Males were more likely than females to attribute success to ability (t_{157} = 1.826, p<.07), failure to environment (t_{160} = 2.219, p<.05),
* Females perceived, more strongly than males, that they were encouraged to participate actively in class (t_{138} = 1.86, p <.1),
* Compared with males, females considered that their teachers placed a greater emphasis on providing opportunities for interacting with them and showed more concern for their personal welfare and growth (t_{143} = 3.42, p <.05),
* When asked what, if anything, they would like to change about mathematics lessons, 25% of the boys nominated 'bring girls back', compared with 10% of the girls who wrote 'bring boys back'.

Time 2 - term 3, i.e., July-August
1. *Student interviews*

(1) Grade 10 students

Sample size
Fifty-three students, 25 males and 29 females, were interviewed individually. Most interviews took approximately 15 minutes.

Students' perceptions of their grade 10 single-sex mathematics classes
The main areas explored are summarised under the relevant heading.

1. Students' responses to their single-sex classes
Students were asked why they thought single-sex classes had been introduced. The main reasons given by the boys emphasized academic concerns - e.g., 'To make people work harder'; 'So students can concentrate a lot better'; 'Because girls would work better in a single-sex class'. Other answers focused, directly or indirectly, on the negative effect the boys had on the girls. The boys thought girls were 'distracted' by boys; boys 'intimidated' girls or 'stopped girls from learning'; and that teachers thought boys 'got more attention'.

The girls gave three main reasons. The first concerned the negative effect the presence of boys had on the girls as agents of embarrassment and/or inhibition. Girls spoke of being too 'embarrassed' to ask questions, of being 'harassed' by the boys, of 'annoyance', of 'being made fun of' and of feeling 'pressure' from the boys. The second referred to the 'distraction' associated with boys' behavior towards girls or

their 'distraction of the class'. The third main area was related to the actual work - whether or not girls would work better if not 'distracted' by boys.

Just over half the boys (52%) said they would not choose single-sex classes again if they had the option. This was in contrast to an overwhelming 92% of girls who said they would.

2. The effect of single-sex classes on the learning of mathematics

When asked whether their performance in mathematics had changed during the year, half (50%) of the girls indicated that their achievements had remained much the same. Of the remaining group all but two considered that their mathematics had improved. While some gave being in a single-sex class as the reason for the improvement, others attributed this to working harder or to the teacher. For example, more work was done because of having 'a better teacher', or because the teacher was 'explaining it better', and especially in conjunction with 'no interruptions from the boys'.

Of the boys interviewed, only 12% considered that they were having greater difficulty with mathematics and cited not working well and the teacher as reasons. The 56% who considered they were doing better also cited the teacher as a reason and/or their own improved concentration.

When asked how things had differed in single-sex classes, some boys said they could ask more questions now that the girls were not there. For example, when the girls were there 'you tried to impress them'; now 'the guys act more like guys and you talk about the girls ... If you got the answer wrong it didn't really matter because the girls can't say anything'. Several boys commented that there was not really any difference; as one boy put it - 'just no girls'. Many responses did not refer to the presence/absence of girls. Many girls commented that they were able to get more work done in the single-sex setting than had been possible the previous year when they were in a co-educational class. 'Girls were more into working [this year] than impressing the boys' was a representative comment. The teacher's manner ('was nicer') and a more acceptable rate of instruction also attracted favourable comments.

Responses from boys and girls on when and for what subjects they would introduce single-sex classes were similar. The majority of students (44% boys and 61% girls) considered grade 9 the best year to introduce single-sex classes as grade 9 was seen as an unsettled year and single-sex classes could have a settling effect. However, the girls added another dimension: because of 'the maturity level of the boys'. Some girls, as well as boys, considered that by grade 11 mathematics classes could return to being co-educational. The effect of the

looming VCE[2]. was regarded as being motivation enough for concentrated study and application.

Both boys and girls favored the introduction of single-sex classes for some grade levels, mostly for grades 9 and 10, but only for some subjects. Mathematics was considered suitable. So was a combination of mathematics and English. Few thought that English alone should be taught in single-sex classes. Some girls mentioned science as a possibility.

3. Working with the opposite sex

For small group work, many girls (46%) preferred being in a single-sex group. Reasons given included a greater sense of ease: It was 'easier to talk to girls', more 'relaxed', more 'comfortable'. Boys were seen as less likely to do the work than the girls. In contrast to the girls, the majority of boys (72%) preferred to work in a mixed group. Reasons centred around greater diversity of input, less competition, and the fact that girls work hard and are often more willing to help others.

4. Students' perceptions of their teachers' attitudes to single-sex classes

The majority of girls thought their teacher liked teaching a single-sex class. Most students who had a female teacher thought she must like it because it was 'easier' - this word was mentioned many times - a single-sex class was 'easier to settle down', 'easier to handle'; it was 'quieter' and there was 'not as much talking'. Students with male teachers appeared less certain how their teacher liked teaching a single-sex class. Comments varied from, 'I just think, just feel he does', to 'He had trouble controlling us', and 'We settle down quicker'. None thought that their teacher did not like teaching a single-sex class.

Many boys (44%) thought their teacher liked teaching a single-sex class; 32% did not believe this to be the case. Of those who had male teachers, the main reason for assuming that the teacher liked single-sex was equated with teaching boys. Comments included: 'He makes jokes with us', 'He makes jokes that involve girls', 'He mucked around a fair bit. He would not have done that if there were girls in the class'. If girls only were taught, one boy suggested: 'He would have to worry about what he said'. Despite some comments about the perceived difficulties some female teachers might have teaching boys, the vast majority of boys (84%) expressed no preference for being taught by a man or a woman. One commented, 'A teacher is a teacher. If you have a teacher that is good, if its a female teacher or a male teacher it doesn't matter'.

Like the boys, most girls (79%) also considered that it made

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[2]The Victorian Certificate of Education. Students gain entry to university courses etc. on the basis of results obtained during this two year program.

no difference whether or not they were taught by a man or a woman. The efficacy of the teaching was the most important factor. Girls made comments such as, 'I have had female teachers and I have had male teachers, and it doesn't matter why as long as they teach you, because they are going to teach the same thing anyway'.

5. Relevance of mathematics for the future

Both boys and girls (88% and 82%) responded positively to the importance for them of the study of mathematics and of its use in the future. Both generally considered that there was no difference between a boy's and a girl's later use of mathematics.

(2) Grade 9 students

Sample size

Seventeen students were interviewed - 8 girls and 9 boys. The format of the interview followed that used for the grade 10 sample, as far as was feasible. As before, the interviews were taped (except for one female who asked that the tape not be used).

Summary of Findings

Both boys and girls believed that boys' dominance and noisy behavior in class, and the negative effects of this on girls' academic progress, were the main reasons for the introduction of single-sex mathematics classes in grade 10. One boy volunteered that his class had seen a film on discrimination which portrayed the girls as neglected because the teacher was distracted by the boys. When questioned, he indicated that the film had captured what happened in his class 'some of the time'. While most boys did not want to be in a single-sex class the following year, most of the girls interviewed did.

The girls generally thought they would benefit from a single-sex class - they could ask questions without fear of the boys' teasing; the teachers would have more time for them. Most of the boys, however, did not want single-sex classes because of 'the settling influence of girls'. One argued that learning is not dependent on the composition of the class but on attitudes to work. However, whatever their preferences, neither boys nor girls expected to find it difficult to adjust should they find themselves in single-sex classes in grade 10.

When asked how much girls contributed to lessons, boys' responses ranged from'not much' to being much more positive. Mentioned were: girls' ability to help them, more varied conversation, and girls' sensitivity and friendship. Although the girls tended to mention the boys' propensity for disruption, distraction and causing embarrassment, this was sometimes mitigated - 'they muck around a bit - but not much', - or the boys made it 'funnier', 'added variety', gave 'a better sort of feeling'.

When asked about competing with the opposite sex, most of the boys said they did not compete with girls because the girls

were 'smarter' or worked harder. There was also little enthusiasm from the girls to compete with the boys, although one girl (who preferred co-educational classes) said she competed with the boys because 'you have to tone them down a bit'.

Slightly more girls than boys thought a single-sex class would help them to understand mathematics better. Both girls and boys considered the competence of the teacher as a more important factor than class composition.

With respect to the best year to introduce single-sex mathematics classes, less than half the boys and about half the girls considered grades 9 or 10 to be best. They cited grade 9 as a year when the work became difficult - this was frequently mentioned. However, there was mention of grades 7 and 8 by both sexes and strong nomination of grade 11 by the boys, particularly in relation to the demands of the VCE. Both boys and girls considered single-sex classes should be conducted for a limited period and for some subjects only. Mathematics was mentioned most frequently. Science was also suggested, though less frequently. English, a subject considered to need a varied input, was spoken of only occasionally.

All the boys preferred to work in small groups with boys and girls. Their reasons seemed to suggest that this aided their work output and helped in the socializing process. Only two girls liked working in a mixed group. Of the rest, four favored single-sex groups and two had no preference. If they had to work in pairs, none of the girls wanted to work with a boy. Yet three of the boys preferred working with a girl. The reasons given were: the 'equality' of the arrangement, girls' greater responsibility, and the difference in perspective.

All boys and girls considered that it did not make any difference whether they were taught by a male or a female. However, more boys than girls considered that the sex of a teacher would make a difference when teaching a single-sex class. They believed that students would relate better to a same-sex teacher. One boy who considered that the sex of a teacher made no difference commented that female teachers, 'get their message of maths across quicker. You get better marks if they're female teachers, but you get more work done with the male teachers'. When asked to elaborate he claimed 'that female teachers explain more clearly but male teachers discipline better'.

All students considered the study of mathematics to be important to them, could see themselves using it in the future and generally considered that they would feel the same way were they of the opposite sex. However, one boy who thought he 'probably' would, commented, 'I don't know if I would aim as high ... because I think the girls aren't offered as good an opportunity as boys'.

Most boys and girls seemed to want single-sex classes for 'important' subjects such as mathematics and science but not for creative subjects which were evidently considered not as important.

(3) Grade 11 students
While there was much overlap in the questions asked students at grades 10 and 11, the interviews with the latter group were less structured.

Sample
Four females and four males who had experienced single-sex classes when in grade 10 were interviewed.

Summary of Findings
Males and females considered that they had benefited from a single sex class in grade 10. The special structure had given them more confidence and taught them how to work effectively. Referring to their increased maturity, they felt that it was not necessary to continue single-sex groupings into grade 11. For the most part, their responses generally reflected those of grade 10 students and are therefore not reported in detail. Like the grade 10 students, the grade 11 students rated the academic competence and effective disciplinary practice of the teacher as the a more important factor than learning setting.

2. *Parents questionnaire*
Sample size
* 94 questionnaires were returned from 59 students (33 girls, 26 boys) representing a 34% return rate on households.
* More mothers responded than fathers (55 vs 39).

ABOUT THE QUESTIONNAIRE
Two copies of a two page questionnaire were sent home with each grade 10 student. The results of the questionnaires were tabulated separately for the four categories of mothers/fathers; sons/daughters. The questionnaire contained 15 questions. Eight required a yes/no response. There were opportunities for the parents to elaborate on their views in the remaining seven questions.

RESULTS
Question 1: Are you aware that your child is currently in a single-sex class for mathematics? (Yes/No)
* Mothers were far more aware than fathers that single-sex classes had been introduced (91% vs 54%).

Question 2: Why do you think single-sex classes were introduced?
* To benefit the girls **(40%)**, e.g.,
  To avoid distractive and intimidatory behavior from the boys.
* To benefit both sexes **(47%)**
  To avoid distractive and intimidatory behavior from the opposite sex. (32%)

As a trial to see if performance or attitudes improved. (9%)

* Other reasons (6%)
* To benefit the boys **(2%)**
* No response or no idea **(10%)**
* Mothers with daughters were the most likely to indicate a preference for single-sex classes (70%) for girls, while fathers with sons were least likely (13%) to do so.

Question 3: ***To what extent do you support this scheme? Fully/Partly/Unsure/Not at all***

* More than half the parents fully supported the single-sex classes (58%).
* Only a small number of parents showed no support (6%).
* Mothers with a daughter gave the highest support (73% full support).
* Fathers with a daughter gave the lowest support (41% full support).
* 52% of mothers with a son fully supported the scheme, compared with 59% of fathers with a son.
* It appeared that mothers' level of support was influenced more than that of the fathers by the sex of their child.
* From comments made by parents, it seems that there is a strong interest for feedback from the school about the program.

Question 4: ***Please explain your reasons for your view of single-sex classes.***

* The reasons given by parents who gave <u>full support</u> reiterated their responses to Question 2.
* The reasons given by parents who indicated less than full support were -
  Mothers with daughters: Teachers could do more to integrate the girls, and girls cope with the co-ed system in other subjects.
* Fathers with daughters: Sceptical about the research that girls get less attention in classrooms.
* Mothers with sons: Good for girls but not for boys. More time is wasted.
* Fathers with sons: Schools should mirror the 'real' world.

Question 5: ***Have you discussed with your child what it is like to be in a single sex class for mathematics?***

* Mothers were more likely to have done so than fathers.

Question 6: ***Have you noticed anything different about your child's attitude to mathematics that supports your view of single-sex classes?***

* 43% of parents had noticed something different in their child's attitude to mathematics.

Comments:

* Parents who gave full support said their child was more relaxed, more confident, enjoyed and seemed to understand maths more, and their marks in mathematics were

improving.

* Of those parents who indicated less than full support, the mothers with sons were more critical and indicated the single-sex classes were more disruptive.

Question 7: Has your child told you anything that supports your view?

* More than half of the parents (56%) said their child had told them something to support their view of single-sex classes.
* Nearly twice as many mothers than fathers indicated their child had told them something to support their view of single-sex classes.

Comments:

* Many mothers wrote that their daughters had said they were doing better in the single-sex classes. Their child had spoken about the atmosphere in the class being more relaxed and so it was easier to work. Some fathers with daughters also indicated that their daughters had spoken to them of their preference for the single-sex mathematics classes.
* Two daughters told their mothers they preferred mixed classes.
* All other groups of parents gave a mix of three responses; students had indicated the classes were of benefit, the classes had not made a difference or they were detrimental to their marks and behavior.

Question 9: Would you support extension of this scheme into other grade levels? Yes/Maybe/No

* The majority of parents were in favor of some form of extension of single-sex classes (57%) and a further 29% said 'maybe'.
* Mothers with daughters gave the highest support for extension of the scheme (72%).

Parents were also asked to give their views on whether single-sex classes for mathematics should be extended to later or earlier years or both.

* Most of the parents who supported an extension of the scheme had no preference whether this occurred at higher or lower grade levels.

Did parents of the same child agree about the benefits or disadvantages of single-sex classes?

* Half of the parents did not differ in their levels of support. This held whether they had sons or daughters.
* When the parents' opinions differed, fathers of daughters were less likely than the mothers to support the scheme. In the case of a son, mothers and fathers were similar in their lack of support.

Time 3 - term 4, November

Pen-and paper instruments similar to those administered at Time 1 were completed by the cohort of grade 10 students. The students completed the instruments numbered 1 and 2 (as

described earlier under 'Self-report measures') but the instruments numbered 4 and 5 were not re-administered. The variations made to the other instruments were:

1. Instrument numbered 3: when asked 'how good are you at mathematics?' etc., students were also asked 'how good were you at the beginning of the year?'. The questions about how good students would like to be and how good they thought their parents would like them to be were omitted.
2. Additional multiple-choice and open-ended items were added. Students were asked:
   - Did you like being in a single-sex maths class this year? Please explain.
   - If you had the choice in grade 11 mathematics, would you like to be in A. a single-sex class B. a co-educational class C. don't mind either way D. not sure.
   - Please list all subjects you are taking in grade 11
   - Do you expect to take mathematics in grade 12. If yes, or not sure, please specify
   - What are your long-term career plans?'

Sample size

The sample size was 151 (76 males and 75 females). Student absence accounted for the reduced sample size from Time 1.

Results

As at Time 1, there was much overlap between males' and females' responses. Gender differences were found as follows:

* Females were less stereotyped about mathematics than were males ($t_{98.9}$=-2.51, p<.05). A large difference was found in the standard deviations of males' scores ($\bar{x}$=25.06, sd=4.95) and females' scores ($\bar{x}$=26.70, sd=2.42). The magnitude of the standard deviation for the males indicates that there were some males strongly stereotyping mathematics as a male domain.
* Males were slightly more confident about themselves as learners of mathematics than were females (t_{139}=1.76, p<.1)
* Males attributed success to ability to a greater extent than did females (t_{139}=2.30, p<.05) (see Figure 3)
* To a greater extent than males, females attributed failure to lack of ability (t_{140}=-2.11, p<.05), failure to lack of effort (t_{139}=-1.96, p=.05), and failure to task difficulty ($t_{128.2}$[1], p<.01) (see Figure 3)

PLACE FIGURE 3 ABOUT HERE

* Compared with the females, males believed that they were better at mathematics at the beginning of grade 10 (t_{147}=2.99, p<.01), better at mathematics at the end of grade 10 (t_{146}=4.46, p<.001), their teachers would rate them slightly better at mathematics at the end of grade 10 (t_{146}=1.89, p<.1), their parents would rate them better at mathematics at the beginning of grade 10 (t_{145}=2.73, p<.01) and at the end of grade 10 (t_{145}=2.43, p<.05)

On only one item was there a significant difference in beliefs about relative mathematics achievement at the beginning and end of the year.

* Males considered themselves better at mathematics at the end of the year than at the beginning of the year (t_{72}=-1.68, p<.1)

Descriptions of grade 10 mathematics classes

The most frequently mentioned characteristics of their mathematics classes given by <u>males</u> were that they were disruptive (43), boring (10), good (9), fun (6) and hard (5). Comments were made about the teacher by seven students (some positive, some negative).

Eg. Maths has been noisy and a little disruptive

Boring. Some difficult. Some easy.

People were good, work was hard.

The <u>females</u> most frequently described the negative effects of a change in teacher (17), that lessons were boring (6), quiet (6), good (5), noisy (5) and fairly traditional (5).

Eg They were good and I learnt a lot but some days I slacked off a bit

I have had four different teachers in one year so my classes have been varied. Every time I start to understand the way one teacher teaches, I have a change of teacher. This makes it difficult. I was an A student last year.

Very boring

What students would like to have changed in their grade 10 mathematics classes and why

Most frequently the males wrote that they would like to: change the teacher (21), have girls return to the class (20), remove disruptive students (14), or no change at all (5).

Eg. Teachers and girls

Throw the childish idiots out so we can work in peace, and so there are fewer students per teacher so she has time to answer our questions

I would change nothing

Females would have liked: to change nothing (23), not to have had changes in teacher (20), to have the males back (6).

Eg. I wouldn't have wanted to change anything

I wish we didn't have to change teachers

I would change the single-sex, because it didn't make a difference

Did you like being in a single-sex mathematics class this

year? Please explain.
Students' responses were classified into four broad categories: yes, no, makes no difference, and unsure. The noteworthy results were as follows:

* A considerably larger proportion of females (73%) than males (25%) enjoyed their single-sex classes
* A much larger proportion of males (54%) than females (12%) did not like their single-sex classes

Females who preferred being in single-sex classes felt free of the intimidation they had experienced from males in mixed classes, free of the pressure to conform to some sort of stereotype, and felt they could work better.

Eg. Yes because you don't have the guys to annoy you and tease you. You could do your work and actually understand the subject

Yes because you didn't have to worry much about what people thought of you & the class was pretty understanding

Males who answered 'yes' gave two main reasons: i. they felt less pressured without females around and could concentrate on their work and ii. they were freer to 'muck around'.

Eg. Yes, because I got my work done

Yes 'cause we stuffed around

The few females who said they did not like the single-sex classes either missed the boys' assistance or their presence.

Eg. Not really, mainly because we got their help last year and they could help us like they did in grade 9.

The main reasons males gave for not liking single-sex classes were that the classes were less disciplined without girls, and that girls were needed to moderate their behavior. Other comments were along sexist lines.

Eg. No - all guys talk too much. We need girls in the class.

No, because girls make you behave and work harder

No. No-one to look at

If you could choose in grade 11 mathematics, would you like to be: A. in a single sex class, B. in a co-ed class, C. don't mind either way, or D. not sure?

The results for this question were categorised according to how students had responded about their enjoyment of single-sex classes in grade 10. The results are shown on Table 1:

PLACE TABLE 1 ABOUT HERE

The results indicated that:

* A considerably greater proportion of females (40%) than males (6%) would choose single-sex classes in grade 11.
* A much larger proportion of males (51%) than females (16%) would choose co-educational classes in grade 11.
* Approximately one third of the males (39%) and of the females (35%) would not mind single-sex or co-educational classes in grade 11.
* Only a very small proportion of males (4%) and females (9%) indicated they were unsure about their preference.

Mathematics subjects selected for grade 11 in 1994
The school offers the following mathematics subjects and combinations for grade 11:

1 mathematics subject: General Mathematics
OR 2 mathematics subjects: General Mathematics and Mathematical Methods

Students were asked to list all the subjects they anticipated taking in grade 11. At the beginning of 1994, actual enrolment data were obtained from the school. Comparisons were made between anticipated and actual mathematics subject enrolments.

The data revealed that:
* the anticipated and actual enrolment figures matched closely
* the proportions of males and females taking the various combinations of mathematics subjects were very similar:
  - about 5% of the students were not taking any mathematics subjects in grade 11
  - approximately one third of the students took only one mathematics subject
  - just under two thirds of the students took the double mathematics combination

Do you expect to take mathematics in grade 12? Yes, No, Not sure. If your answer was YES or NOT SURE, please specify which grade 12 mathematics subjects

Three mathematics subjects are offered in the final year of schooling. There are restrictions on the combinations which can be taken. These, in turn, are dependent on pre-requisites from grade 11. Specialist Mathematics is the most demanding of the grade 12 mathematics subjects and can only be taken in combination with Mathematical Methods. Mathematical Methods is also available as a single subject or in combination with Further Mathematics (the least demanding of the grade 12 subjects). Table 2 shows the combinations of mathematics subjects the students anticipated taking in grade 12.

PLACE TABLE 2 ABOUT HERE

These data indicate that:
* 75% of males and 64% of females were likely to take at least one mathematics subject in grade 12
* A slightly higher proportion of females (17%) than males (14%) did not expect to take mathematics in grade 12

(NB. 9% of males and 18% of females who indicated they were likely to study mathematics did not list any subjects)

* more males (30%) than females (5%) would take the most demanding combination of grade 12 mathematics subjects: Mathematical Methods & Specialist Mathematics
* a higher proportion of females than males expects to study only one mathematics subject:
  Mathematical Methods: 26% females, 19% males
  Further Mathematics: 23% females, 17% males

What are your long term career plans?
The range of career options listed was very broad for both males and females.

Other comments
Additional comments from the <u>males</u> took up the themes prevalent in earlier questions: disruptive classes and unacceptable behavior, preference for co-educational classes, and comments about teachers. Many of the additional comments from the <u>females</u> centred on the change of teacher. Other comments were made in favor or against the single-sex classes, their enjoyment of classes, and positive reactions to their experiences for the year.

2. **Comparisons of data gathered at times 1 and 3**
Effect sizes were calculated for the changes in mean scores from the first to the second administration of the affective measures. The first measures were considered the control measures with the second set comprising the experimental ones:

$$ES = (\bar{X}_2 - \bar{X}_1)/sd_1$$

Effect sizes were calculated separately for males and for females. (NB. Males: N_2=76, N_1=81; Females: N_2=75, N_1=83)

The results are shown on Table 3:

PLACE TABLE 3 ABOUT HERE

<u>Summary of results</u>
For males:
  small ES for USEFULNESS (.17), F/ABILITY (-.19), F/TASK (-.17), HGM (.33), and PGM (.24)
  small - medium ES for TGM (.46)
For females:
  small ES for TEACHER (-.24), S/TASK (-.24), F/ENVIRON (.29), and TGM (.24)
  small - medium ES for S/ENVIRON (-.44)
NB: a positive ES means that the end of year score was higher

Compared to the beginning of the year:
<u>Males</u> believed:

* more strongly about the usefulness of mathematics
* less strongly that their failures were due to lack of ability and to task difficulty
* they were better at mathematics and that their teachers and their parents would consider them better at

mathematics

Females believed:

* their teachers were less supportive of them as learners of mathematics
* less strongly that their successes were due to ease of task and to environmental factors
* more strongly that their failures were due to environmental factors
* their teachers would rate them better at mathematics

Performance data

Performance data were collected from the teachers of the eight grade 10 classes. There were 4 single-sex classes for males and 4 for females. On a 1-5 scale (1=poor, 5=excellent), teachers recorded students' achievement levels for three time periods: beginning (B), middle (M) and end (E) of the year. Results are shown on Table 4.

PLACE TABLE 4 ABOUT HERE

$SPSS_x$ was used to analyse the performance data. The research design was between-within subjects and nested. The two between subjects independent variables were pupil gender (PG) and class grouping (CG), with class grouping nested within gender groups. The within subjects effect was the repeated measure of achievement levels assigned by the teachers over the three time periods: B, M and E.

Two separate MANOVAs were performed. For one male class and one female class no achievement levels were recorded for the beginning of the year. This reduced the data set to six class groups for the first MANOVA in which the three repeated achievement measures: B, M and E were incorporated. For the second MANOVA only two repeated achievement measures were considered, M and E. Univariate ANOVAs were also conducted for each of B, M, and E by PG and by CG. The results of the statistical procedures are summarized below.

Univariate ANOVAs (t-tests where appropriate) revealed that:

* For each of the three separate achievement measures, there were significant differences by class grouping (B: df=5, F=3.08, p<.05, M: df=7, F=2.24, p<.05, E: df=7, F=3.66, p<.01)
* For each of the three separate achievement measures, there were no significant gender differences
* For male class groups, there were significant differences for each of the three separate measures (B: df=2, F=5.98, p<.01, M: df=3, F=3.86, p<.05, E: df=3,F=4.58, p<.01)
* For female class groups, there were no significant differences by class grouping for B or M. Significant differences were found by class grouping for E (df=3, F=3.49, p<.05)

MANOVA 1: 3 repeated measures of student achievement x PG x CG nested within PG (included only 6 out of the 8 class groupings: 3M and 3F)

* the three measures of achievement did not differ significantly across all students
* there were no gender differences across the three measures
* there were significant differences between the patterns of scores for the three male classes and the three female classes over the three achievement measures (Pillai's trace=.137, p<.05)

MANOVA 2: 2 repeated measures (M and E) of student achievement x PG x CG nested within PG (all classes included in procedure)

* the two measures of achievement did not differ significantly across all students
* there were no gender differences across the two measures
* there were no significant differences in the patterns of scores for the four male classes and the four female classes across the two achievement measures

The mean achievement levels that males and females attributed to themselves for the end of the year were compared with their teachers' assessments of their achievement at that time. The data are shown on Table 5.

PLACE TABLE 5 ABOUT HERE

The data indicated that:

* the teachers scored the females (4.01) higher than the males (3.81)
* the males (4.08) believed they were better at mathematics than did the females (3.23)
* the males (4.08) overestimated their achievement levels compared with their teachers' assessments (3.81)
* the females (3.23) underestimated their achievement levels compared with their teachers' assessments (4.08)

Discussion

a. Students' beliefs about themselves as learners of mathematics

Key affective variables are found in several models explaining gender differences in mathematics learning outcomes; confidence, attributions for success and failure, and sex-role congruity with mathematics are included. Beliefs about significant others - parents, teachers and the peer group - are also considered important.

In the present study students' beliefs were determined on two occasions, at the beginning of the project year and at its end, and comparisons were made. Many of the gender differences on the affective variables noted on the first occasion conformed to those frequently reported in the literature. These differences tended to persist or were more pronounced at the end of the year. There were also some shifts in mean scores in the same direction for males and for females (see Table 3 for mean scores over the two occasions and effect sizes). Examples of these findings and their implications are

discussed below.

The males were more confident about themselves as learners of mathematics than were the females at the beginning of the year and there was no change in this gender difference over time. Males were slightly more stereotyped about mathematics as a male domain than were females at the beginning of the year; the gender gap was greater at the end of the year. While females considered their teachers more supportive of them as learners of mathematics than did the males at the beginning of the year, the females were less sure of this at the end of the year and the gender gap closed.

Males attributed their successes in mathematics to ability to a greater extent than did females at both times of the year. Both males and females were less likely to attribute failure to lack of ability at the end of the year. But at both times the females scored higher than the males. For both ability attribution variables there were slight increases in the gender differences across the two measurements. Over the two measurements, interesting changes were noted for females' but not for males' attributions for success and failure to environmental factors. At the end of the year, females believed more strongly that their failures were attributable to environmental factors and less strongly that the environment contributed to their successes.

The questions tapping students' beliefs about their achievement levels indicated that the males believed that their mathematics performance had improved considerably over the year and that this would be recognised by their teachers, parents and classmates. The females only felt that their teachers would rate them higher at the end of the year.

Taken alone, the results from the measures of students' beliefs over the two time periods do not indicate that the single-sex classes at grade 10 were a means of overcoming gender differences evident at the commencement of the project. Nonetheless, there were positive effects on some beliefs for both males and females. The performance data, the interview data, the students' subsequent mathematics subject choices, and the results of the parents' questionnaires discussed below provide a broader perspective on the impact of the project.

b. Performance measures

The teachers' assessments of student performance over the three time periods (beginning, middle, and end of the year) revealed a slight, but insignificant increase in mean performance scores over the three measures (see Table 4) for males and for females. The changes in performance of some class groups were significantly different from those of others. Overall, females outperformed males in mathematics at each time of year although these differences were not significant. There was evidence that the males had greatly overestimated their achievement levels at the end of the year and that the females had underestimated theirs to the same

extent (see Table 5).

Evident from these data is that performance levels did not deteriorate over the project year. This is particularly noteworthy for the females. However, the patterns of difference in males' and females' believed and actual achievement levels replicate previously reported findings and suggest that males' confidence levels have been boosted more than females' by the single-sex experience.

c. Interview data

At interview, many grade 10 students suggested that more work might be done in single-sex mathematics classes and that the programme had been introduced for the likely benefit of females. A far greater proportion of females than males appeared satisfied with the arrangements. Most students believed that their mathematics performance had improved or had not deteriorated in the single-sex classes. Both females and males, though fewer of the latter, mentioned the absence of members of the opposite sex as a contributing factor. Having 'a better' teacher was also given as a reason for improved performance in mathematics.

Most students believed that their teachers enjoyed teaching single-sex classes; they were more certain about same gender teachers. They made it clear that teaching proficiency was a more important factor than the gender of the teacher, however.

Of the Grade 9 students interviewed, the females were much more supportive of the single-sex mathematics classes they would experience in grade 10. They mentioned the likely benefits for their learning. The males said they preferred mixed classes, indicating that females curbed their unruly behaviour. Both the male and the female grade 11 students who were interviewed believed they had benefited from the single-sex experience the previous year. Greater confidence and the ability to work more effectively were the benefits they claimed to have derived.

From the grade 10 interview data alone it can be inferred that females more so than males enjoyed and benefited from the single-sex mathematics classes. The grade 11 students challenge this perspective. There appeared to be stronger recognition that males as well as females had gained from the experience. Why the grade 9 males who had yet to experience the single-sex classes and the grade 10 males who were experiencing them at the time were considerably less supportive of single-sex classes than were the females remains unclear. Perhaps, as the parent questionnaire data appear to suggest, grade 9 and 10 students were reflecting their parents' views.

d. Parental support

More mothers than fathers completed the questionnaire. Mothers were more aware of the single-sex programme in the school, were more likely to have discussed it with their offspring,

and were generally more supportive than were the fathers. Interestingly, mothers of daughters were the most supportive group and fathers of daughters were least favourably inclined. Of the parents who were not fully supportive, fathers tended to be sceptical that females were disadvantaged in mixed settings or believed that schools should mirror the outside world; mothers believed that more could be done for girls in mixed settings or that only girls were likely to benefit from single-sex classes. Parents who had discussed the programme with their offspring reported that what the child had said generally mirrored their own views on the programme.

The parent questionnaire data appear to reflect the students' perspectives and suggest the strong influence that parents can have on their children's views. One interesting finding was that when there was disagreement between parents this occurred more often with parents of a daughter; mothers were found to be more supportive than fathers.

e. Students' subject choices

One positive benefit of the single-sex classes for females appears to have been their mathematics subject choices for grade 11. Their anticipated and actual enrolments in the various combinations of grade 11 offerings were no different from those of the males. However, for grade 12, more males than females indicated the likelihood of taking the most demanding grade 12 mathematics combination. The proportions indicated (30% males and 5% females) were lower than state average figures. The data for the two grade levels may be indicative of career aspirations or beliefs formed prior to the single-sex programme. They signal caution in the interpretation of their relationship with the outcomes of the project.

Conclusions

The diversity of data sources employed in this study attests to our recognition of the range of factors relevant to gender issues in mathematics learning. Each set of results has its own story to tell. Taken together the picture presented is complex.

The results suggested that:

- both female students and mothers were more favourably inclined towards the single-sex mathematics programme than were their male counterparts
- during the year of the project, some of the beliefs of both male and female students shifted slightly in directions considered more positive. However, many of the gender differences present initially either persisted or were more marked over time
- performance levels for males and females were not significantly different throughout the project year. Males were found to overestimate their achievements and females to underestimate theirs
- anticipated and actual subject choices for grade 11 were

no different for males and females. However, anticipated subject choices for grade 12 showed more difference than past state average statistics

It would appear that there has been no detrimental effect on either males' or females' mathematics performance outcomes as a result of the single-sex programme. Previous research (and the school's previous pattern of enrolment in grade 11 mathematics) would suggest that females would be less likely to select the more demanding optional mathematics subjects in subsequent grade levels. Given the finding of no gender differences in grade 11 mathematics enrolment patterns, it could thus be argued that the programme has had some beneficial effects for the females. There are, however, some signs that males may have benefited at least equally if not more than the females. The indicators are: the larger gender differences on some of the key affective measures at the end of the year, their strong (although greatly inflated) beliefs about their mathematics achievement levels, the comparative patterns of anticipated enrolments in grade 12 mathematics subjects and the interview data from grade 11 males.

This study has not provided unequivocal evidence that single-sex mathematics classes per se address well-documented gender differences in mathematics learning outcomes. However, the programme evaluated did not appear to have been detrimental to the majority of grade 10 students in the school investigated and may well have benefited many. We did not investigate all the factors which may have contributed to the success or failure of the programme. Students suggested a number of avenues worthy of further research. For example, several students believed that single-sex mathematics classes should be introduced at earlier grade levels, such as grade 9; some students alluded to differences in male and female teachers' attitudes towards single-sex classes and to their differing teaching styles. The significance of parents' attitudes and whether single-sex classes should be compulsory or voluntary are additional questions deserving of research attention.

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Table 2: *Mathematics subjects students anticipated taking at grade 12*

COMBINATIONS OF GRADE 12 MATHEMATICS SUBJECTS	M%	F%
Mathematical Methods	19	26
Further Mathematics	17	23
Mathematical Methods & Further Mathematics	9	10
Mathematical Methods & Specialist Mathematics	30	5
No mathematics subjects	1	17
Taking mathematics, but no subjects listed	8.5	18
No response	2.5	1

Table 1: *Preferred mathematics class settings for grade 11*

DID YOU LIKE YOUR SINGLE-SEX CLASSES?	Yes		No		Unsure	
WHAT WOULD YOU PREFER IN GRADE 11?	M%	F%	M%	F%	M%	F%
single-sex	5	40	1	0	0	0
co-educational	1	7	50	8	0	1
don't mind either way	15	23	3	1	21	11
not sure	4	3	0	3	0	3

Table 3: *Effect sizes for affective measures for males and females*

	MALES[1]				FEMALES			
	$\bar{X}_2$	$\bar{X}_1$	sd_1	ES	$\bar{X}_2$	$\bar{X}_1$	sd_1	ES
USEFULNESS	24.22	23.28	5.66	.17	23.04	22.73	4.64	.07
MALE DOMAIN	25.06	25.43	3.84	-.10	26.70	26.78	2.80	-.03
PERSISTENCE	20.76	20.35	4.70	-.09	20.49	20.75	4.42	-.06
CONFIDENCE	22.32	22.21	5.97	.02	20.44	20.58	5.69	-.02
TEACHER	19.99	19.79	4.65	.04	20.56	21.73	4.80	-.24
S/ABILITY	14.35	14.03	4.00	.08	12.82	12.90	3.76	-.02
S/EFFORT	12.46	12.74	3.76	-.07	13.01	13.19	3.14	-.06
S/TASK	14.25	14.53	3.19	-.09	14.13	14.75	2.57	-.24
S/ENVIRON	13.24	13.12	3.85	.03	13.49	14.74	2.83	-.44
F/ABILITY	10.92	11.58	3.46	-.19	12.31	12.77	3.40	-.14
F/EFFORT	12.52	12.72	3.30	-.06	13.47	13.60	2.74	-.05
F/TASK	12.83	13.43	3.47	-.17	14.45	14.20	2.80	.09
F/ENVIRON	12.31	12.46	2.96	-.05	12.23	11.51	2.48	.29
HGM	4.08	3.65 (3.85)[2]	1.29	.33	3.23	3.22 (3.26)	1.07	.01
TGM	3.78	3.17 (3.53)	1.32	.46	3.38	3.10 (3.23)	1.15	.24
PGM	4.04	3.76 (4.05)	1.14	.24	3.54	3.55 (3.50)	1.19	-.00
CGM	3.71	3.56 (3.68)	1.30	.12	3.68	3.45 (3.60)	3.45	.07

NB. 1. Males: N_2=76, N_1=81; Females: N_2=75, N_1=83
2. Shown in brackets are the mean scores for achievement given by students at the end of the year for their achievement levels at the beginning of the year

Table 4: *Means and standard deviations for teachers' ratings of student mathematics achievements in the 8 year 10 classes at the beginning (B), middle (M) and end (E) of the year.*

	MALES					FEMALES					
CG	2	6	7	8	All Ms	1	3	4	5	All Fs	Overall
B	3.46 (1.53)	4.41 (.91)		3.09 (1.34)	3.65 (1.40)	4.14 (1.13)	3.68 (1.00)		3.67 (1.46)	3.84 (1.22)	3.74 (1.32)
M	3.17 (1.71)	4.41 (.96)	3.18 (1.65)	3.32 (1.25)	3.51 (1.50)	3.96 (1.30)	3.95 (.97)	3.35 (1.64)	3.62 (1.50)	3.71 (1.39)	3.61 (1.44)
E	3.58 (1.50)	4.55 (.67)	3.27 (1.24)	3.86 (1.17)	3.81 (1.26)	4.30 (1.02)	4.47 (.51)	3.44 (1.47)	3.91 (1.30)	4.01 (1.20)	3.91 (1.23)

Table 5: *Mean scores for teachers' and students' assessments of achievement levels at the end of grade 10*

	TEACHERS	STUDENTS
MALES	`.81	4.08
FEMALES	4.01	3.23

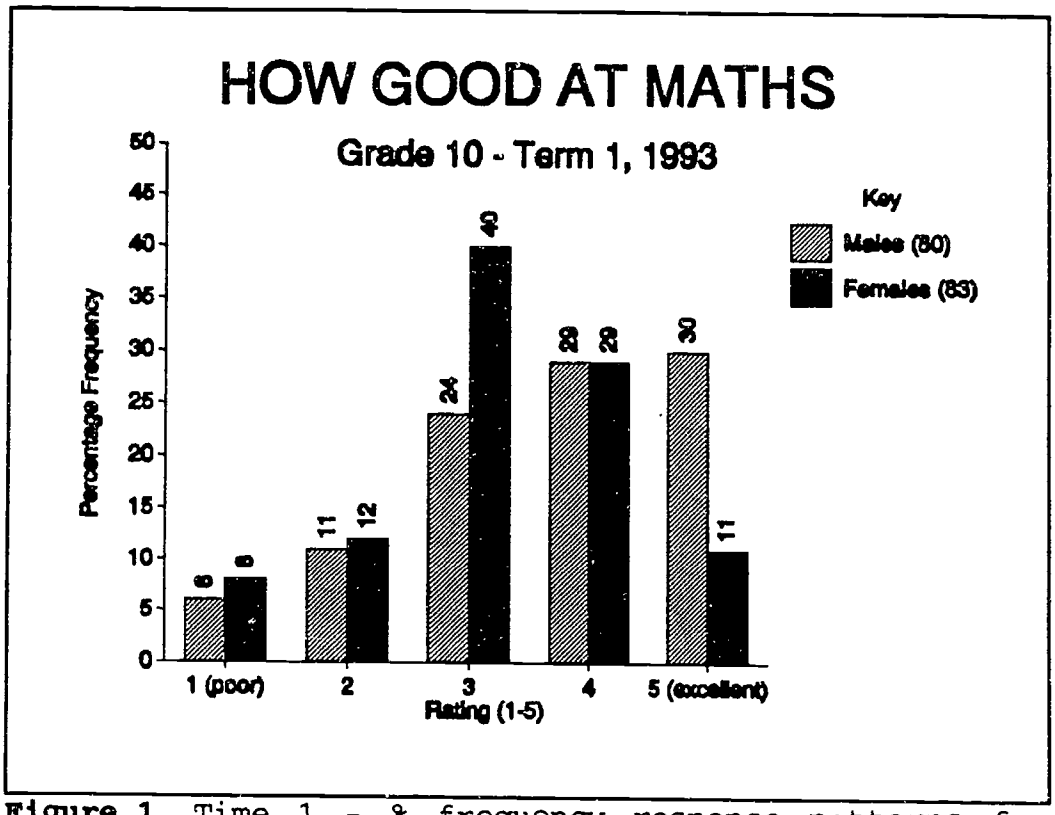

Figure 1 Time 1 - % frequency response patterns for males and females

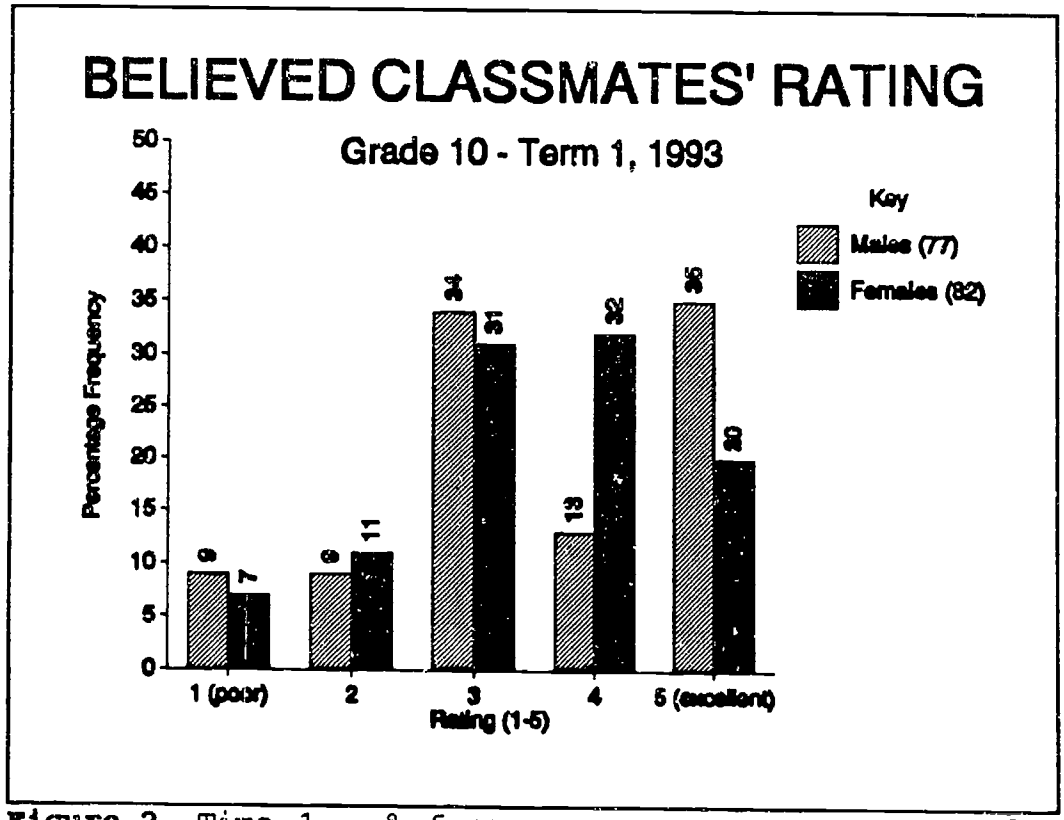

Figure 2 Time 1 - % frequency response patterns for males and females

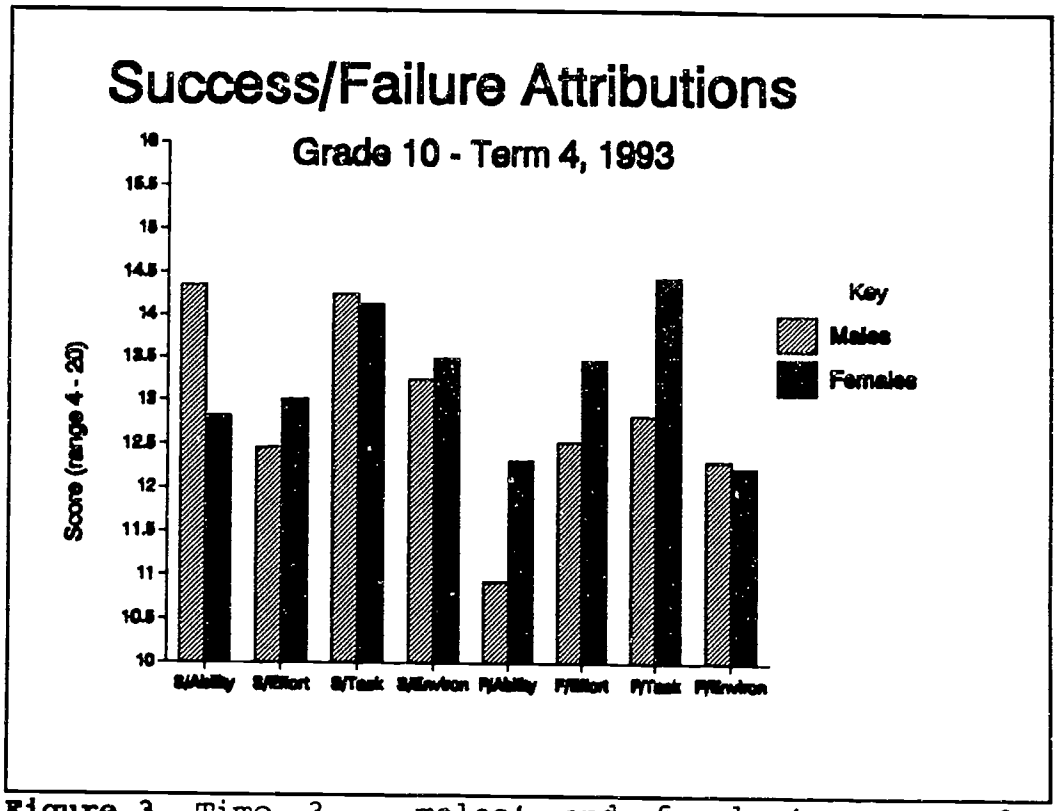

Figure 3 Time 3 - males' and females' scores for success and failure attributions