Equity: The Case for and Against Gender

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ABSTRACT

In recent years there has been renewed interest in gender differences in education generally, and in mathematics achievement and participation in particular, not only from researchers but also from practitioners and policy makers. In this paper I provide a brief overview of historical evidence describing females' involvement in mathematics and illustrate that research on gender and mathematics education has increasingly reflected a greater diversity of inquiry methods used to examine and unpack critical factors. I examine changing perceptions over time – with boys now perceived by some as disadvantaged compared to girls, highlight insights to be gained from cross cultural perspectives, and document that our understandings of, and reactions to, gender differences in mathematics are affected by a lesser reliance on methods favored in psychology, and a greater acceptance of traditions prevalent in other disciplines. Theoretical considerations are supplemented by reference to "cases". Assessment practices, changing beliefs about the perceived advantages and disadvantages of single-sex and co-educational settings and of diverse grouping practices are among the examples explored.

Keywords
Gender, equity, social perceptions, research foci

INTRODUCTION – SOME HISTORICAL NOTES

Reviews of gender differences in mathematics learning frequently start with a discussion of the situation that prevailed in the early 1970s. Yet concern about the education of females can be traced to much earlier times. Over three centuries ago, for example, the English writer Daniel Defoe noted:

> I have often thought of it as one of the most barbarous customs in the world that we deny the advantages of learning to women … If knowledge and understanding had been useless additions to the sex, God almighty would never have given them capacity; for he made nothing needless (Defoe, 1697, pp. 283-284).

The experiences of Mary Somerville, who is often included in historical lists of successful female mathematician, provide a revealing picture of the education available to females in earlier times.

Is mathematics suitable for girls? The case of Mary Somerville

Mary Somerville was born in 1780, in Scotland. From descriptions of her early life we can glean some insight into the prevailing educational customs. A tutor was engaged to teach Mary's brothers. Appropriate books were available in the home library. Yet for Mary it was initially deemed sufficient to be taught to read. Learning to write was not considered a priority. Eventually, at the age of ten, Mary was sent to a fashionable boarding school for 12 months. From there she emerged "with a taste for reading, some notion of simple arithmetic, a smattering of grammar and French, poor hand writing and abominable spelling (Patterson, 1974, p. 270). Although she subsequently had lessons in ballroom dancing, playing the piano, horse riding, cookery, drawing and painting, Mary's year at boarding school was her only formal education. Some years later, fortuitously, she came across a problem which aroused her curiosity. In her own words:

> At the end of the magazine, I read what appeared to me to be simply an algebraic question, but on turning the page I was surprised to see strange-looking lines mixed with letters, chiefly Xs and Ys and asked 'what is that?' 'Oh', said (my) friend, 'it's a kind of arithmetic; they call it algebra; but I can tell you nothing about it.' … On going home I thought I would look if any of our books could tell me what is meant by algebra. (Tabor, 1933, p. 98)

Mary continued studying mathematics, very much against her father's wishes, but with some help from her brother's tutor. Over time, she was fortunate enough to obtain support from other sources. The early death of her first husband gave her financial independence, freedom, and an opportunity to pursue her studies. William Wallace, a professor of mathematics at Edinburgh University and the editor of The Mathematical Repository, one of several periodicals catering for popular mathematical interests, was a supportive friend and mentor. Mary's second husband accepted and encouraged her mathematical endeavors.

This brief vignette illustrates how opportunities to engage with mathematical studies can be affected by the social and economic environment – an observation still relevant today.

The "girls should study/not study mathematics" debate

The United States

The literacy and numeracy rates of males and females in the early days of Colonial America are useful for gauging differences in the educational opportunities available to the two groups. By the middle of the eighteenth century literacy rates of 80% for males and 45% for females were not uncommon. Girls were usually not taught arithmetic "because it was assumed that women had no need of it in adult life" (Cohen, 1982, p. 140). Over time, with improved schooling and levels of participation in education, this perception changed.

> In the 1820s, with the spread of the common-school system and the insertion of arithmetic into the elementary curriculum, female pupils for the first time encountered arithmetic, and educators, also for the first time, were forced to articulate the reasons why arithmetic beyond the Rule of Three was inappropriate for girls to learn. A whole corpus of books and articles asserted that it was useless or even impossible to teach girls to reason logically about mathematics.... It seems supremely ironic that at the precise moment when arithmetic was finally within the reach of the female half of the population, because it was not decently taught in local schools, the stereotype of the non-mathematical feminine mind became dogma (Cohen, 1982, p. 139).

The United Kingdom

The desirability of girls studying mathematics beyond elementary arithmetic was also questioned in the United Kingdom. The headmistress of a leading college for girls maintained

> …I do not think that the mathematical powers of women enable them generally – (their physical strength, I dare say, has a great deal to do with it) to go so far in the higher branches (of mathematics), and I think we should be straining the mind (which is the thing of all things to be most deprecated) if we were to try to force them to take up such examinations … (Evidence given by Dorothea Beale in 1868 to the Schools Inquiry (Taunton Commission, quoted in Clements, 1979, p. 317)

Yet in earlier evidence given to the Commission Beale had argued: "suppose there is a taste for mathematics (in a girl), I would like to encourage it. I do not see why we should limit it where we find a special taste, …[but] I would not insist upon it for all" (Clements, 1979, p. 316).

In their summation of the evidence presented, the Commission concluded that

> as far as higher mathematics for girls is concerned … mathematics do not appear to be much in use…. But in favourable circumstances, … girls who have an aptitude for the subject are said to make good progress, and the study of it is approved by some of the ablest mistresses" (Clements, 1979, p. 317).

Australia

Educational authorities in colonial Australia were heavily influenced by the debate in England about girls and mathematics. Examination records from the time females were first allowed to matriculate and enter university indicate "that in the 1870s and 1880s many of the girls who presented for matriculation took two, and some even took three of arithmetic, algebra, and Euclid" (Clements, 1979, p. 318). Some of these girls performed well. For others the hurdle of being taught by "persons with minimal qualifications in the subject" (Clements, 1979, p. 319) was reflected in the moderate results obtained. Significantly, the first female to win the matriculation mathematics exhibition (in 1890) attended a "Ladies' College" with sufficient financial resources to employ a highly qualified, specialist mathematics teacher.

In brief

With appropriate support, personal and institutional, females were able to cope well with the mathematics curriculum deemed suitable for males. More frequently, however, girls wishing to study mathematics had to manage with teachers whose own knowledge of mathematics was limited, and with social ambivalence, if not disapproval, about the wisdom of doing so. These obstacles inevitably influenced their performance in mathematics and reinforced the beliefs of those who argued that girls could not cope with more advanced mathematics and should not be encouraged to do so.

TOWARDS THE PRESENT

In the 1970s, gender differences in mathematics performance and participation in post compulsory mathematics courses began to attract considerable research attention. A careful reading of the literature consistently revealed a substantial overlap in the performance of males and females. When found, gender differences in performance – typically in favor of males – were small and influenced by many factors - including the students' grade level and the format, scope, content, and setting of the test. Gender differences in favor of boys were also more likely to be found when the sample consisted of high achieving students.

Over the years, means to achieve gender equity have been introduced in many countries. These have included putting in place legislation to address discriminatory practices in fields such as education and employment, media campaigns to encourage females to continue with mathematics and enter traditional male fields which rely on strong mathematical background, and welfare grants to schools to initiate special intervention programs. What have these intervention programs achieved?

CURRENT EVIDENCE: GENDER DIFFERENCES IN MATHEMATICS PERFORMANCE – DATA FROM SELECTED LARGE SCALE TESTS

International Examples

The Programme for International Student Achievement [PISA]

More than 400 000 (15-year-old) students from 57 countries participated in PISA 2006. Overall, relatively few changes in performance were found when data from successive testings were compared. "For most countries, performance in mathematics remained broadly unchanged between PISA 2003 and PISA 2006….The performance advantage of males (also) remained unchanged … at some 11 score points" (OECD, 2007, p. 320). More specifically, boys performed significantly better in mathematics than girls in 35 of the participating countries. No significant differences were found in 21 countries. Girls outperformed males in only one country, Qatar.

Trends in International Mathematics and Science Study [TIMSS]

In many countries no statistically significant gender differences in mathematics performance were found in the TIMSS 2003 testing and when such differences were found they varied by country. The United States was among those in which males performed statistically significantly better than females at both the eighth and fourth grades level; Australia and Japan among those in which males performed somewhat but not significantly better than females at both these levels; and Singapore among those in which females performed significantly better than males at both the grade four and grade eight levels[1].

Gender differences by content area (in TIMSS 2003) also showed considerable between-country variations. For students in grade eight, the most striking gender differences were found on the algebra items, with females significantly outperforming males in 22 of the participating countries. Fewer differences were found for the number, measurement, and geometry items with males outperforming females in 12, 13, and 11 countries respectively. At the grade four level males outperformed females on the measurement items in well over half the participating countries.

National Examples

National Assessment of Educational Progress [NAEP]

The NAEP program provides a nationally representative and sustained overview of the performance of America's students in grades 4, 8, and 12 in various

[1] Subtle changes to these findings were reported in the TIMSS 2007 data which were released after the ICME 11 conference was held. Males again outperformed females in Australia and the USA. In the former the difference was statistically significant at grade 8 but not at grade 4; in the latter the difference was statistically significant a grade 4 but not at grade 8. No difference was found in the performance of males and females in grade 4 in Japan, but females performed non-significantly better at grade 8. Females again scored significantly higher than males in Singapore, at both grades 4 and 8.

subject areas, including mathematics. The tests are administered in selected American schools each year. Results are reported at various levels: overall and by specific group (e.g., by grade level, gender, race/ethnicity, region, and state). McGraw, Lubienski, and Struchens (2006) examined NAEP data from 1990 to 2003 and concluded that

> Gender gaps favoring males (1) were generally small but had not diminished across reporting years, (2) were largest in the areas of measurement, number and operations (in Grades 8 and 12) and geometry (in Grade 12), (3) tended to be concentrated at the upper end of the score distributions, and (4) were most consistent for White, high-SES students and non-existent for Black students. (p. 129)

Australian data

The Australian Mathematics Competition [AMC] and the Victorian Certificate of Education [VCE]

Leder, Forgasz, and Taylor (2006) compared the performance of grade 12 students in two large scale testings: the AMC and the VCE. The former is a highly respected voluntary national competition; the latter is a high stake State-wide examination, compulsory for students enrolled in grade 12, the final year of high school for students across Australia who wish to proceed to university as VCE results are converted into a score used for tertiary entrance. The authors concluded:

> retention rates in the final year of secondary schooling are higher for females than for males Australia-wide. Yet more grade 12 males than females engaged in formal (VCE) and informal (AMC) mathematical endeavours. At the highest levels of achievement, males outperformed females in both of the tests monitored, whether comparisons were made with or without adjustment for the differences in cohort sizes. Male dominance was more marked and more consistent for the voluntary AMC than for Mathematical Methods, the important VCE gate keeping subject. (p. 39)

In brief

Gender differences in performance, most often in favor of males, continue to be reported, particularly on selected mathematical tasks assessed through standardized or large scale testings, for students in advanced post compulsory mathematics courses, and when above average performance is considered.

The emphasis in this section of the paper on continuing gender differences must not be allowed to obscure the large overlap in the performance of males and females. As pointed out by Hyde (2005),

> It is time to consider the costs of over inflated claims of gender differences. Arguably, they cause harm in numerous realms, including women's opportunities in the workplace, couple conflict and communication, and analyses of self esteem problems among adolescents. Most important, these claims are not consistent with the scientific data. (p. 590)

BEYOND LARGE SCALE TESTING: THEORETICAL CONSIDERATIONS

Elsewhere (Leder, 2004) I have sketched the changing lenses through which gender and mathematics learning have been viewed as follows:

> Gender differences in achievement in areas such as mathematics were typically assumed to be the result of inadequate educational opportunities, social barriers, or biased instructional methods and materials…. It was generally assumed that the removal of school and curriculum barriers, and if necessary the resocialization of females, would prove to be fruitful paths for achieving gender equity. Male (white and Western) norms of performance, standards, participation levels, and approach to work were generally accepted uncritically as optimum. Females were to be encouraged and helped to *assimilate*. This notion, helping females attain achievements equal to those of males, was consistent with the tenets of *liberal feminism*…. Undoubtedly influenced by work developed in the wider research community, those working within the mathematics/science area also began to frame research questions guided by a different set of assumptions. The themes fueled by Gilligan's (1982) *In a different voice*, and the feminist critiques of the sciences and of the Western notions of knowledge proved particularly powerful. New questions began to be asked …. Rather than expect them to aim for male norms, attempts were made to use females' experiences and interests to shape curriculum content and methods of instruction. The assumptions of *liberal feminism* that discrimination and

> inequalities faced by females were the result of social practices and outdated laws were no longer deemed sufficient or necessary explanations. Instead, emphasis began to be placed on the pervasive power structures imposed by males for males. …Some researchers …wished to settle for nothing less than making fundamental changes to society. Advocates of this approach, often classed as *radical feminists,* considered that the long-term impact of traditional power relations between men and women could only be redressed through such means. (pp. 106-107)

Others have used different theoretical perspectives and nomenclature to chart the developments in research on gender and education. In the comprehensive two tomes of Gender and education (Bank, 2007) gendered theories of education are discussed under a number of headings, listed in Table 1 below.

Table 1: Gendered theories of education – selected perspectives

Academic Capitalism
"in times of financial stress or uncertainty, individuals and organizations often adopt market like strategies to strengthen or bolster their relative position in the economy (Metcalfe & Slaughter, 2007, p. 7)

Black Feminism,Womanism, and Standpoint Theories
"Black feminist perspectives stress how various forms of gender, race, and class oppression work together to form a matrix of domination. These perspectives are deeply interwoven into social structures …" (Wheeler, 2007, p. 22)

Cultural Capital Theories
"… insightfully draws attention to the power dimensions of cultural practices, dispositions, and resources in market societies …. Cultural capital theories have rarely been utilized to explain inequalities of gender or race…" (Reay, 2007, p. 23)

Feminist Reproduction Theory
"… arguably the form of educational feminism aligned most closely with Marxist and neo-Marxist feminist thought…. (Its proponents argue) that education and other social forces in the cultural field (e.g., media) play a very substantial part in reproducing … gender, race, and class divisions in the state"(Dillabough, 2007,p. 31)

Liberal and Radical Feminisms

"Liberal feminism has argued that women are as rational as men and that gender should not affect the forms that education takes… radical feminism criticized existing educational provisions as part of a patriarchal order … and argued for education for women that would enable them to resist and transform the patriarchal order"(Weedon, 2007, p. 38)

Multicultural and Global Feminisms

"… are two related modes of feminist thinking that emphasize women's differences, disagreements, and situated identities, even as they strive to identify both commonalities in women's experiences and opportunities for women to work together to achieve shared goals"(Tong, 2007, p. 47)

Postmodern and Poststructural Theories

"Poststructuralism is a branch of postmodernism that places particular emphasis on the ways in which socially and culturally produced patterns of language … construct people and the power relationships among them … (it) has also challenged feminism, particularly its tendency to categorize people by gender and its claims to being a movement that will emancipate women" (Francis, 2007, p. 55)

Queer Theory

"Informed by lesbian and gay studies, as well as feminist and poststructural theorizing, queer theory is less a systematic method or framework than a collection of approaches to questioning normative assumptions about sex, gender, and sexuality" (Talburt, 2007, p. 64)

Relational-Cultural Theory (RCT)

"In reframing relationships as the context in which we experience optimal psychological development and emotional well-being throughout our lives, RCT articulates as a means by which we can create and nourish mutually empathic growth-fostering relationships in therapy and life" (Comstock, 2007, p. 78)

Sex Role Socialization

"Sex role socialization … involves developing beliefs about gender roles, the expectations associated with each sex group, and … gender identity, an understanding of what it means to be a male or female" (Stockard, 2007, p. 79)

Social Capital Theories

"… social capital can be seen as an investment of a resource with an expectation that there will be a return on this investment. Theorists' definitions of the concept have varied" (Horvat, 2007, pp. 87-88)

Social Constructionism
"… social constructionism occupies an important position in questioning the so-called positivist research paradigm in which the world can be understood only through the ways in which it is mediated by culture and through ways in which people understand and interpret their experiences" (Gordon, 2007, p. 93)

In brief

The theoretical stances summarized above are at times overlapping, sometimes complementary, and sometimes contradictory. The different perspectives encapsulate a variety of personal values and beliefs. They are based on different assumptions which can directly or indirectly shape the research undertaken, the selection of research methods and design employed, and the conclusions ultimately drawn. Collectively they capture the ingenuity with which subtle and elusive gender differences continue to be explored.

CASES – THE INCONSISTENCY OF GENDER DIFFERENCES

Beliefs "they are a-changing"

The Fennema-Sherman [F-S] Mathematics Attitudes Scales [MAS] (Fennema & Sherman, 1976) were published in 1976 and have been widely used since then to examine gender differences in mathematics learning. An extensively modified version of one of the subscales scales, the Mathematics as a male domain subscale [MD] was administered several years ago to a sample of approximately 860 students in coeducational high schools in Victoria, Australia. The questionnaire was used to tap students' perceptions about the learning of mathematics and possible gender-linked differences in those perceptions (see Forgasz, Leder, & Kloosterman, (2004). For each of 30 statements students were asked to indicate whether they believed (1) the statement to be definitely more likely to be true for boys than girls, (2) probably more likely to be true for boys than girls, (3) there was no difference between boys and girls, (4) probably more likely to be true for girls than boys, or (5) definitely more likely to be true for girls than boys. In Table 2, the data obtained from the administration of that questionnaire were compared with findings previously reported in the relevant research literature.

Table 2. Research findings (in italics) and predictions based on previous research

ITEM	*Pred*	*Find*	*ITEM*	*Pred*	*Find*
1 Mathematics is their favourite subject	M	*F*	16 Distract others from mathematics work	M	*M*
2 Think it is important to understand the work	F	*F*	17 Get wrong answers in mathematics	F	*M*
3 Are asked more questions by the mathematics teacher	M	*M*	18 Find mathematics easy	M	*F*
4 Give up when they find a mathematics problem too difficult	F	*M*	19 Parents think it is important for them to study mathematics	M	*nd*
5 Have to work hard to do well	F	*M*	20 Need more help in mathematics	F	*M*
6 Enjoy mathematics	M	*F*	21 Tease boys if they are good at mathematics	M	*M*
7 Care about doing well	M/F	*F*	22 Worry if they don't do well in mathematics	M/F	*F*
8 Think they did not work hard enough if don't do well	M	*F*	23 Are not good at mathematics	F	*M*
9 Parents would be disappointed if they don't do well	M	*F*	24 Like using computers to solve mathematics problems	M	*M*
10 Need mathematics to maximise employ opportunities	M	*M*	25 Teachers spend more time with them	M	*nd*
11 Like challenging mathematics problems	M	*nd*	26 Consider mathematics boring	F	*M*
12 Are encouraged to do well by the mathematics teacher	M	*nd*	27 Find mathematics difficult	F	*M*
13 Mathematics teacher thinks they will do well	M	*F*	28 Get on with their work in class	F	*F*
14 Think mathematics will be important in their adult life	M	*F*	29 Think mathematics is interesting	M	*F*
15 Expect to do well in mathematics	M	*F*	30 Tease girls if they are good at mathematics	M	*M*

There were only eight items, it can be seen from Table 2, for which the responses were consistent with previous findings consistently reported in the research literature. These items were largely related to the learning environment and to peers. For example, boys were still believed more likely to distract others from their work (Item 16) and to like using computers to solve problems (Item 24). Girls, it was still indicated, were more likely to get on with their work in class (item 28). In the past, boys were generally believed to have more natural ability for mathematics than girls, were considered to enjoy mathematics more, and to find it more interesting than did girls. Yet the more recent data revealed that, on average, students considered boys more likely than girls to give up when they find a problem too challenging (Item 4), to find mathematics difficult (Items 27 & 18), and to need additional help (Item 20). Girls were considered more likely than boys to enjoy mathematics (Item 6) and find mathematics interesting (Item 29). Responses on so many items inconsistent with previous findings surely implies that changes have occurred over time in gendered perceptions related to mathematics education, that, in other words, the energy expended on documenting gender inequities in Australia and attempting to redress them have left their mark.

Administration of this instrument in other countries has yielded similar results, i.e., with some changes over time in perceptions of gender differences in mathematics learning[2].

Assessment practices – do they matter?

In Victoria, Australia, the final examination program at the end of secondary school contains three different grade 12 mathematics subjects. These are Further Mathematics (the least difficult option), Mathematical Methods (the most popular mathematics subject and a prerequisite for a large number of university courses) and Specialist Mathematics (the most challenging mathematics subject and a prerequisite for tertiary courses with a strong mathematics component). Some years ago, the format of the examination for these subjects was changed. Three Common Assessment Tasks, or CATs, were introduced. These were set by a central body for all three subjects. The first, CAT 1 consisted of an investigative project or challenging problem, to be solved during school time and at home. Initial solution attempts were expected to be redrafted after

[2] Relevant publications include Leder and Forgasz (2000) – Australian students; Barkatsas, Forgasz, and Leder (2001) – Greek students; Forgasz, Leder and Kaur (2001) – Singaporian students; Forgasz, Leder and Kloosterman (2004) – American students; and Brandell, Leder, and Nyström, (2007) – Swedish students.

some teacher input. CATs 2 and 3 were traditional timed examinations, to be completed under supervision. CAT 2 contained multiple-choice questions and questions requiring a short answer. Questions in CAT 3 typically required more extended written answers. All students in a given year needed to complete each of the three CATs.

Clearly, the new assessment procedures offered a unique opportunity to explore the affect on student performance of different types of assessments – for under the new examination structure, the same group of students was required to sit for three distinct examination tasks during the school year. The format of CAT1 was less traditional: time constraints were less rigid. Solutions had a strong language component as considerable explanations were required of the methods used and solution steps taken. The other two components, CATs 2 and 3, were traditional timed examination papers. The students' performance on the different test components are shown in Table 3, for Mathematical Methods, the most popular grade 12 mathematics subject.

Table 3: Mean scores (converted to percentages) obtained in Mathematical Methods, by gender, for 6 successive years

Year	*CAT 1 (%)*	*CAT 2 (%)*	*CAT 3 (%)*
	M F	M F	M F
1994	72.0 75.5	64.4 63.6	53.3 49.3
1995	64.1 67.6	56.2 54.8	36.5 32.6
1996	64.0 66.0	50.9 48.9	42.0 38.9
1997	68.0 70.4	55.8 54.3	44.5 40.7
1998	65.0 67.0	47.6 45.9	41.7 40.0
1999	69.3 72.2	55.8 55.1	38.1 36.6

Consistently, it can be seen, girls outperformed boys on the more innovative examination task CAT 1 while boys outperformed girls on CAT 2 and CAT 3, the more traditional examination formats. Clearly, the format of the examination task influenced students' performance and hence their perceived mathematical ability. Who is apparently good at mathematics can be affected by the nature of the assessment task.

Single-sex v co-educational settings

Australia has a long history of single-sex schooling. Concerns about educational outcomes for girls initially fuelled research on the advantages and disadvantages of single-sex and co-education. More recently perceived disadvantages in boys' educational outcomes have often been the driving forces behind such work. Investigations – often with inconclusive findings – typically involve comparisons of single-sex schooling; single-sex classes in co-educational settings; other single-sex models; and sex-segregation differences by subject area.

Exhibit 1

In a series of articles my colleague Helen Forgasz and I (see Leder & Forgasz, 1994; 1997a; 1997b, Forgasz & Leder, 1995) reported on an evaluation of the implementation of single-sex mathematics classes in one public co-educational high school in Australia. We were invited to evaluate the program not long after it had first been implemented at the grade 10 level, and were then invited back three years later to re-evaluate it. The single-sex classes at that time were at the grade 9 level. Data were gathered from students, teachers, and parents through questionnaires and interviews. The first evaluation did not:

> provide unequivocal evidence that single-sex mathematics classes per se address well-documented gender differences in mathematics learning outcomes. The program evaluated did not appear to have been damaging to the majority of Grade 10 students in the school investigated, and may well have benefited many. Although the school's aims for the program, and the students' and parents' beliefs were that females would benefit most from single-sex classes, there were signs that males derived equal, if not more, benefit from the program than the females (Forgasz & Leder, 1995, p. 44).

Three years later, it was found (see Leder & Forgasz, 1997) that relatively fewer males and females had enjoyed their single-sex classes, and relatively fewer females wanted the single-sex classes to continue into the next year. The teachers were also found to have adopted different teaching approaches in the boys' and the girls' single-sex classes. Over the two evaluations, parents' support for the program overall had waned. The parents of daughters were much less supportive than initially, but the mothers of sons were more supportive. They seemed to believe that their sons' education at the school was in need of special attention. Thus at the time of the second evaluation, parents' and students' perceptions had changed: boys rather than girls were deemed to be disadvantaged educationally.

Exhibit 2

After a recent survey of research comparing students' performance in single-sex and co-educational settings (for an unpublished study) Helen Forgasz and I summarized the findings with respect to mathematics education as follows:

Collectively, the findings reported from mathematics classes mirrored those drawn from the broader classroom setting. When differences were found, girls typically liked the single-sex setting and performed somewhat better academically than in coeducational classes. In a number of the studies surveyed, boys were more ambivalent than girls about the single-sex setting with some indicating a firm preference for coeducational classes. These differences, however, could often be attributed to differences in student background factors rather than the sex-segregated setting per se. In the majority of studies, the focus was on the shorter term effect of single-sex / coeducational grouping. In the few studies in which longer term effects were examined, earlier advantages attributed to the single-sex grouping appeared to dissipate and those students who originally favored single-sex groupings seemed less enthusiastic. Two explanations for the equivocal findings emerged: certain groups of students (e.g., those being harassed in a coeducational setting) benefited from a single-sex environment while for other groups it made no difference. Teacher strategies and the prevailing school climate, rather than the gender grouping in the mathematics class, seemed critical to students' success and perceptions of the class environment.

In brief

Gender differences in mathematics, if found, do not occur in a vacuum but are susceptible to societal expectations and environmental and contextual influences.

THE FUTURE

Research on gender differences in learning mathematics, per se or interactively with other factors, continues – as is evidenced, for example, by the continuing stream of papers on the topic published in peer reviewed journals, presented at national and international research conferences, and reported in the popular media. From the different theoretical perspectives summarized in Table 1 above, there are clearly many different lenses through which research can be planned, gender issues can be explored, and data gathered can be interpreted.

Contradictory findings continue to emerge. At times, females are considered to be the educationally disadvantaged group; at others it is males for whom it is considered that more support is needed.

The media undoubtedly capture and reinforce current expectations and beliefs about gender issues and have a more than negligible input into shaping future directions. A focus on some recent print media articles, then, concludes this paper.

Seemingly contradictory reports appear, as can be seen from two articles printed in the New York Times on the same day, December 4, 2007. From the one it might be concluded that females are doing well.

> This year, more than 1,600 students nationwide entered the Siemens competition [a prestigious math/science/technology award]. After several rounds of judging, 20 finalists were chosen to present their projects at N.Y.U. and to vie for scholarships ranging from $10,000 to $100,000. Eleven of the finalists were girls. It was the first year that girls outnumbered boys in the final round. Most of the finalists attend public school. … Three-quarters of the finalists have a parent who is a scientist. (New York times, December 4, 2007)

From the other, it appears that gender stereotyping is persistently robust:

> Dr. Hopkins helped start a national discussion about girls and science two years ago when she walked out of a talk by Harvard University's president, Lawrence H. Summers, after he suggested that innate differences between men and women might be one reason that fewer women than men succeed in math and science careers. Dr. Summers apologized during the ensuing furor; he announced his resignation as Harvard's president 13 months later. (New York times, December 4, 2007)

Articles such as these should not be allowed to disguise a broader problem identified in many countries: the drift away from the mathematical sciences and related careers. How best to counteract this trend is a topic of intense interest, and indeed some interventionist activity, in many countries.

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