GENDER EQUITY IN MATHS & SCIENCE

GEMS

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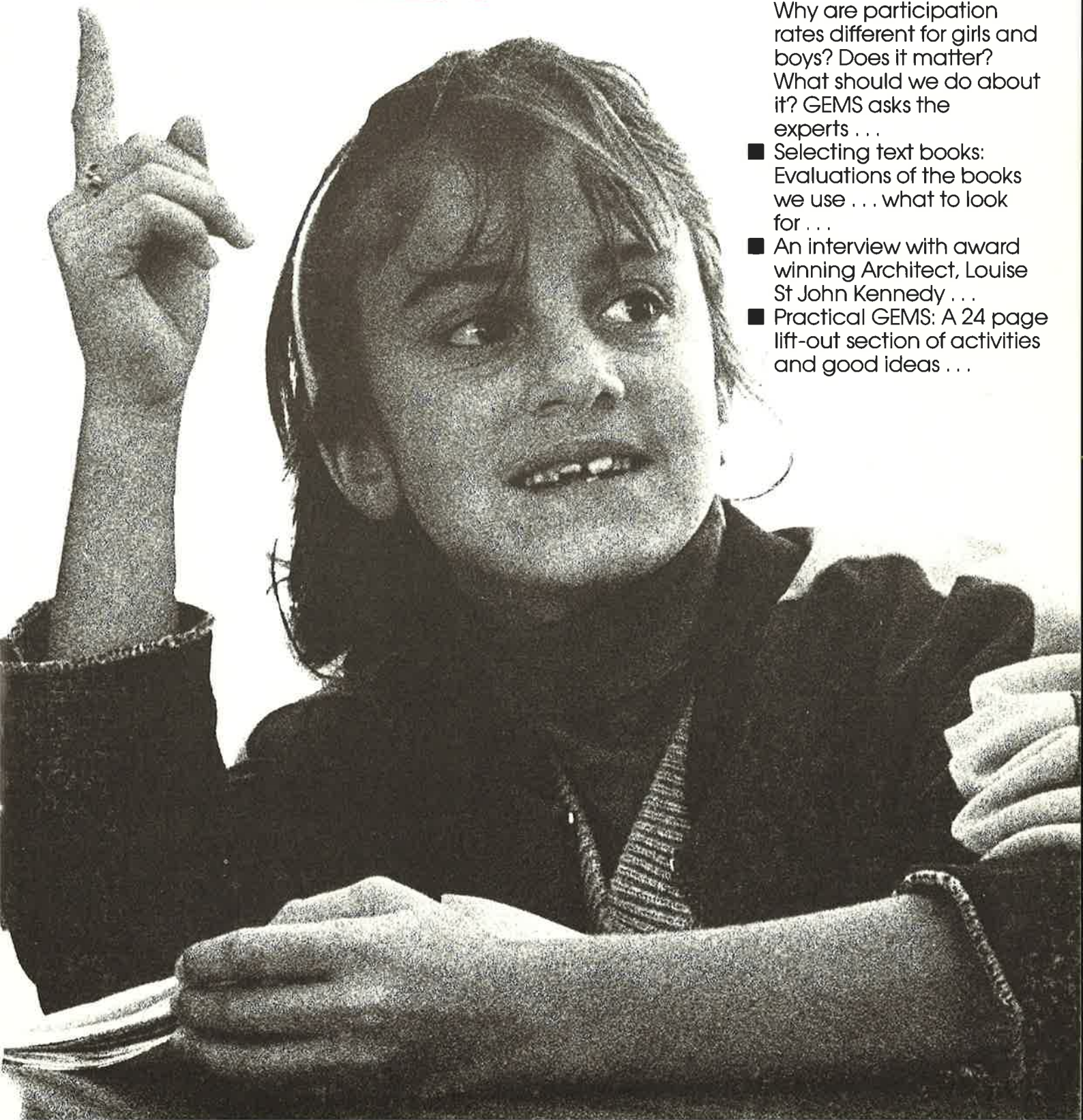
This is a professional development magazine; please ensure that the following people in your school see it —

- ☐ mathematics teachers
- ☐ science teachers
- ☐ careers counsellors
- ☐ equal opportunity advisers.

- ■ Girls in maths and science: Why are participation rates different for girls and boys? Does it matter? What should we do about it? GEMS asks the experts . . .
- ■ Selecting text books: Evaluations of the books we use . . . what to look for . . .
- ■ An interview with award winning Architect, Louise St John Kennedy . . .
- ■ Practical GEMS: A 24 page lift-out section of activities and good ideas . . .



It is now widely acknowledged that the mathematical and scientific talents of many girls are under-utilised. The overall levels of achievement of girls and boys in mathematics and science are very similar but in the upper secondary years girls participate less than boys in the highest levels of mathematics and the physical sciences. The government regards this situation with concern for two reasons.

Firstly, girls and boys should have available to them the full range of post-school options. Presently, women do not share equally with men the economic advantages available to those engaged in mathematics, science and the related occupations. Furthermore, it is important that women take a greater part in the political and economic decisions society makes about technology and hence about the social and physical environment in which we live. In order for such participation to become a reality girls and women must have greater access to mathematics and science.

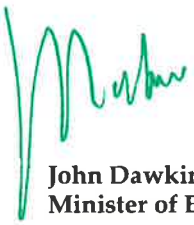
Secondly, Australia's economic recovery must be knowledge based and for this the nation needs more highly skilled people, particularly in mathematics, science, technology and the related fields. To achieve this it is essential that we tap the mathematical and scientific talent of girls more. Increased participation of girls and women in school mathematics and science clearly is in Australia's economic interest.

The reasons for the differences in the participation rates are complex and the solutions are not immediately obvious. Schools cannot be held responsible for community beliefs about female and male intellectuality, inclination, needs and futures and the conflicting community and media messages girls and boys receive about the home and work responsibilities of women and men. Nor are schools responsible for the gender segregated nature of the current labour market where employment structures often require that job entry and progress must happen during the major child bearing years.

Nonetheless, schools are one place where it is possible to intervene in order to overcome the cycle of social inequality. Furthermore, schools must take some responsibility for the differences in girls' and boys' educational experiences and their consequent post-school options. Clearly, the quality of mathematics and science education needs to improve in ways that are sensitive to the needs, experiences and interests of girls. Also mathematics and science must be seen as equally central to the education of girls and boys. Only then will girls be in the position to make real choices about post-school options which involve mathematics and science.

Many and competing demands are being made on schools and the difficulty of coping with them all cannot be underestimated. The Commonwealth government has made a specific commitment to support schools in their efforts to convince girls that mathematics and science offer good opportunities for them and to encourage girls to regard these options and occupations as part of their natural range of choices. It has provided one million dollars over two years to the Curriculum Development Centre for the *Education of Girls in Mathematics and Science Program.*

This professional development magazine, GEMS, is one of the products of this Program and I commend it to you.



John Dawkins
Minister of Education

In the September budget of 1987 the Commonwealth government announced a new initiative to increase the participation of girls in mathematics and science. One million dollars over a two year period was provided to the Curriculum Development Centre for the Education of Girls in Mathematics and Science Program, which is to be spent on the production of materials to support teachers in their efforts to convince girls that mathematics and science, at all levels, are for them.

This magazine is one of the first products of the Program.

Our cover photo shows Marianne Scerri, a student at Dominic's School, Broadmeadows, Victoria. Photo by Kevin Morgan, West Brunswick, Victoria, phone (03) 386 6163.

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EDITORIAL

GEMS is a new quarterly magazine for all teachers of mathematics and science, in primary and secondary schools alike, and for those who provide advice to girls on post-school options. We hope GEMS will help you to focus on the issues involved in gender equity in mathematics and science.

Articles will range in subject from classroom practice to policy at school, system and government level, and from the immediately applicable to the more conceptual. We will bring you the latest evidence on girls' and boys' participation and achievement in mathematics and science in Australia and discuss how participation and achievement in these fields relate to girls' and women's post-school options. A range of authors will analyse factors influencing girls' educational and occupational experiences and choices and draw implications for school practice.

Each issue will report on efforts around the country to address differences in girls' and boys' levels of participation in mathematics and science. These will include examples of good practice ranging over classroom pedagogy, curriculum content, awareness raising for students, teachers and parents, and professional development strategies.

GEMS will also review resources and support materials as they become available, report interesting developments around the country, research projects, new policy directions, conferences and contact points.

We would be delighted to hear about your efforts to deal with gender issues in mathematics and science — your successes and failures. Failures can often contribute as much to our understanding of change strategies as successes. The emphasis in GEMS, however, will be on strategies which have the potential to effect long term change rather than on bandaids.

The magazine will provide evaluations of existing commercial text materials in mathematics and science. We hope these evaluations will indicate some of the subtle, and not so subtle, gender biases in texts used by students. We also wish to assist schools' in their choice of student materials and provide practical advice for teachers about how to overcome the worst problems of some of the available materials. Importantly, we hope to influence future textbook production.

Finally, each issue will include, as an insert, reproductions of existing materials on gender inclusive teaching in mathematics and science. These will include student materials, teacher resource materials, and professional development materials. They may relate to the mathematics or science curriculum as such, to classroom and school practice with regard to girls, or to understanding work and post-school options. The intention of this section is to make readily available the efforts of others who have attempted to change their practice. The materials will vary in their scope, style and sophistication. We have not evaluated these materials and offer them, on the whole, without comment. Some may suit your circumstances and inclinations, others may not. We would be interested in your comments on the activities you try and information about other materials to which teachers should have access.

The community as a whole imposes particular forms of credentialling on girls' and boys' educational experiences as well as certain employment and family structures on women's occupational experiences. Schools are only part of this broader community and we do not wish to exaggerate what they alone can do. Nonetheless, schools play an integral part in the process of gender construction and must do as much as possible to ensure that the full range of post school options are equally accessible to young women and men.

The emphasis of this magazine will be on classroom practice in mathematics and science because it is in classrooms that the long term and fundamental educational solutions lie. This is not an issue that can be left to the committed, the experts, or the policy makers — it must be addressed by every teacher of mathematics and science.

CONTENTS

What do the experts say?

For this first issue of GEMS Margo Haysom asked a range of people from around Australia for their views on the participation of girls in mathematics and science. We invited five women and men to comment on mathematics and five more to comment on science. The questions we asked are below and on page 5 and question 4 was adapted to suit the person. The answers were diverse and interesting but we have been forced to print selections only (in order to save the trees). We would be interested to hear your views on these matters.

We asked about girls and maths:

1. *What are the main reasons the participation rates in the higher level of maths are different for girls and boys?*
2. *Do you think it matters? Why?*
3. *What should we do about it?*
4. *What do you see as (educators'/politicians'/industry's/society's) role in this?*
5. *Do you think that the jobs really will be there for women?*

Cheryl O'Connor, Principal, Giralang Primary School.

The finding that girls' overall levels of achievement in maths is similar to boys in primary and lower secondary masks some important differences in mathematics learning. I see a decline of girls' interest in mathematics by the end of their primary years. In effect, they are already choosing not to participate. At Year 4 level, girls demonstrate that they can fulfil work requirements, but already they need constant reassurance as to their ability. Normally they stay on the verge of confidence, but continue doubting their abilities. They need constant pushing and encouragement. The competence of girls in mathematics at this stage is better than boys, but they are aware that maths is not a girls' subject and their confidence wanes.

Obviously this matters. Girls' life choices are restricted, and the ensuing consequences to the community are huge in terms of hard cold cash. Firstly, because there's a huge untapped talent going to waste and, secondly, because the social reality is that it is primarily mothers taking sole care of children who are the poorest group in our community and who must be supported by the state.

. . . I believe that much greater responsibility for educational outcomes must be taken by principals who should develop and maintain active programmes for girls. So often, as soon as a school loses a principal who is active in these areas, the programme she or he instigated goes down the gurgler. If the impetus doesn't come from the top, it's very hard for change to happen.

Richard Sweet, Education Consultant, Work Skills Australia.

One of the most obvious, if rarely addressed, reasons for girls' low rates of participation in mathematics and science is that they are not required to study them. I am a great believer in systemic structural solutions, and have always found it appalling that students in junior high school in some states are able to opt out of mathematics and science.

There is much in favour of Metherell's clumsily executed attempt to extend the notion of mathematics and science as core disciplines to the end of Year 12. The French certainly take this attitude towards mathematics, with all the baccalaureate streams containing it. The Americans seem to extend this view into the junior college level in many cases.

The two main reasons for advocating increased participation in mathematics and science are cultural and those that relate to labour market screening mechanisms. Firstly, we live in a scientific and numerate culture. Those who have no grounding or interest in these matters lock themselves out of understanding some of the more important political issues of the time. Secondly, they also act against their own self-interest. While few jobs require high or even moderate levels of mathematics and science that cannot be taught on the job (the Vice-President of the Japanese Sony Corporation originally trained as an opera singer), employers often believe that they do, and select staff accordingly. Having studied mathematics and science helps you to get a foot in the door. It also demystifies the frequently simple levels of mathematics and science actually required in many jobs.

I am, however, not persuaded by the economic demand arguments. The proportion of jobs requiring high levels of mathematics and science is unlikely to grow dramatically, even if there is modest growth, and even if the level of competence required in those jobs will rise. We are already at the top of the OECD league in our output of science graduates, and

"One of the most obvious, if rarely addressed, reasons for girls' low rate of participation in mathematics and science is that they are not required to study them."

average in our production of engineers. We equal the U.S. and Japan in the proportion of higher education entrants in scientific and technological disciplines. Kinmonth, in the Comparative Education Review 1986 30 (3) debunks the view that the Japanese economic miracle is based upon a high output of engineers. He shows that the numbers are really no higher than in the U.S., and the real difference lies in how skills are used once produced.

Gilah Leder, School of Education, Monash University

It matters, because in our society mathematics is a qualification for many important life options — it becomes a critical filter; without good mathematics qualifications many tertiary courses and apprenticeships are not possible. A whole range of options are closed off, because the outside world equates maths with cleverness. Survival with dignity requires mathematics. Also maths is a cumulative subject, and until recently there have been no second chances in mathematics — no way to pick up on maths once it has been dropped. Only now are people being given a second chance to learn maths.

What should we do? Life is made up of a lot of things besides mathematics, and there will always be students who do not want to participate in the mathematics area, so I am ambivalent about what we could or should do. Some girls who don't want to do maths show good sense — they don't like the 'maths life style.' I think that we should make it clear what it means to opt out of maths. However, I wonder about the possibility that if maths was made compulsory, so that students couldn't opt out of the subject, the content might be watered down too much.

I think it should be perfectly acceptable for 25 year old people to go back to study maths, and appropriate environmental and teaching strategies be incorporated to enable mature learners to 'go back'. In fact, it should be possible to opt back in again at any time, from lower secondary level, to upper secondary and tertiary level.

Participation rates in upper secondary mathematics in Australia

The tables below indicate broad patterns of participation in the mainland states in 1986. The table has been compiled from Jones (1988) which provided no information for Tasmania and the Territories. Deckers, De Laeter & Malone (1986), however, provide 1985 data for the ACT and Tasmania which suggest that the corresponding participation rates for the ACT are somewhat higher, and for Tasmania somewhat lower, than for the mainland states.

TABLE 1: Students Studying at least one Year 12 Mathematics Course in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	44	42	94	99
VIC	16 (21)	21 (25)	31 (40)	50 (59)
QLD	55	50	90	92
SA	21 (29)	28 (35)	36 (50)	54 (69)
WA	32 (44)	39 (47)	61 (84)	81 (97)

TABLE II: Students Studying a Highest Level Year 12 Mathematics Course in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	7	13	16	30
VIC	4	10	8	24
QLD	6	15	10	28
SA	7	14	11	27
WA	4	12	8	24

Note: The tables have been compiled from data provided in Jones (1988) and course enrolment ratios of males and females obtained through telephone calls to relevant bodies and other published data. They are consistent with the information provided for the National Data Base on Girls and Education which is yet to be published later this year.

For Victoria, South Australia and Western Australia the unbracketed figures show the percent of students enrolled in externally examined or moderated Year 12 courses, the figures in brackets include the school assessed courses which are not used for the calculation of tertiary admission scores (TES).

While within any particular state TES courses are likely to be mathematically less demanding than school-based courses, the same assumption cannot be made across states since whether or not a course can be used for TES depends on tertiary admission structures. For example, in Western Australia, Mathematics IV could be used for TES in 1985 but not in 1986, however, it was the tertiary admission structure which changed in 1986 and not the course.

Furthermore, while there appears to be considerable variations among the states and territories in both male and female participation in mathematics, comparisons should be made very conservatively since the pattern of participation depends considerably upon the upper school curriculum and accreditation structures.

Given these reservations, these tables show that, although in most Australian states girls are increasingly taking mathematics in Year 11 and 12, attempts to convince girls to participate in the highest levels of mathematics (which often means taking a double unit of mathematics) have not met with overwhelming success.

Mary Barnes, Mathematics Learning Centre, University of Sydney.

It is a very complicated situation, and a brief answer is hardly likely to be adequate but, in my view, the main reasons for differences in the participation rates of girls and boys in mathematics are:

- girls do not perceive mathematics as relevant to their interests and concerns or likely to be useful to them in their future lives.
- girls have less confidence than boys in their ability to succeed in

"We need to . . . ask why girls don't see mathematics as relevant, why they are less confident."

mathematics, even when they are achieving well in the subject.

But these 'reasons' do not really explain anything, they are merely further symptoms. We need to go behind these, and ask why girls don't see mathematics as relevant, why they are less confident. The explanations for these lie partly in the way mathematics is taught in schools and partly in the way girls are brought up.

Mathematics in schools tends to be seen as a body of knowledge to be memorised, rather than a way of knowing. It is taught generally in an authoritarian manner, which emphasises competition, speed, and getting the right answer by the approved method. It is seen as important for utilitarian reasons, for its uses in science, engineering and business and as a credential for entry to jobs and courses of study. This view of mathematics has less appeal for girls than boys, and its applications in male-dominated areas such as physics and engineering lead to its being seen by many people as a male domain.

The upbringing and education of girls, on the other hand, leads to them forming beliefs about the kind of behaviour appropriate for females, and about what the future is likely to hold for them. For example, girls, and their teachers tend to attribute their successes to hard work and good behaviour, rather than ability and so have decreased expectations of success when the work becomes more difficult. Also, girls come to expect family needs to play a more important role in their future than a career. And so mathematics (seen as a qualification for many careers) is less important for them than for boys. Girls, in choosing a career, are more likely to choose the 'caring' professions than the technological ones.

. . . What should we do? I think we need to change the mathematics curriculum, to make it more inclusive of girls and relevant to their interests and needs. This would include presenting mathematics more as a human endeavour, with applications to important social issues; including and valuing the interests and achievements of women and girls; and emphasising the creative and imaginative appeal of mathematics. It would also involve changing teaching methods to make more use of discussion methods, small group collaborative activities and open-ended investigations, and to emphasise cooperation rather than competition. It is important to cater for a variety of learning styles and to allow students some opportunity to choose what and how they will learn and how their learning will be assessed. Most of these changes would benefit boys as well as girls. It is also important to bring the issue of gender relations in the classroom into the open, and to discuss with both boys and girls the amount of teacher attention directed towards (demanded by) different groups within the class.

But, changes to the mathematics curriculum alone will not be enough. Mathematics is part of the whole school curriculum, and is influenced by the attitudes and expectations of the whole school community as well as the wider society. The teaching of mathematics therefore needs to take place in the context of a school committed to equality of educational opportunity, to removal of stereotyping on the basis of gender, and to change girls' restricted expectations for their futures and restricted beliefs about their aptitudes and abilities.

Education has to take the principal role. By changing the climate within schools, what we teach and how we teach it, we can make a start at changing deep-seated attitudes about gender roles and about the nature and relevance of mathematics. By reaching out through the students to their parents, we can begin to influence community attitudes.

Brian Martin, Department of Science and Technology Studies, University of Wollongong

Brian Martin has been involved with the radical science movement for 15 years and with the Women in Science Enquiry Network since its formation.

. . . It is important that all people, but especially members of less privileged or powerful groups, are able to understand mathematics and science sufficiently to have confidence to join in public debates, social action and decision-making on the numerous issues that involve mathematics and science, such as taxation, computing and nuclear power.

A few things can be done within schools, including encouraging girls and presenting the social relevance of mathematics and science, for example in the home, in workplaces and in controversies like those over reproductive technologies. The ultimate solution will depend on struggles against male domination in a range of spheres, from rearing of infants to the gender division of labour.

Academics can do what anyone else can do, which is to act to promote equality in all spheres of life. Depending on their discipline, some academics can scrutinise assumptions of innate male superiority in mathematics and science, analyse processes of male domination and examine strategies to challenge and supersede it.

. . . It is an illusion to think that a large cohort of technically well qualified women will be able to gain jobs in technical occupations. As well as direct harassment and gender-biased assessment of achievement, the career structure discriminates against anyone who does not have a 'wife' to do the housework and care for children.

In any case, it is my opinion that it is the wrong goal for women collectively to aspire to half the career slots now occupied by men, without questioning the career structure itself. The hierarchical structures in corporate, government and other bureaucracies are ideally designed to maintain male domination. At best a fraction of the higher-level positions will be filled by women, mainly middle-class women. A different goal is a less hierarchical society, with more cooperative work arrangements cutting across the usual public-private split. In such a society, adult involvement with mathematics and science would not be so restricted to full-time professionals. The 'problem' with female participation rates is only

"A whole range of options are closed off, because the outside world equates maths with cleverness."

partially solved by addressing the factors affecting participation; it is also necessary to confront the nature and role of mathematics and science in our society, and their place in a range of oppressive social structures from male domination to the war system.

Peter Duncan, Minister for Employment and Education Services

. . . We must inculcate non-traditional educational practises for girls and boys. This should include special curriculum in teacher training, and changes in the curriculum for pre school, primary and secondary students to address gender equity.

. . . the jobs will be there. Companies which have supported affirmative action and employers who have employed women in significant numbers in middle and senior management have already benefited from doing so, simply because they've got the best people doing the work. There will have to be more flexible employment in the future including job sharing. We must, of course, also acknowledge the hidden view that keeping women at home is seen as a cheap way to reproduce the work force — women work for nothing to keep their 'men at work' well cared for, and to produce another generation of workers and nurturers.

We asked about girls and science:

1. *What are the main reasons the participation rates in physical sciences are different for girls and boys?*
2. *Do you think it matters? Why?*
3. *What should we do about it?*
4. *What do you see as (educators'/politicians'/industry's/society's) role in this?*
5. *Do you think that the jobs really will be there for women?*

Rhonda Galbally. Chief Executive, Victorian Health Promotion Foundation

. . . Career counselling in schools is not targeting anyone, let alone girls. Counselling isn't regarded as a permanent or significant part of school work allocation, so the career teacher is often marginal. She or he is often doing career counselling on top of a million other jobs, so that the intensive work that needs to be done when you are overcoming barriers in junior and secondary school, which is when girls get turned off, is just not there. Career counselling needs to have a much higher profile in schools.

One of the important issues emerging from some studies is the apparent lack of relevance of the vocations that are based on mathematics and science. They are not seen as viable vocations by girls, their teachers and parents or by the tertiary faculties. If you're a girl, why would one study these subjects that appear to lead nowhere — or to no outcome that has ever been considered as appropriate for a girl?

The image of a lot of those jobs, however, is inaccurate. For example, engineering is seen as dirty, when in fact there is a lot of white collar engineering. Mistaken images need to be changed because they are very serious barriers . . .

. . . The breakthroughs that lead to innovation and productivity, ('intrapreneurship', if you like), are very much related to a feminine value system and having women in those workplaces and doing those jobs is going to be very important to Australia's productivity for the future. If we want to continue with a commodity based productivity — which is about digging things out of the ground and sending them overseas for innovation — then we can afford not to have women in those jobs and in those education disciplines. But if we want to have a truly value added productivity then we need women's thinking — we can't continue without it. We're a very uninnovative country; we don't add value to product, and we don't have women in many of those related fields. And I think the pudding's in the eating.

That doesn't mean throwing away humanity studies, and in particular design and cultural studies. Maths and technology alone will not be sufficient for economic or any other recovery in Australia. Without people who are excellent in understanding the value of design and culture we can't use science and technology creatively. We must have an integrated view, and the combination of subjects at HSC level in future ought to include art and design and science and mathematics, and integration at tertiary level of art and design faculties with engineering faculties. At the moment the arts are completely marginal. Our lack of relationship to Australia's culture; our lack of design capacity, which is evident in a lack of identity in design, is a very great disadvantage in productivity terms.

. . . We also have to have every Australian person literate in science and technology. There are major decisions we're all going to have to make which have to be made democratically because the impact of those decisions is enormous. Those issues are to do with human life, (like reproductive technology); the environment, (like biosphere destruction isssues), nuclear holocaust, (like very major sustainability issues), and the issue of redundancy, or the planned introduction of technology.

What can we do about it? We have to make changes in curriculum, restructure significant areas of teachers' workloads, and get resources ready. And we have to get the wider culture to pick up these issues. Television programs and radio programs and rock songs should show girls doing everything. 'Neighbours' ought to exemplify these values — Kylie Minogue and Kylie Mole should both be exemplifying these issues. We could make ads about it for television and radio. We need mass campaigning right down to the local educational level.

Money could be raised from

"Part of our problem is to increase the numbers of teachers in these subjects and improve their training — and we need to reward them."

corporate sponsorships and foundations. I suspect that the private sector would be very interested in a well thought through campaign package in that area. It shouldn't just be government supported because it is the private sector that is going to use these young women to their great advantage.

Jim Falk, Department of Science and Technology Studies, University of Wollongong

The reasons are complex and stem from the way in which girls and boys observe such things as the roles their parents play, the attitudes of teachers, and the way in which girls and boys themselves conduct their interactions. It leads to greater and greater differentiation between the sexes. Girls in many ways adopt to the stereotyping of nurturing, being closer to the earth, feeling and expressing emotions better. Boys adopt the role of conquest, manipulation, material control. It makes a serious barrier between the sexes.

It matters, of course, because this adoption of stereotypical roles reflects a cutting off of capacities of both boys and girls — girls could learn to manipulate, to shape their own rights, boys could expand their nurturing abilities etc. It matters because this stereotyping restricts the social world in which they move, and it matters to a country that half of its population is disconnected from the area which is regarded as most productive — that is, the technological area.

Of course, it is a loaded statement that technology is productive. What we value in technology is what increases production, consumption makes us wealthier but it leads to bad technological practises. When we attempt to overcome the barriers which form the stereotypical roles of females and males and expand the abilities of both males and females, perhaps we will also improve our bad technological practises.

Participation rates in upper secondary science in Australia

Note: The tables have been compiled from data provided in the National Data Base on the Education of Girls which is to be published later this year. The percents in the last three tables are provided to one decimal place because many are quite small.

TABLE I: Students Studying at Biology in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	23	12	50	28
VIC	23	11	44	25
QLD	41	27	67	50
SA	45	23	77	45
WA	41	24	79	49
TAS	15	8	46	29
NT	27	11	71	39
ACT	26	14	32	19

TABLE II: Students Studying Chemistry in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	11	15	23	36
VIC	10	14	18	35
QLD	41	27	25	42
SA	12	21	20	41
WA	9	16	17	34
TAS	15	8	16	32
NT	27	12	21	46
ACT	26	14	22	27

TABLE III: Students Studying Physics in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	6	17	12	40
VIC	4	14	8	33
QLD	8	21	13	39
SA	9	25	16	48
WA	7	18	13	37
TAS	3	13	11	47
NT	6	16	15	53
ACT	11	27	14	36

TABLE IV: Students Studying Geology in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	0.7	1.5	1.4	3.5
VIC	0.3	0.2	0.6	0.5
QLD	0.7	2.3	1.2	4.2
SA	3.4	4.6	5.8	8.9
WA	0.5	0.9	0.1	1.8
TAS	1.9	2.6	3.6	9.4
NT	5.5	4.6	14.4	15.3
ACT	0.6	3.1	0.8	4.1

TABLE V: Students Studying Physical Science in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	0.6	0.9	1.2	2.2
VIC	0.2	0.4	0.4	0.9
QLD	—	—	—	—
SA	0.2	2.0	0.3	3.8
WA	2.7	3.8	5.0	7.8
TAS	0.2	1.1	0.7	4.0
NT	0	0.9	0	3.0
ACT	2.3	4.8	2.9	6.3

TABLE VI: Students Studying General Science in 1986

	As a % of Year 8 cohort		As a % of Year 12	
	females	males	females	males
NSW	5.0	4.9	10.7	11.7
VIC	—	—	—	—
QLD	5.3	6.6	8.9	12.0
SA	0.6	1.4	1.0	2.7
WA	0.8	1.9	1.5	3.9
TAS	0.8	0.6	2.3	2.3
NT	2.0	1.4	5.2	4.7
ACT	13.9	10.4	17.5	13.7

While there appear to be considerable variations among the states and territories in both male and female participation in science, comparisons should be made very conservatively since the pattern of participation depends considerably upon the upper school curriculum and accreditation structures.

The tables do, however, show gendered patterns of participation in the sciences. Biology is the science with the highest participation of girls in all Australian states and territories and of boys in two states. More than three fifths of biology students in Year 12 are female.

Girls tend to participate in the physical sciences less than do boys and girls take fewer science subjects than boys. Approximately one quarter of Year 12 physics students and almost two fifths of Year 12 chemistry students are female. Enrolments in general science tend to be considerably smaller but almost half of the enrolled students are girls. Generally participation rates in physical science and geology are very small but, with the single exception of geology in Victoria, more boys than girls enrol.

There is no simple technological fix. The whole issue of the stereotypical division of responsibility at home and work may be hard to tackle in some areas but it is practical and possible to at least shape the

"It would be good to believe that our national leaders are fired by a vision of achieving justice for girls and women and of creating a more fully human science for a more fully human society."

school experience.

Don Aitkin, Chairman, Australian Research Council.

. . . We start with a deliberately intellectual and academic approach, and it may appeal to children who respond well to attacking, pushing all the time. We should change our approach to encompass the the idea of cooperation with nature rather than conquering it.

. . . Part of our problem is to increase the numbers of teachers in these subjects and improve their training — and we need to reward them. The ASTEC report of 1987 said that science/maths teachers should be paid $5,000 more than teachers in other disciplines but this finding caused an outcry from the Teachers Federation. They said 'that's not what it's all about — all teachers should be rewarded the same no matter what they teach. What happens to teachers who can't be science teachers?' It will take a while for that attitude to be displaced. It is characteristic of a time when it really didn't matter. We were a wealthy nation, and we gave our students a broad based, rounded education because we could afford to. Competition is keener now, so education has to be finely honed for the market place.

Jobs will be there — there is a tremendous shortage now in areas like electronics, engineering, computer science, electrical engineering, radiology, and radiography. There's no indication that those jobs are going to be filled quickly. Conventionally, we have regarded the outcome of graduates as being dealt with adequately when the last of them has a job. That means that if someone wants a biochemist we have to say 'Sorry, you'll have to wait till next year, all this year's biochemists are employed.' We could probably employ twice as many graduates as we are producing in some areas. We need a lot more people to finish high school with the capacity to say 'There's a wide range of things I can do. I know there is a broad range of jobs out there, and I want to choose a tertiary course which still keeps my options open.'

George Hutton, Business Council Education and Training Committee, Federation of Industry.

Business believes that the provision of opportunities for each student to develop maximum potential should be a major goal of educators, and that to attain that goal business and the education sector should work closely together to devise strategies to improve quality of education and achievements for students.

This principle is pre-eminent in the context of the Business Council's education and training policy, but in endorsing it, the Business Council sees no differentiation between boys and girls. However, we do recognise that unfortunately, there is a serious imbalance in some areas of the education sector to the disadvantage of girls. We believe that this is particularly so in the study of mathematics and science, and the openings that exist in the world of work for students who pursue these subjects. In recognition of this, the Business Council's education policy, in advocating higher participation rates, supports equal opportunity in education, and an emphasis on increasing the percentage of girls/women specialising in technical subjects.

The reasons for the imbalance are complex, and it is a situation that has developed over many years; there was traditional acceptance in the past that boys took mathematics and science with the goal of a technical career, while girls studied liberal arts.

It is the Business Council's view that educationists and business should have a hard look at the curriculum; that there should be more resource material prepared by or with the cooperation of industry, and that business should spend more time in the schools so that it can present a more comprehensive and detailed portrayal of the world of work.

The Business Council has placed emphasis on the need for greater attention to the transition from education to work through a number of initiatives, and is pleased to learn of the proposed professional development magazine.

Christina Hart, physics teacher, Sacre Coeur Secondary School

Ms Hart is a member of the McClintock Collective, a group of teachers who are working to increase the participation of girls in science. She is also involved in designing the new senior physics course in Victoria for the Victorian Certificate of Education, which will replace present courses in 1991.

The reasons are complex, but fundamentally they are to do with our views of the nature of science, of the roles which men and women can play in society and of ourselves as individual women or men. We construct these views within a powerful framework provided by family and society. Within that framework boys are encouraged to develop by seeing themselves as independent operators, relating to other people and to the world as though these are objects outside of and separate to themselves. Thus they readily identify with science as an objective way of understanding the world and gaining power over it. Girls, on the other hand, are encouraged to know themselves through relationships, so that a science that requires them to separate themselves from the objects they are studying and from other people is alienating. This congruence of male values and male ways of knowing with the values of science and the scientific way of knowing is compounded in school. Textbooks, problems, videos, a myriad of other resources, and a preponderence of male teachers in physical science, combine to convey

"Mathematics and science have to be as much a part of our lives as football is."

an excessively male image of science.

. . . I believe it is necessary that we challenge the view that it is appropriate and desirable for the scientist to detach her or himself emotionally from the object they are studying. Science, has brought us great benefits, but it has also been used in ways which alienate people from one another and cause the threat of nuclear holocaust or environmental catastrophe. For our survival we need a science that is informed by ways of knowing through connectedness and interdependence, and by values such as concern for people.

Curricula in physical sciences need to be challenged and changed as do the methods of teaching and assessing those subjects. Curricula and assessment in physics and chemistry have emphasised convergent, deductive, mathematical and analytical modes of thinking; and yet more feminine modes of thinking — intuitive, global and verbal — are at least as important to the scientist. The place of creativity in real science also needs to be acknowledged by including tasks such as writing, researching and designing. Girls are likely to be more comfortable with such open-ended tasks than with learning someone else's correct answer to a problem which ignores all the ambiguities of the real world. Curricula also needs to consider the nature of science, to challenge the notion that science is value free, to ask who determines the values that do prevail and to consider what alternatives there might be.

We should change our practice to take account of and value experiences which girls bring to the science classroom and their particular needs and talents. I think it is important that I become aware of what I teach and ask myself who places value on that learning and why, and what other learning we might value in physical science. These questions relate to curriculum and they must be addressed whenever we have the opportunity within schools and also in the bodies beyond schools which determine secondary school syllabuses. Curriculum change inevitably involves one in political activity and I see this as a further and necessary role for concerned educators to play.

Even at the level of trying to change my own practice, though, I found it hard to act alone, to know what to do or to preserve the conviction that it was worth doing. So I think networks of teachers such as the McClintock Collective are important. They act as a forum for exchanging and generating ideas, and provide an effective channel for political action. But perhaps most importantly, they provide the support which people trying to bring about change need, and which can only come from other people engaged in the same endeavour.

Will the jobs be there? I suppose if governments and industry didn't believe there is or will be a shortage of skilled people in science and technology, then they wouldn't be funding programs to increase the participation of girls in physical science. Indeed, the question seems to be based on the tacit acceptance that this is the real reason for the interest in girls' participation in physical science. It would be good to believe that our national leaders are fired by a vision of achieving justice for girls and women and of creating a more fully human science for a more fully human society.

Barry Jones Minister for Science, Customs and Small Business

. . . Science and maths are part of the language. We live in an increasingly complex society, and if we don't make an attempt to come to grips with what's going in the world around us, the whole thing becomes more and more bewildering. For instance, we either become passive users of technology and treat it as though it's given to us like a cargo cult, 'Oh, look, God came down and put a computer in my lap,' or we do something about educating more girls and boys in science and mathematics so that they can understand the world and use technology to improve their lives.

Mathematics and science have to be as much part of our lives as football is. I'm conscious that I've missed a lot in life by not being able to talk about football — it's a very Australian language of camaraderie. When my colleagues say, 'Canterbury did well the other day,' they don't have to go into the terms of reference and say, 'There's this game in Sydney. They've got a team called Canterbury, understand? They've got a ball — are you with me? There's 18 players a side and they wear coloured jerseys.' And so on. Football is understood. Science and maths isn't. You don't have too many discussions about the second law of thermodynamics round the parliamentary lunch table!

When science is in a position of national disrepute, as it is in Australia at present, it's very difficult to say to girls or boys, 'thats where you should go.' There's a sharp contrast between the attitudes we had towards science in the 'twenties and 'thirties, when we were fascinated with home made crystal sets and it was possible to work out how to repair a watch. Now technology is part of our society at the using level. We all use digital watches but one doesn't start to comprehend any science by taking one to pieces. You can't say to a student, 'Go away and and enjoy discovering how your digital watch or transistor radio works.' And as for the idea of introducing girls to the concepts of cogs and gears with an egg beater — who wants to talk about cogs and gears now? . . .

. . . The jobs will be there. Smart women will replace dumb men. But I think there will have to be a lot more convergence of roles — women and men will have to share the nurturing role more than they do now.

"The ultimate solution will depend on struggles against male domination in a range of spheres, from rearing infants to the gender division of labour."

Aysha Osborne, Year 7 student at Holder High School, Canberra, combining science and technology. Photographer: Alan Moore.