1990

Gender equity : Retrospect and prospect, with recommendations for the School of Education: Part 3

Lesley Patricia Newhouse

LN135/LPN/MBS/1990

GENDER EQUITY : RETROSPECT AND PROSPECT

WITH RECOMMENDATIONS FOR THE SCHOOL OF EDUCATION

PART 3 : SUBJECT CURRICULA FOR GIRLS
: MATHEMATICS FOR GIRLS
: SCIENCE FOR GIRLS
: COMPUTER EDUCATION FOR GIRLS
: INDUSTRIAL ARTS FOR GIRLS

By: Lesley Patricia Newhouse
WA College of Advanced Education
Department of Education Studies
Nedlands Campus

October 1990

TABLE OF CONTENTS

PART 3

SUBJECT CURRICULA FOR GIRLS

Introduction:

Concern for Deeper Issues - Specific Subject Area Curricula of Girls.

One aspect of gender equity concerns the curriculum, including subject content, presentation and distribution of resources (human & material) as well as, teaching method, classroom organization and pupil evaluation - and each teacher needs to examine how issues of equity relate to his/her own specialism.

This final section of the report will focus on school subjects which the population as a whole considers to be 'male' or 'masculine'; to which girls and boys often respond differently; and where different achievement levels become apparent before compulsory participation ends, namely Mathematics, Science, Computer Studies and Industrial Arts.

Mathematics, in particular, acts as a 'critical filter' (Sells 1973, Moody and Linn 1986) in determining whether an individual can proceed along many training and career paths.

> "It is noteworthy that a mathematics qualification is a necessary prerequisite for entering many of the areas of employment where gender inequality is particularly marked, such as Science, engineering and technology" (Issacson 1986:225).

When planning curricula in school with a focus on "education as investment" for the economic and technological needs of society, we are required to focus on the characteristics required of girls and boys to fulfil these adult vocational roles effectively.

Newhouse, C.K. (1989:91) lists the desirable characteristics of engineers and Cross (1989:38) considers the new concept of science for the 1990's, which has as its basis a feminist philosophy and "caring" morality for humankind.

Characteristics of a desirable end product of education:

o interested and capable in the mathematics and science areas,

o enjoy logical reasoning and systematic argument,

o have a practical bent

o show imagination and curiosity

o appreciate aesthetic beauty

o like to work in a team,

o want to contribute to society

o aware of massive, environmental and social problems on planet earth

o effective creative problem solvers, who are caringly conscious of the needs of humankind in a technological world (Newhouse 1989:91, Cross 1989:38).

o fit and healthy both mentally and physically (Reference Research, Sport and Physical Recreation and Self esteem).

The Need to value Other Subject Curricula as well as Mathematics, Science and Computing:

It is clearly evident from these characteristics that we must also as educators, consider "education as consumption" that is meeting the needs of the individual and their particular interests.

(1) Consider the characteristic "appreciate aesthetic beauty" be developed through art, music, home economics (cooking, fabrics and design, homemaking), Industrial Arts (furniture, ceramics, silverware), English literature, Drama (theatre), history (architecture, ancient buildings), foreign languages and a study of different cultures (through a variety of subject curricula).

(2) "Have a practical bent" may be enhanced in many of the above mentioned areas and others such as art, music, home economics, sport, industrial arts, drama and business studies.

Teachers need to be alert to the cultural "gendered" expectations inherent in these subject areas and the differential outcomes for boys and girls. (For example sport is a critical area of concern for girls and currently being researched by J Browne and I Rate of WACAE, Perth).

Science and Mathematics have much to learn from the Arts, Social Studies and Liberal Arts. Science and technology can no longer be considered to be the sole panacea to cure all society's ills.

"the elimination of sex bias in education gives the most promising prospect for the cultivation of individual talents and the expression and recognition of differences between people" (Sutherland 1981:201).

Boys' Education:

"It would be unreasonable to suggest that changes are to be made only for the benefit of girls' education. From what has been said so far it emerges that boys also are far from receiving the ideal education ..." (Sutherland 1981:201).

"In Western Australia, "Girls are opting out of maths and sciences and boys are opting away from humanities". (Paynter 1986:66).

Parker and Offer (1987:154) raise the issue of the "huge disparity between girls' and boys' achievement in English, a disparity which is sustained at upper school level. It raises questions about the teaching of English and acquisition of language competence of boys: Are existing remedial programmes appropriate? Does the "ocker" stereotype mitigate against the progress and success of boys in English?"

However, though we have WA Education Department (1989) directives related to "inclusiveness", I do believe from all the research on the education of girls that "current curriculum change in Australia is, at best, only at the level, in the Schuster and Van Dyne (1984) paradigm, where girls are still a "disadvantaged subordinate group". (Foster 1989:28-29)

It is from this perspective that I have researched the curricula in Mathematics, Science, Computing and Industrial Arts, since as masculine domains, the research highlights even more clearly the dilemma of girls in fully benefiting from their formal education.

Gender Equity Issues and Teachers in Western Australian Schools 1990:

"Achievement can be enhanced by teaching practices and the problem is not essentially girls' failure, but the failure of mathematics educators to teach mathematics in a way that ensures equality of outcomes" (Fennema 1981 cited in Girls and Tomorrow 1985:17).

Thus wrote Fennema in 1981, of mathematics teachers. It is disquieting to note that in 1990, in answer to Item 33 in a survey questionnaire given to a wide sampling of Western Australian teachers that: 46% of female teachers and 57% of male teachers answered that they "did not support the notion that their teaching in all areas should take account of the special educational needs of girls". (EOC (Perth) 1990). Further, 25% of the total sample gave voluntary comments to this item, only (10) of which were positive, while (200) gave responses which ranged from extremely abusive and negative (12) to comments indicating bias or lack of awareness. Overall in the survey, the greatest single number of comments on any aspect of discrimination were directed towards Gender (54), both positively and negatively. (EOC (Perth) 1990:18).

Newman (1989) commenting on the innovations in WA Education since 1984, states:

> "A real 'catch 22' situation has occurred with regard to equity. A system largely uneducated on the subtleties of inequity, has been forced to implement radical change, a combination of hasty implementation and lack of consultation has resulted in more inequities evolving, rather than the implementation of new initiatives being used to reduce these problems" Newman 1989 in (EOC (Perth) 1990:67).

The report highlights:

> "Gender inequity in subject choice and counselling by teachers"
>
> "Teachers of certain subject discourage certain sexes from doing them. Especially in Physics and Chemistry".
>
> "Boys are discouraged from doing Home Economics .... Some girls are discouraged from being involved in originally male dominated subjects, such as manual arts".

The Report concludes that "since the Better Schools policy was issued in 1987, clear cut information, particularly in policy areas is not available to schools and to individual teachers", in many important areas including equity and gender equity (EOC (Perth) 1990:44).

The Report recommends in:

"Recommendation 7"

That the Ministry of Education finalize its equity policies and guidelines and promote them so as to foster positive attitudes within schools and the wider community

"Recommendation 6"

That the Ministry of Education institute intensive inservice training courses which directly involve educators in discriminating role-reversal situations in order to increase their awareness of the potential for both conscious and unconscious discrimination in schools.

"Recommendation 5"

That given the importance of awareness and attitude formation during the pre-service education of teachers, the Ministry requires the Tertiary Institutions which provide teacher education to include a larger number of compulsory courses in the Socio-cultural and multicultural aspects of teaching (EOC (Perth) 1990:21).

Conclusion:

It is clear that a knowledge of Equity Policies and educational intervention for Pre and Post service teachers is essential for both attitude change and teaching proficiency in promoting equity in outcomes for girls.

A National Statement on Girls and Mathematics published in July 1990 by The Australian Association of Mathematics Teachers:

> "strongly urges all those concerned with the teaching and learning of school mathematics to become actively involved in implementing the recommendations of this statement."

Clearly in Western Australia there is a great deal to be done first in changing attitudes towards acknowledging that girls do, indeed have special needs which must be met, before they can hope to become productive, confident and competent learners.

SITUATIONAL ANALYSIS WITH REGARD TO MATHEMATICS EDUCATION FOR GIRLS, BOYS, INTENDING TEACHERS AND MATHEMATICS TEACHERS

The Vision for the 21st Century:

"As we look towards the 21st century, highest priority must be given to arresting and reversing the dangerous decline in the quality of Mathematical education. Significant curricular innovations must be introduced to arouse widespread interest in Mathematics, and to highlight not only its intrinsic beauty, but also its potentially limitless applications to nearly every aspect of life" Haimo and Friedlander (1989:353).

Mathematics Education and the Economic Situation Worldwide, with a Particular Focus on Australia:

"Nations are at risk, students do not seem to be learning well and teachers receive little respect and possess little authority". Malone (1989:325).

Malone (1989) believes the demand for educational reform has never been stronger in order to meet the economic and technological needs of societies for the twenty-first century. Fewer students are choosing careers in science and technology; enrollment in teacher education in the Mathematics area is critically low, so too the supply of well-qualified teachers in the schools (Long 1989:369).

In Australia, the demand is that "educational policies and practices support economic strategies", but "the political wisdom of the day decrees that Mathematics and Science education is to be improved at little or no cost, through redeployment of resources and other "efficiency measures". (Thomas 1989:445-446).

The present situation shows that there are insufficient people with Science, Mathematics and Technology qualifications to improve the technology base of industry. The teaching professions is not attracting the best qualified people, especially Mathematicians and Scientists, due to the relative low pay, conditions and the lack of esteem as a career.

The situation is exacerbated further by the low participation rates in Mathematics and the Physical Sciences in the final years of schooling, and even those who participate may not be mathematically literate to pursue occupations and careers in a technological age.

Perceptions of the Mathematics Curriculum for the 21st Century and the Role of the Mathematics Teacher:

The Inappropriateness of the Traditional Teaching of Mathematics:

Cockcroft (1982) "did much to shift the emphasis away from teacher exposition and practice of skills and routines, and towards a focus on classroom processes and pupil's learning, with particular reference to the contributions of practical work, discussion, problem-solving and investigations". (Price 1989:380).

Research revolving around the issues of gender, non-English speaking background and socio-economic status that influence participation in Mathematics also have highlighted the inappropriateness of the traditional teaching of mathematics for both these students and their teachers. (Thomas 1989).

New Technology and its impact on Mathematics Curricula:

(a) Exciting Prospects:

The issue of a Mathematics curriculum that is evolving in terms of utilizing new technologies, where both computers and calculators "are a powerful force for curriculum change" (Phillips 1989:237).

(b) The need to monitor "marginalization of vulnerable groups"

Zaslavsky (1989) considers three ways in which the total integration of technology with mathematics may disadvantage groups of students by inadvertently blocking them out of the new "constructivist" curriculum in terms of:

- the availability of computers
- the low affectivity of the learner towards computers and the way it may affect their active, enthusiastic participation in mathematics learning, and
- finally teachers with outdated computational skills, traditional attitudes to Mathematics teaching, low expectations of success for students who are female, working class or of different ethnic backgrounds, lack of confidence and competence in computer use as an educational tool, with little time or opportunity to develop these skills. Torok (1989:320).

A New Perception of the Role of the Mathematics Teacher within a Constructivist Paradigm of the 1990's:

"Knowledge is constructed in the mind of the learner" (Bodner 1986; Von Glaserfseld 1984 cited in Malone 1989:326).

Constructivist theory maintains that knowledge, in this case Mathematics, originates as the product of a subject's activity. Thus in the classroom both teacher and students are perceived as "active learners", with the teacher also as "curriculum developer", in the context of constructivism. (Price 1989).

Malone (1989:327) believes in the short term the "most promising scenario would consist of the coexistence of a top-down curriculum model detailing broad topic areas, but containing the flexibility and freedom for the constructivist teacher and his or her students to pursue the ideal of the epistemology".

Teaching and learning is increasingly being perceived as a "process of interaction and communication between student and teacher" where the goal is to find out what the student knows and develop learning experiences to capitalize on that knowledge. Price (1989) and Reynolds (1989) have highlighted the way in which the examination system is "being used as a

model to bring about large scale change in teaching and learning methods" since it is concerned with different learning styles of students and their attitudes towards assessment.

<u>The Need for Professional Development</u>:

"Curriculum development is teacher development" (Price 1989:30).

Chang (1989) focuses on the additional need to develop an effective program to assist and educate teachers to prepare the "disabled learners for the 21st century" and highlights the attitudes, beliefs, expectations, knowledge of subject matter, skills (especially in new technology) and problem-solving orientation required by them to achieve this goal. She highlights three areas of challenge:

"'<u>Teacher' Challenge</u>" - The need to change attitudes and beliefs about the teacher role, as both "learner" and "curriculum developer" (Price 1989; Chang 1989).

"It is crucial for Mathematics teachers to develop a belief that they are people of mathematics because they do and teach mathematics. As a person of mathematics, it is also crucial for them to develop a belief that they understand the mathematics of their students and how to foster its construction" (Steffe 1989:463).

"<u>Curriculum Problem</u>" - The need to enable students to apply mathematics in a problem solving situation in a real world situation and the stumbling block of textbooks and curricula which are "still very classical".

"<u>Student Problem</u>" - Within the context of a traditional curriculum, research has indicated their negative attitudes, lack of motivation and confidence towards mathematics, lack of study skills and reading illiteracy (Chang 1989:366).

<u>Action Research in the UK and the Necessary Changes to Aspects of the Curriculum</u>:

Price (1989:325-328) highlights four initiatives in UK located within the constructivist paradigm and summarizes a number of general areas being developed in UK school mathematics:

the use of a full range of teaching styles;
the role and use of language; (and communication);
investigations and problem solving;
mathematics across the curriculum;
the role of the computer;
the development of a "calculator aware" number curriculum;
the development of children's own mathematical thinking;
mathematics for low attaining children
multicultural and gender issues;
the role of parents.

Hersee (1989:437-438) further highlights the expectation of <u>changes in content</u> in reflecting new technology, new directions for mathematics, new needs for future careers or social reasons, and <u>changes to reflect research</u> on how pupils learn.

American Initiatives with regard to education of Mathematics Teacher Leaders in Primary Schools

Long (1989:372) discusses the education of Mathematics Teacher Leaders in the USA, who in the context of a "whole school approach" work towards "attaining and maintaining visibility for and excitement about mathematics" with the primary schools and their wider community.

Teacher Leaders are responsible for the development of Mathematics Resource Teams, including other teachers, reading and science specialists, guidance counsellors, librarians, students and parents. The Mathematics Teacher Leader is also responsible for training young teachers, liaising with senior high school teachers; planning and implementing parent and community programs, maintaining links with professional organizations; developing proposals for funded projects, conducting research; integrating mathematics with science and the two with other curriculum areas; selecting and evaluating text books and other resources; and assessing and diagnosing pupils.

This action research model with whole school and community support is vital in such a crucial area as mathematics education and the professional development of teachers.

The Need for Networking Amongst Mathematics Teachers to Effect Curriculum Change with the Schools:

Guidi (1989) describes how the enthusiasm and expertise of a small group of mathematics teachers in Brazil resulted in new curriculum proposals for years 1-8 and the successful progressive drawing in of four thousand specialist mathematics teachers into the development and implementation of the programme. It is proposed that they too will "educate" other maths teachers through Curriculum Development and implementation.

Australian Initiatives Highlighting the Mathematics Teacher as the Critical Agent of Change in the Mathematics Curriculum:

Brinkworth (1988) has drawn attention to parallel developments in Australia and the role of the teacher as a "critical agent in curriculum change and implementation".

Thomas (1989) discusses the concomitant "need for teachers to change" to meet the challenges of the 1990's, together with proposals for retraining existing teachers as mathematics and physical science teachers in Victoria; and the current intensive in-service program for existing mathematics and science teachers which began in 1987.

"Both government and the community are woefully ignorant of the magnitude of the task involved in improving mathematics education and advise is seldom sought from mathematics educators". (Thomas 1989:450)

I believe it has been important to discuss the curriculum changes in Mathematics in the wider context in which the needs of girls and the need for girls in the field of Mathematics are being addressed by a few concerned Mathematics Educators.

However, there is a crucial need for Mathematics Educators to be fully aware of the difficulties facing girls in a traditionally masculine field of endeavour, who may be further marginalized by the proposed integration of computer technology.

A National Statement on Girls and Mathematics has just been published by the Australian Association of Mathematics Teachers (July 1990). This statement is a concise, succinct statement which is the product of twenty two years of world-wide research, both action and theoretical and philosophical of women predominantly and some concerned men of vision who have been able to step out of the patriarchal paradigm.

The need for a national and state policy for the education of girls that perceives the interconnectedness between masculine subject areas, future employment in non-traditional careers and occupations; and the enhancement of girls' self esteem, confidence and competence.

Early Efforts in UK and Australia

1. Three Case Studies presented by Foster (1984:110-115) provided personal perceptions of the needs of Australian women in a technological world. They, all believed that "the study of technical subjects, machinery, physics and maths should be compulsory and that girls should be encouraged to continue these subjects throughout their schooling" ....

   One also has strong views on domestic equality between men and women, where the husband and wife would "do at least an equal share of housework and child care" (Foster (1984:114-115).

2. G.I.S.T. (Whyte 1986) in Britain, provided ample evidence of the reciprocal importance of Industrial Arts to the study of Mathematics and Science. The enhancement of girls' self esteem, confidence, competence in practical skills and improved spatial awareness is well documented in the schools with a whole school policy related to the Education of Girls.

3. Girls into Mathematics (Burton 1986) looked closely at the need for girls to be "computer literate" for their changing world. The growing "partnership" developing between graphic calculators and computers and the study of Mathematics (Malone et al 1989) makes "Computer literacy" an even more urgent need for girls in the 1990s. Otherwise this may become the next "critical filter" that girls could be ill-equipped to pass through.

4. Girls in Schools October (1988), provided the first of five annual reports in Australia which "incorporates reports from government school systems and the major non-government school bodies as well as from the Commonwealth Department of Employment, Education and Training (DEET)". Commonwealth of Australia (1988-iii).

   This report was intended as a "stock take", with due regard for the "historical contexts and policies"; descriptions of existing programmes and those that have emanated as a result of the National Policy (1987); with indications of future plans and priority areas.

5. Situation in Girls' Schools St Mary's Anglican School for Girls in Western Australia present a picture of a well-rounded education for girls, where the school has "emphasised excellence in the fields of Computing, Mathematics and Science" and in 1989, explored the "introduction of technical drawing, plastics and metalwork and the need for expansion and upgrading of science laboratory facilities". (Commonwealth of Australia October 1988 111-112)

6. Situation in State Schools

Girls Education Strategy (GES) was launched in New South Wales in March 1989. (Bates 1989:81; Commonwealth of Australia October 1988: 31-42). This policy replaced the 'Non-Sexist Education Policy' - because reviews of the impact of this document indicated that girls were continuing to have inequitable outcomes for their education. The Policy has three main objectives:

(1) To increase participation rates in girls in Mathematics and Science (especially Physics and Chemistry)

(2) To broaden career options of girls from traditional areas of sales, clerical and service industries.

(3) To boost self esteem and confidence of girls, (which appears to suffer a marked decline in adolescence).

The NSW Department of Education is now required to respond at system, regional and school level.

The GES focuses at the school level on the Computer, Science, Maths and Industrial Arts. A pilot study was initiated in 1989, in 35 schools (25 secondary and 10 primary) with small seeding grants to assist with the implementation of GES. There were a number of general guide-lines set out for these schools namely:

o provision of single sex classes in maths and science with clear rationale for arrangement given to both girls and boys.

o examination of timetable to ensure it is free of gender stereotyping

o promotion of group work and collaboration rather than competitive methodologies

o provision of gender inclusive textbooks

o inservice for parents

7. The Situation for Boys in Independent Schools:

The National Council of Independent Schools "encouraged schools to examine their policies, programs and practices in the context of their philosophies, achievements and resources. There were no sanctions to ensure compliance with the National Policy.

A full report on existing exemplary practice was to be compiled in 1989. Clearly boys' schools need to address the issues of equity and the nature of mathematics, science, computing and industrial arts for its masculine philosophy, ideology, morality, content, strategies and evaluation practices.

8. The Catholic Education authorities in Australia are committed to the promotion of the education of girls in Catholic Schools (co-educational and all girls). Curriculum reforms in Mathematics; Science; Computing; Practical and personal Living Skills; Physical Education and Sport; the special needs of Aboriginal Education and Sport; the special needs of Aboriginal and Rural Girls; Leadership training and Pastoral Care. (Commonwealth of Australia, October 1988:96-103).

9. The Seventh Day Adventist Church School System hold the philosophy that "girls be provided with every incentive to achieve their potential in a well balanced educational environment (co-educational).

   They advocate: "Promotion of career opportunities for girls in trades and professions traditionally regarded as male preserves; access to industrial technology; and exposure to "as wide a range of educational experiences as boys". Sponsoring special prizes and awards for girls who achieve excellence in academic, sporting and cultural pursuits. The needs of "non-matriculating girls in Years 11 and 12, by providing alternative programs, that contribute to widening of career choices and quality of life". (Commonwealth of Australia, October 1988:113-115).

   THE NEED OF A NATIONAL DATA BASE RELATED TO THE EDUCATION OF GIRLS IN AUSTRALIA, to supplement the qualitative annual reports Girls in Schools (Commonwealth of Australia, October 1988).

Dr Helen Waite has developed a comprehensive data base related to equity and the education of girls in all the states and territories to provide a national view of the education of girls and their increasing life chances. The data collected highlights their participation rates in subject areas, retention rates in upper school, TAFE and universities. (National Data Base on the Education of Girls in Australia Schools, July 1988).

This data base will provide quantitative "performance indicators" nationally with regard to increasing retention of girls in schools, their participation in the 'non traditional' subject areas particularly, and opportunities in post-schooling, TAFE and universities.

Major References - World wide and Australian Context (See References in Maths, Science, Computing and Industrial Arts)

Commonwealth of Australia (1988), National Data Base on the Education of Girls in Australian Schools, NSW Ministry of Education and Youth Affairs, July.

Commonwealth of Australia (1988), Girls in Schools: Report on the National Policy for the Education of Girls in Australian Schools. Department of Employment, Education and Training, Australian Government Publishing Service, Canberra.

Department of Employment, Education and Training, (1989), Girls in School 2, Commonwealth Government Printer, Canberra, November.

Foster, V. (1984), Changing Choices: Girls, School and Work, Hale & Ironmonger, Sydney.

MATHEMATICS FOR GIRLS:

SITUATIONAL ANALYSIS WITH REGARD TO MATHEMATICS RETENTION AND PARTICIPATION OF GIRLS IN USA, UK AND AUSTRALIA:

Moody and Linn (1986) found, in the USA, significant absences of girls and minorities in Mathematics classes. Differences in outcome in terms of 'O' level and 'A' level passes and grades in UK are well documented in Burton (1986a:10-12). Issacson (1986:233) remarked "that the good proportion of girls getting CSE is not a cause of celebration, they should be getting 'O' levels" ... she assessed "the downward drift of girls from top sets to lower ones as they go through secondary schooling" and noted the few girls doing "A level mathematics and beyond" in UK.

In Australia, Deeker et al (1986) analysed participation statistics in Mathematics and found there had been a "swing away from the more demanding courses at school level".

Girls lower participation rates in School Mathematics are still a matter of concern. The ratio of boys to girls in higher level mathematics courses in schools has been gradually decreasing over the past few years, nationally there are nearly twice as many boys as girls, with the ratio varying from 2:1 to 3:1 in different states and territories (Willis 1988). The male domination of Mathematics is still evident.

Situational Analysis of Girls' Retention and Participation Rates in Mathematics:

1. Parker and Offer (1987:148-152) analysed the lower secondary school achievement in the four core subjects between 1972 and 1986. In Mathematics, 25 per cent of awards were allocated to each of Advanced, Intermediate and Elementary categories. What was significant was that all students were exposed to the same syllabus for the same length of time, so that the achievements of boys and girls could be compared. They found a shift in the proportion of females and males in the Advanced award category:

1972	0.76 (Female)	:	1 (Male)
1973	0.95 (Female)	:	1 (Male)
1982	1.11 (Female)	:	1 (Male)
1986	1.07 (Female)	:	1 (Male)

In the Ordinary and Elementary Award Category there were equal proportions; but amongst the Basic Awardees over the years 1972-1986, there was a decrease from 0.94 (females) to 1 (male) in 1972 to (0.85:1) in 1986, having reached a low of (0.80:1) in 1981.

2. The Secondary Education Authority in Western Australia have analysed candidates by sex sitting upper school mathematics from 1985 to 1989.

Table 1 shows progressively "equitable numbers of girls and boys sitting Mathematics I (1985-89) but in Mathematics II and III a persistent 2 boys to 1 girl have pursued prestigious upper school mathematics (TEE 1986-89).

TABLE I : ANALYSIS OF CANDIDATES BY SEX SITTING UPPER SCHOOL MATHS IN WA SCHOOLS

	Maths I		Maths II		Maths III		Maths IV	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
1985	2792	2681	624	1402	626	1399	1578	1109
							(TAE 1985)	
1986	3199	2959	531	1317	532	1316	30	16
1987	3430	3413	580	1354	576	1350	-	-
1988	3815	3820	550	1430	549	1418	-	-
1989	4032	4076	593	1321	587	1308	-	-
							(TEE 1986-89)	

3. Girls' Aspirations and Participation in Maths:

According to Blackstone 1987, Beare 1987, Parker and Offer 1987; the problem appears to be concerned with girls' aspirations not girls' ability or achievements in Mathematics (See also Burton (1986a:10-12) UK affirmation).

The Year 11 and 12 subject choices of girls (See TEE subject choices by Sex 1985-89) in Western Australia would appear to be an early manifestation of the problem identified by Blackstone and Beare (1987).

"It is imperative that teachers, parents, employers and students be made aware of the evidence regarding girls' high ability and achievement - and that strategies be devised to remove the limiting effects of girls' aspirations". (Parker & Offer 1987:154).

Girls' Perception of the Usefulness of Mathematics for Future Employment:

Stereotyped views about careers must have implications for maths performance. Russell (1983) found that academic girls often rated mathematics as their "most liked" subject, but they tended to rate biology as "more useful" since it was related to traditional occupations and the "mother" role. Students are likely to find "useful" subjects more "interesting to study". The dilemma is how to change girls' value of mathematics as a "useful" subject to study for future occupations.

REVIEW OF THE RESEARCH RELATED TO GIRLS AND MATHEMATICS EDUCATION:

o Research indicates that girls have less confidence in their ability to learn mathematics. (Fennema and Sherman 1977, 1978; Hackett and Betz 1982; Deboer 1986; Handel 1986; Joffe and Foxman 1986)

o Research indicates that boys are more positive than girls about their mathematics ability and are more likely than girls to attribute success to ability (Stable factor) and failure to lack of effort (unstable factor) (Burton 1986a; Wolleat, et al 1980; Gitelson, Peterson and Tobin-Richards 1982; Leder 1982, 1984, Leder 1989).

These attributional styles significantly affect competence in mathematical skills and confidence in mathematical abilities of girls (Moody and Linn 1986).

- o Research indicates that gender linked differences in attitudes to mathematics as well as different patterns of interactions between teachers and girls and boys were linked to parallel differences in achievement, retention and participation in mathematics by Grade 10. (Leder 1989:96) and affirmed by Issacson 1986 UK).

- o Research indicated that girls do not perceive mathematics as worthwhile, necessary and useful, or as a "critical filter" to many training and career paths. (Sells 1982; Moody and Linn 1986; Issacson 1986:225).

- o Research indicates that the structure and climate of mathematics classrooms does not meet the needs of girls (Good, Sikes and Brophy 1973; Brophy and Good 1974; Becker 1981; Reyes 1984; Brown 1984; Crawford 1984; Fennema and Peterson 1985; Eccles and Blumenfeld 1985-USA; Galton, Simon, Croll 1980; Spender 1982-UK; Moore and Smith 1980; Gore, et al 1983; Tobin 1987; Leder 1987).

- o Research indicates that the marginality of women in the field of Mathematics and girls in the Mathematics classroom results in feelings of not being valued or encouraged to contribute and "men only" having "Mathematical genius". (Spender 1982; Ramsey 1983; Issacson 1986; Burton 1986a:26-27).

- o Quantitative research has verified the under achievement and drop-out rates of girls (See Situational Analysis) and qualitative research has focussed on contributing factors including, the male image of mathematics and its relationship to other "masculine" subject areas (Issacson 1986).

- o The differential expectations, aspirations, attitudes and feelings of teachers, parents and employers towards girls and their pursuit of mathematics. (Good and Findley 1985; Walden and Walkerdine 1985; Towns 1985; Barnes 1989; Newhouse C. 1989).

- o Concerned educators have noted the lack of awareness of girls concerning the "freedom" that pursuit of mathematics affords them in terms of life chances and career choices. (Burton 1986a and 86b(Ed); Issacson 1986:227).

- o Research indicates that lack of spatial ability skills and a field dependent cognitive style in girls is negatively connected with achievement in traditional mathematics. (See Part 1 of the Report papers 16-18).

- o Research indicates that in the mathematics classroom aspects of organization and interaction that favour and focus on boys.

- o Research shows lack of consideration for different teaching strategies commensurate with learning styles of girls which seriously affects their achievement and approach to problem solving and their feelings of "marginality" and their perceived unimportance in the "mathematics classroom" (Carss and Barnes 1980; Stanworth 1981; Burton 1986a; Doenau 1987).

- Research indicates that gender bias in teaching materials and textbooks is still evident, with the marginalization of females; the male context of applications and the male dominance of resources; and the context of problems both in class and under examination conditions. (Burton 1986a).

- Research indicates that assessment is biased towards boys in terms of types of assessment, bias in questions, strategies in tackling tests. (Burton 1986a:13).

- Action Research indicates that career guidance and education can raise the career aspirations of girls in mathematics-related fields and facilitate educational goal setting and career paths for girls (See Section of Career Education for Girls Part 2 of the report).

- Action Research indicates that professional development of teachers does create critical awareness of prejudices, behaviour patterns, gender bias in all aspects of teaching; that intervention programmes do change teachers' behaviour towards differential expectations of boys and girls; and interest in the nature of mathematics itself (Burton 1986a; Whyte 1986; Vasey 1989).

- Action Research indicates that parent re-education and involvement in their children's mathematics is highly successful in changing attitudes towards mathematics and their own achievements in Maths. (Vasey 1989)

- Action research indicates that students can be helped in achieving capabilities and confidence in mathematics (Barnes 1989).

- Action Research in its myriad of foci indicates that intervention programmes for teachers, parents, administrators, counsellors and students, can break the vicious cycle created by cultural 'gendered' stereotypes that inhibit girls' achievements in mathematics and limit their future life chances. (See Career Education for Girls, Part 2 of this report).

- Action Research indicates that girls' spatial ability can be improved by intervention strategies from K-12. In school situations where technical craft courses are valued for both girls and boys, skills learned in this area are readily transferable to mathematics and science. Girls' only clubs have proved to be highly successful in developing both confidence and competence in traditional male craft areas. (Catton 1985, cited in Whyte 1986).

Major Needs of Girls to Achieve in Mathematics:

- Need to raise aspirational levels of girls with regard to future careers and adult roles. (Parker and Offer 1989).

- Need to develop awareness that Mathematics is a "critical filter" for many careers (Sells 1982; Issaccson 1986).

- Need to develop competence in Mathematical skills and confidence in their mathematical and spatial abilities, with a degree of assertiveness for full participation in the Mathematics classroom (Eynard and Walkerdine 1981; Evans 1982; Moody and Linn 1986; Burton 1986a).

- o Need for "Mathematics" role models both past (literature) and present visibility in the home, schools, industry and research. (Burton 1986a; Vasey 1989).

- o Need to work in a cooperative Mathematics climate where they are not "marginalized" through bias in text books, questions set, classroom interaction, and evaluation. (Burton 1986a).

- o Need for opportunities to work within the framework of their preferred learning styles (Galton 1981; Burton 1986).

- o Need for career guidance and education to alert girls to the Mathematics, technical and scientific qualifications required to broaden their life chances and career opportunities (See Part II of this report).

- o Need teachers who are aware of the "gender agenda".

Professional Development of Teachers in the Mathematics Classroom, With Regard to Positive Awareness, Skills and Competencies to Promote Gender Equity.

- o Need awareness activities to identify prejudices, cultural gender expectations and the significant absence of women in Maths classes. (GAMAST 1986).

- o Historical development of Mathematics for Girls in UK and Australia (Cooper 1968, Burton 1986a).

- o Need to gather information on their school mathematics enrollment and capability in following up mathematics course selection for girls especially. (Parker and Offer 1989).

- o Need to develop skills in monitoring and identifying classroom interaction that fosters gender equity and reduces the perceived and actual marginality of girls (Stanforth 1981; Spender 1982; Burton 1986a).

- o Need to develop skills in identifying sex bias and lack of gender inclusiveness in resources, literature and all other materials, visual aids and conscientiously including "herstory" in Mathematics. (Burton 1986a; GAMAST 1986).

- o Need to incorporate teaching strategies that match preferred learning styles of girls (Galton 1981; Joyce and Weil 1976).

- o Need to look at a new concept of problem solving in Mathematics (Brown 1984 in Burton 1986b:196 and Malone et al 1989).

- o Need to scrutinize questions/problems used in class and under examination conditions for contextual gender bias. (Burton 1986a).

- o Need to study "analysis of freedom philosophy" as an essential prerequisite for creating awareness in girls of the valuing of mathematics and its usefulness in widening life chances and occupational choices. (Issacson in Burton (ed) 1986b:223).

The Way this may be Achieved:

A National Statement on Girls and Mathematics (1990) states that:

"At primary, secondary and post secondary levels teachers must become aware of, and seek to eliminate, any gender bias in their current practices. To this end, gender issues in the teaching and learning of Mathematics needs to be addressed by:

- pre-service education courses for teachers of all levels of mathematics
- all professional development courses for teachers of mathematics
- specific professional development courses directed towards gender issues
- teachers, individually and collectively in their own schools, and
- working in close liaison with employers, parents and inviting achieving females and people in non traditional roles to visit and lecture in schools (Whyte 1986).

In my opinion this may only fully be achieved if there is a "whole school policy and programme" that fully supports the educational needs of girls, particularly in Mathematics, Science and Technology - that will require dramatic attitude change.

Meanwhile, it takes time to bring about attitude and teaching change.

- it is essential for those teachers interested in gender issues to maintain a network with like minded others. (eg GEMS).
- to attend conferences - like Women in Education, August, Perth 1990
- to disseminate 'action research findings', and finally,
- to encourage and inform other Mathematics Teachers of the need to address gender equity into classrooms.

Historical Development of "Mathematics as a Subject for Girls" - The UK and Australian Experience:

According to Burton (1986a), Mathematics is not a neutral enquiry; it is socially produced and has changed over the years to meet perceived social and economic needs.

In the early 19th century classics was the "critical filter", but later with the evolution of the new Public Schools for boys of aspiring and powerful middle-class families, the new subject was Mathematics. In the relatively few girls' schools "arithmetic rather than mathematics" was taught, some parents protesting that the latter was "unsuitable" for girls' education. The study of Mathematics was therefore a form of exclusive male middle-class distinction.

1870 - 1880's:

Arithmetic was acceptable in a number of English girls' Grammar Schools, even then as the Cross Report (1880) stated:

> "As the time of the girls is largely taken up by needlework the time they can give to arithmetic is less than to that which can be given to boys".

20th Century:

The argument moved away from whether or to whom mathematics should be taught and to considerations of content and quantity. Females were provided with "different kinds of maths" according to their "perceived" biological, psychological and social differences.

"Girls should deal with detailed accounts accompanying shopping and housekeeping ... boys should establish by experimental methods, some of the more important theories of elementary geometry". (Cockcroft Report 1982).

Educators argued that spatial skills favour boys; that girls were less rational or logical than males; and that most girls would become wives and mothers and therefore there was no point in studying Mathematics.

1923 - 1944:

The differentiated mathematics curriculum was influenced by the notion of "domestic subjects" for girls, and boys need to "pursue maths".

1944:

The establishment of Tripartite education in Britain, found girls in some areas had to obtain higher marks to qualify for Grammar school places at 11+. Had the same cut off point been used for both sexes, many more girls would have been educated in prestigious Grammar schools.

1950's:

Stereotyped assumptions still limited the schooling of many girls, which was particularly evident in the Mathematics taught. Burton (1986a:Figure 1.6) analysed the content of three school books used in 1952 and found the Mathematics/Arithmetic dichotomy still present and related to class and gender; where boys were given progressively along lines of social class, more abstract Mathematics with applications related solely to male occupations.

Arithmetic for girls was firmly placed in domestic terms only. Middle class Grammar school girls of ability did pursue Arithmetic, Algebra and Geometry.

1960's:

With the Comprehensivization of State Schools in UK, Mathematics became part of the curriculum for all pupils up to 16 years, but there were substantial differences in time allocation depending on humanities base (10%) or Science base (22%) which favoured males.

1968 Cooper (1968) over all awareness of differential curriculum for girls in Australia (1939-1968)

1975 Girls School and Society - Australia

1970 -1980 Both in UK and Australia there was a growing awareness of inequities in Mathematics provision and the realization that Mathematics was the "critical filter" for many occupations. The question of girls' underachievement in maths was the focus of an appendix in the Cockcroft Report (1982) and became an issue of public concern in UK and "Girls and Tomorrow" (1985) in Australia.

1986 Research into societal views of mathematics by Burton (1986a:9) found, from a collection of anecdotes, the views men and women held about themselves with regard to Mathematics namely:

(1) Women were more likely than men to consider themselves mathematical failures (whether or not justified)

(2) Women were more likely to regret their lack of success and to feel hampered by it in their careers

(3) Women were more likely to feel that their Maths interests were discouraged in one way or another at school.

(4) Even when women are extremely successful in terms of qualifications, they tend to hold fewer posts of responsibility, and to be less confident than their malé counterparts.

Intervention Programmes became very important in UK and Australia to counter societal views through re-education of parents and parental involvement in mathematics programmes (eg. GAMAST 1986; FAMPA; Vasey 1989) within the curriculum.

Women's contributions, both past and present, were acknowledged as important knowledge for girls to have to encourage them to do mathematics. (Barnes, Plaister and Thomas 1984; Burton 1986a:26; Spender 1982(b), noted how women's contributions had been "systematically devalued because of their gender".

1986 Issacson (1986) moved into the philosophical debate in relation to "freedom and girls education" with particular reference to mathematics. This was matched with intensive pockets of action research both here in Australia and UK.

1990 There are now "few formal barriers to girls' pursuit of mathematics, but the remnants of past barriers" inhibit their whole hearted, confident interest in mathematics by creating a poor image of mathematics for girls. Strong, usually negative feelings are often engendered by the mere mention of the word "Mathematics" (APU 1981). Feelings of "dislike"; "irrelevance"; "panic"; "anxiety"; "fear"; "isolation"; "lack of confidence"; "inadequacy" and "stupidity" are encapsulated in this concept "Mathematics" (Burton 1986a 36-39).

Labels such as "unfeminine" "blue stocking" are attached to those girls who do pursue maths, such that "fear of success" can develop in these bright girls (Leder 1984). For non-starter or reluctant girls, mathematics is perceived as "too difficult", "boring", "lacking in interest", "irrelevant in her life", "too speedy" and "maths lacking opportunities for discussion" (Burton 1986a:16); Buxton 1981; Brown & Fitzgerald 1981).

This poor image is further exacerbated by:

(a) Boys believing that "girls can't do well at "mathematics and science" (Phillips 1979) and a strong perception of Mathematics Physics and Chemistry as "boys'" subjects (Keeves and Read 1974).

(b) Teachers continuing to devalue girls' ability in maths and science, hence promoting self-fulfilling prophesies and the belief that maths is too difficult for girls and "for boys only".

(c) Parents' attitudes and their own feelings about maths may reinforce "inappropriateness" of mathematics learning for girls. Further their cultural and class backgrounds can set further limits on the motivation and life chances of their daughters by exclusion from maths.

1980-1990 Innovatory Programmes, such as FAMPA (linked with PEP) have been successfully implemented in Australia by fostering numeracy and positive attitudes to mathematics in the Community and with parents on the one hand leading to successful learning of mathematics by all children K to 12) especially girls. The cooperative teaching efforts of parents and teachers are emphasised. This is based on an "action research" model (See Also Whyte 1986).

There are many small scale innovations:

o The thematic organization of content where social studies and mathematics are integrated, in the cognizance of preferred learning styles and "person orientation" of girls.

o Focus on the classroom for gender bias: in teaching materials, problem context and examinations (questions and time allowed); classroom interaction; teaching strategies and learning styles (Problem solving, group cooperative efforts); enhancing "spatial ability in girls; linking career education with mathematics;

o Professional development of mathematics teachers as "transformative action researchers" is currently of immense importance. (Burton 1986a; GAMAST 1986; Malone et al 1989 (eds)).

o Focus most recently on Mathematics itself and the underlying philosophy, ideology and morality (Mares 1989, 85-87).

1990 A National Statement on Girls & Mathematics (GEMS 1990).

The Mathematics curriculum should now begin to reflect gender inclusiveness with an underlying caring morality and philosophy:

o focus on the development of mathematical thinking rather than rote learning

- present mathematics as a human endeavour.

- incorporate applications of mathematics to important social issues.

- include and value achievements of women and girls

- emphasize the creative and imaginative appeal of mathematics. (GEMS 1990:6)

The Unintended Effects of School Organization on Girls' Underachievement in Mathematics:

School organization reflects the conditions and norms that are current in the society at large:

> "One of the most important factors discouraging girls from a study of Mathematics is the way in which society has viewed it as a male domain" (EOC Perth 1990).

1. The sex and race distribution amongst senior persons in schools does not reflect the distribution of men and women across all grades ... and the predominance of white males in these positions can influence pupils attitudes with regard to the "equation of mathematics' future importance and masculinity" Burton and Townsend (1986) ... and "the fact that high status jobs are not within the scope of women" (Burton 1986a:63).

2. Girls' schools are usually under resourced for teaching of laboratory based subjects compared with boys' schools. Even where there are the same resources timetabling can impose other inequities. (eg. Physics (Masculine) timetabled against Home Economics (Feminine). Research shows that studying mathematics is helped by studying other maths - related subjects. Girls clearly are disadvantaged by such timetabling arrangements.

3. Classroom organization - sex segregated class registers and seating arrangements can favour boys, marginalize girls and convey to both sexes that boys are "more important".

4. Boys domination of computer and chess clubs convey to girls certain activities are principally for boys and men.

5. Uniforms that discourage girls moving around freely and exploring space, may hinder girls' spatial awareness and skills that in turn may disadvantage their ability in mathematics.

What can be done?

1. The need for WHOLE SCHOOL approach to equal opportunity and gender equity in particular. (Eales 1986; EOC, Perth 1990; FAMPA, Vasey 1989).

2. Classroom organization - deliberately countering 'sex-stereotypic' segregation.

3. Single-sex setting may be a possible solution. Smith (1983) found girls in a single sex set achieved a far better average score than girls in a mixed set and only slightly below the average of boys. The criteria to monitor would be achievement of girls in public examinations and their opting to pursue higher mathematics courses. Eales (1986) achieved similar success with fourth year pupils within the context of a whole school approach where the policy was highly supportive to countering sexism in every context of the school life.

Creating Environments to foster Gender Equity in the Mathematics Classroom:

"Evolution rather than Revolution"

Barnes 1988:44 encapsulates the vision of a mathematics classroom which is "gender inclusive" and will hopefully foster outcomes of "androgeny" in both males and females for the betterment of personal development, and life skills for their own and society's needs.

"A better approach is to try to change the mathematical environment so that women can relate to it better. This can mean decreasing stereotyping in textbooks and including more applications that will be relevant and interesting to women and girls. It can also mean monitoring classroom interaction and trying to ensure that girls are not harassed and that they get a fair share of the teacher's attention. But more than this is needed. As we have seen, the authoritarian and competitive atmosphere in the mathematics classroom is one of the principal factors that destroy women's interest in mathematics and sap their confidence ....

Gender inclusive mathematics should stress cooperation and communication, with a teacher who is prepared to listen and accept students ideas rather than being in too much of a hurry to explain his or her own .... We need to present mathematics as a human creation, involving imagination and intuition, by undertaking investigative and problem solving activities and by studying its history". (Barnes 1988:42).

These views of Barnes are affirmed in three articles written by Brown 1986:196; Issacson 1986:233; Burton & Townsend 1986:187 in UK - all believe that Mathematics needs "humanizing" and I commend their philosophical, moral and ideological considerations to mathematics educators and mathematics teachers and student teachers alike.

What can be done?

We "need to work slowly in an evolutionally way towards a new, more humane vision of mathematics, science and technology and at the same time also work at breaking down unnecessary gender stereotypes in behaviour and career aspirations ....

A more revolutionary approach would, I fear, result in losses we can ill afford of existing freedoms and of valuable females modes of thinking and behaviour" (Issacson 1986:239).

The Conundrum of the Extreme Marginalization of Girls in Mathematics:

Barnes (1989:106-107) has focussed on the "interaction between gender identity construction and the way mathematics is perceived and taught in schools".

She formulated a number of key questions in relation to girls under-achievement and lack of participation in mathematics:

Why do girls have lower educational and occupational aspirations?
Why do they see Mathematics as less useful to them?
Why do they have less confidence in their abilities?
Why do teachers interact more with boys?
Why is mathematics taught in a competitive way?
Why do girls prefer to learn cooperatively?

I plan to look at factors that contribute to "Boys' actual and perceived superiority in mathematics" in the presage that follows:

Factors contributing to Boys' Actual and Perceived Superiority in Mathematics:

PRESAGE: (using the Print (1986) and Wlodkowski (1982) Models).

A. Spatial Ability and Field Independence - 'Nature v Nurture (See also pages 16 - 18 of Part 1 of this report)

Spatial Ability may be defined as the:

"Capacity to visualize objects in three dimensional space"

(a) Correlates highly with tasks of field independence (cognitive style) Girls tend to be field dependent and person oriented. (Sjoberg 1989).

(b) correlated with achievement in science, mathematics and technical drawing; and working with machines.

(c) Males in general are superior to females from adolescence to adulthood (Clark 1988:32).

(d) Biological differences are greater than for any other area - specialized activation of spatial function of right hemisphere seems to give males superior ability on tests of spatial skills (Clark 1988:32).

(e) Spatial ability is "affected by a complex interaction of genes, hormones and experience". (Hoyenga & Hoyenga 1979).

(f) Environmental Factors:

(i) Socialization of independence - positively correlated - fostered in boys

(ii) Conformity - negatively correlated - fostered in girls

(iii) Minimal sex differences in spatial ability where male and female, both assertive and independent, yet cooperative.

(g) Sex role stereotypic traits - "field independence" generally considered "masculine" and most valued:

(i) Spatial ability and skills can be fostered. (Whyte 1986)

(h) Young children pursuing stereotypical "masculine activities" were more adept in spatial ability tasks several years later.

(i) Extreme masculinity and extreme femininity often associated with lower spatial ability scores.

What can be done to foster spatial ability in girls and cooperative relationships in boys?

Early Socialization and Play Activities:

1. Clearly a need for early childhood play to encourage girls to "tinker" with toys, as boys are in their socialization, (eg. Lego, Meccano, taking toys to pieces (investigative) and "putting things back together")....

to "unconsciously develop understanding of spatial relationships and patterns which provide the basis of mathematical concepts" Vasey 1989:99

2. (a) In girls' socialization to encourage and provide opportunities for greater independence and assertiveness, yet maintain their preferred field independent "cognitive style" (Sjoberg 1989).

(b) "Need to provide boys with the opportunity to explore nurturing domestic roles" and " to extend girls' role play into traditionally non-female areas" to develop a "person-orientation in boys so vitally needed in technological careers and research (Sjoberg 1989).

3. Adolescence To encourage girls in geometry, ratio and measurement link mathematics with Industrial Arts:

(a) Traditional male craft units for adolescent girls in UK encouraged three dimensional problem solving and design. (Catton 1985).

(b) Encourage and develop visual skills in mathematics such as drawing, interpreting and visualizing diagrams, graphs and other symbolic representations.

(c) Mathematics classes that promote "hands on" mathematical problem solving (eg. John O'Sullivan Maths Kits - John Curtin Senior High School, Fremantle WA).

(d) Possibility of 'single sex' classes for girls to raise confidence, reduce anxiety in Mathematics. (Catton 1985 in Whyte 1986; Buxton in Burton 1986b).

The Curriculum Corporation of Australia plans compulsory technology classes for secondary school girls and single sex classes in mathematics as two further measures to encourage interest in previously male dominated areas (West Australian 1989).

4. Parental awareness and re-education into the needs of pre-school boys and girls, in order to foster spatial skills and field independence style; and a balance of field dependence for cooperative relationships. (eg. The Family Maths Project Australia (FAMPA) Vasey 1989:99).

5. Teacher awareness and education into the needs of pre-school and primary school girls and boys, with input from the children, colleagues and self assessment into their own teaching practices. (eg. "Person to Person" Project Western Australian).

6. Primary school children in "Person to Person" were encouraged to become aware of the activities they pursued in the classroom and playground, and to be "manipulated" into other gender "free choice" activities to engage in role playing to throw light on boys' and girls' perceptions, their social problem solving and their perceptions of the teacher; and, in Art, to foster a more independent, risk taking approach to drawing and painting by the girls". (See "Person to Person" Video-recording 1986).

B. Parents' Attitudes and Differential Expectations of Daughters and Sons:

Parents expect daughters to be "quiet, pretty and charming" and boys to be "active, vigorous and exploratory" at a very early age.

Parents unwittingly restrict the maths development of girls, especially their spatial skills which may not be as fully extended as their brothers.

1. Parents and Child Rearing Patterns

Cockcroft Report (1982) indicated "it is not only the games and toys with which children play but the way they are encouraged to behave which has implications for their mathematical future".

Boys more than girls are encouraged to be independent, to experiment and to solve problems - all important characteristics of able Mathematicians.

2. Parents' Influence and Career Choice:

Influence is considerable when it comes to career and option choice at Secondary level. Parents have different occupational aspirations for girls and boys.

The parents are more likely to coerce boys into useful career subjects - while many girls are left to choose the subjects they like.

Males are encouraged to take Physics or Maths in addition to other science and technical subjects though this rarely happens with girls.

Parents tend NOT TO envisage their children getting a job stereotypically associated with the opposite sex.

3. Parents as Role Models:

Girls are far more likely to study maths to a higher level if both their parents like it and are good at it.

More over Father's high level of maths education is significantly related to their daughter's choice in taking advanced maths courses. (Burton 1986:50).

What can be done with regard to Parent's Attitudes and Expectations of Daughters?

Graham and Roberts (1982) were concerned about the achievement of women and girls in Mathematics and strongly believed that mothers were the "greatest under-used resource" in education. They piloted a course in UK to increase mothers' confidence in maths and enabled them to help their children in the area.

Barnes et al (1984) suggested that a number of points could be raised at parents' evenings to develop awareness and encourage change in behaviour towards girls and mathematics involvement.

Vasey (1989) and the FAMPA project in Canberra has brought all these ideas together in an endeavour to make parents more confident and mathematically literate, so they, in collaboration with teachers, can facilitate mathematics learning in their children at all levels.

GEMS (1990) states "Schools should take responsibility for informing the community about the importance of girls' participation in mathematics by:

- communicating the information contained in this statement to parents and the community, especially that girls can and do achieve well in mathematics.

- providing opportunities to increase parents' and public awareness of women in non-traditional jobs requiring mathematics.

- encouraging parents and other members of the community to participate in programs at schools acquainting them with mathematics taught, the methods used and the importance of the subject in today's society.

C. Cultural Expectations Related to Behaviour in Schools and its Effect on Reasons for Achievement and Perceptions of Ability in Boys and Girls:

According to Barnes, Willis and Clark (Barnes 1989:106) children bring to school a well developed sense of gender identity, formed through their interaction with adults and other children. This is further reinforced through school practices (Deem 1978; Evans 1989:73-83).

Pupils and teachers form expectations about gender-appropriate behaviour and future roles (Newhouse 1990:20-22). Girls come to attribute their success to hard work and their failures to lack of ability - and this stems from the expectations of teachers that only their obedience, hardwork, helpfulness and neatness" will achieve good results.

Boys are expected to be more assertive and to challenge authority and their failures are attributed to lack of effort rather than lack of ability. Even their challenging of rules or boredom may be identified as "latent talent". They are commended for exuberance, excellence and creativity. Walden and Walkerdine (1985).

Boys' and Girls' Expectations of their Adult Roles:

Males have significantly different educational and occupational aspirations to females. Boys are encouraged to expect that they will be the breadwinner and girls to focus on the family. These aspirations and attitudes affect students' selection of mathematics courses. As a result, girls are less likely to plan for a future occupation as boys do and may choose interest based subjects rather than mathematics, which is a passport to many occupations and further education. (Towns 1985; Chipman & Wilson 1985).

Cultural Perceptions of Mathematics so "Off Putting" to Girls:

Mathematics is presented and perceived as a static body of knowledge, primarily conceived by males (Burton 1986a; Barnes 1988).

Teacher Expectations of Boys and Girls and the way these influence the Teacher's Interact with their students:

GIST, (Whyte 1986) found teachers in general did not believe they ever treated boys and girls differently. (See also Burton 1986a:47).

Primary teachers appear to prefer teaching girls (Taylor 1986), perceiving them as "hardworking, cooperative, quick, mature, bright and likeable - boys are deemed more excitable, talkative, need more supervision and attention" Yet at Secondary level, boys are perceived as "more interesting and critical" and their education is more important than that of girls. (Ricks and Pyke 1973 cited in Burton 1986:47).

These teacher perceptions and attitudes foster and maintain sex role differences and in consequence they make less academic demand on adolescent girls and have lower expectations of their success.

McDermott (1983) found with 7th, 8th and 9th year grades in Mathematics, teachers gave:

(a) more feedback to high expectancy students than low expectancy students.

(b) more attention to low expectancy males than high expectancy females

(c) equal amounts or more attention to high expectancy males than low rated males

(d) less feedback to encourage girls, indicating that gender affects the quantity and quality of students communication with teachers in the mathematics classroom.

Whyte, J. (1985) observed different expectations of boys and girls especially in Mathematics and Technology and exemplified in this comment by a 15 year old girl "They won't just tell you how to do it, they'll do it for you and I dislike that"

What can be done about Cultural Gendered Expectations Affecting Every Person in the School:

(1) Ideas offered in GAMAST (1986) attempt to develop awareness as an avenue for change in expectations of boys and girls in the Mathematics classroom.

(2) Professional Development of Teachers and Parents (FAMPA:Vasey 1989).

(3) Intervention programmes that make children and adolescents aware of erroneous expectations and empower them to counteract this in their behaviour. (See 'Person to Person Video and tertiary student awareness studies See Part II of this report).

(4) Promoting career awareness and the usefulness of mathematics for both boys and girls, in teachers, administrators, counsellors and pupils.

   (a) Involve employers in school system - another avenue to stem "erroneous cultural gendered expectations"

   Millman and Weiner (1985) surveyed employers in Leicester UK with regard to statistics related to male/female employees numbers, types of jobs, responsibility, reasons for any existing sexual division of labour and their policy on equal opportunities. This resulted in mixed responses but it did open discussion on gender issues and established links with schools with local employers.

   (b) Career advise provided in the early years of schooling. Broadening horizons by listing career areas where mathematics is needed. (Smith and Matthew, 1984)

(c) Choosing a career. (Burton 1986:57) offers succinct advise to girls to raise their aspirations and realistic assessment of their capabilities for life long education and occupations.

What can Maths Teachers do to promote positive feelings and expectations about Maths:

Achieving female role models from industry and higher education invited to the school (Burton 1986a:44).

Positive attitudes of teachers that "girls will not fail at Maths" Binns (1982) discussed attitudes to maths with girls and challenged stereotyping with the result that their attitudes improved perceptibly.

Seriously focussing on the organization of maths classes, selection of teaching strategies by considering girls' learning styles had a considerable effect on their confidence and anxiety level. Frequent praise and ensuring a degree of success quietly alleviates anxiety. (Burton 1986:44).

It is important for teachers to have high expectations of all students. There is therefore a crucial need for teachers to reflect on all aspects of their classroom behaviour, to monitor their interactions and to be willing to make appropriate changes for the positive benefit of all pupils.

Teachers need to take an active interest in gender equity issues by:

- o reading the available literature
- o formal/informal discussions sharing experiences and strategies with colleagues
- o taking equity issues very seriously
- o discussing equity issues with pupils and challenging stereotype views
- o using inservice packages for teacher and parents. (GAMAST 1986; Burton 1986a)

Then and only then can the National Statement on Girls and Mathematics (GEMS 1990) begin to become a reality.

D. The Contribution of Classroom Interaction to Boys' Actual and Perceived Superiority in Mathematics:

(This should be read in conjunction with Part II of this report)

"The keys to equality of opportunity and outcomes for girls in education are classroom interaction and management" (Ramsay 1983).

Research evidence suggests that at the beginning of secondary schooling boys' superiority in Mathematics starts to manifest itself. The differences are particularly marked when above-average performance is considered (Leder 1980; Benbow and Stanley 1983: Burton 1986a; Bondi 1987; Kissane 1986 cited in Leder 1989:84).

We need to balance these findings with those of Parker and Offer (1987) in Western Australia where compulsory mathematics for boys and girls was mandatory (1982-86) and girls performed equally well in lower school mathematics.

Many explanations have been put forward to account for gender differences in mathematics learning, one such is the differential verbal interaction in the classroom between "teacher and boys", "teacher and girls".

Interaction between teachers and students have been examined in a variety of ways.Brophy and Good (1970) Rowe (1974a and 1974b) monitored dyadic interaction between teachers and single students and found differences in the ways girls and boys are treated by their teachers.

Girls have less interactions with teachers than boys, both teacher and student initiated. Boys often receive more direct often higher order questions, more disciplining interactions, and are praised more than girls for correct answers. Teachers give more serious consideration to boys' ideas.

It is interesting to note that high achieving boys have more teacher interaction than high achieving girls (Good, Sikes and Brophy 1973; Brophy and Good 1974; Fennema and Peterson 1985; Becker 1981; Eccles and Blumenfeld 1985; Reyes 1984-USA research; Galton, Simon and Croll 1980; Cockcroft Report 1982; Spender 1982-UK; Moore and Smith 1980 - Papua New Guinea).

(a) Time and Attention:

Eynard and Walkerdine (1981) "have suggested that active assertiveness and confidence when adopted by children are characteristics necessary for full participation in the learning process". (Burton 1986a:66).

Becker (1981), in USA, observing Mathematics classroom found that it is the most assertive and responsive pupils who participate in Maths lessons and they in turn receive more encouragement and assistance from teachers. 67% of the pupils who called out an answer and commanded the teacher's attention were boys and only 33% were girls.

Evans (1982) in Australia, also found that the "assertive participators" who caught the teacher's attention were mostly boys. Conscientious pupils who worked hard have longer interactions with teachers, though less than assertive pupils, but boys were praised for their work and girls given more general encouragement. The least assistance and slowest teachers' responses were "reserved for quiet, neat, tidy, diligent, average girls" (Evans 1982).

Spender (1982a) found that, when teachers actively tried to redress the balance of time and attention given to boys and girls, it was extraordinarily difficult.
These patterns of classroom interaction are also teaching boys that dominant, aggressive behaviour is expected and they develop skills at demanding and receiving more than their fair share of attention and resources in co-educational settings (Girls and Tomorrow 1985:34).

(b) Wait Time:

Fennema (1980) found teachers are prepared to wait longer for a response from a boy than a girl.

In Australia, Gore and Roumagoux (1983) reported that Grade 4 and Grade 5 teachers had a longer "wait time" for boys than girls in Mathematics lessons.

Tobin (1987) found relationships between student achievement and "wait time" in science and language arts.

(c) Quality of Questions:

Leder (1987:1988) found that Grade 6 teachers spent more time on high level cognitive questions with boys; though at Grade 3 this trend was reversed in favour of girls.

Leder (1989:96) observing Grade 7 classes noted that in one class where a relatively high number of sustained high cognitive level questions were addressed to girls, they scored higher on the Operations Test than their male counterparts. Boys, however, generally received more time per high level cognitive question, whilst girls had more time on procedural exchanges.

(d) Cognitive Processing and the Quality of Interaction:

Crawford (1984) investigating simultaneous and successive processing in Grade 5 children found significant gender and socio-economic differences in simultaneous processing, due to prolonged qualitative and quantitative differences in social interaction.

(e) Girls 'Perceptions of Marginality' - Reinforced by Teacher Behaviour:

Stanworth (1981) cited in Girls and Tomorrow 1985:33 noted how girls evaluated themselves as a result of their interaction with teachers.

"Just a sort of Wallpaper Person"

Teachers tend to be much more aware of their boy students than they are of girl students. They tend to make errors of judgement about their girl students because they do not know them well. As a result they come to feel that their teachers do not value them and low self esteem results.

There is a ray of hope, since Becker (1981) did observe that some girls do appear to try to redress the imbalance in interactions by initiating contacts with the teacher.

Leder (1989) points out that the cumulative effect of "marginality of girls" over several years of schooling may have a significant effect on their learning in high school particularly in "masculine" domains, such as mathematics.

What Can Be Done?

Clearly every aspect of classroom interaction requires systematic review by the mathematics teacher and concerted efforts to modify their communication and interactive behaviour with boys and girls to reduce prejudice created by invidious sex role stereotyping. In particular:

(1) Be aware of effects of praise and criticism and the distinction between internal factors like ability and external ones like effort.

monitor - interjections in class
- use of comments on written work to try to redress balance
- non-verbal inferences are quickly assessed by girls.

Cognisance of "personal exchange" - as girls' preference in Maths class, instead of a preponderance of asking questions and public response (Galton 1981)

(2) Make a conscious effort to pay more attention to "quiet, average, undemanding pupils "the forgotten ones" - often girls.

(3) Need to wait for responses to encourage girls to experiment and try. This may require rethinking types of questions asked and response expected.

(4) "Teacher realization" of how the interaction appears to girls and boys.

When sharing the reasons and methods with pupils, change is much more likely.

(5) Girls should be encouraged to highlight areas in which they excel and be discouraged from making statements about their inadequacies in an overly modest way.

(6) Focus on student achievement, application and motivation in mathematics (GEMS 1990:6).

(7) Ensure a fair distribution of the nature and amount of teacher attention across the whole class.

(8) Need for a classroom observer or classroom interaction skills to monitor one's own behaviour.

(9) Foster assertiveness in girls, an awareness of the invidious effects of sex role stereotyping and provide good role models as teachers. (Video: Are girls calculating; GEMS 1990:6).

(10) Where it seems appropriate, bring the issue of gender in classroom interaction into the open, through class discussion.

E. Pupil Preferences for Different Teaching and Learning Styles which favours the boys in the Traditional Curriculum:

Expository Approach:

Cockcroft (1982) found that success of information transfer was judged by the sequence of questions by teachers and answers from pupils. This encouraged a competitive atmosphere and as a consequence highly conducive to anxiety, especially to those who were low in confidence, notably girls in mathematics. This raises the question of the suitability of exposition for girls at the present time.

Eggleston et al (1976) and Harding (1983) identified pupil centred enquiry methods in science as enabling girls to "develop a liking for science" and to participate more fully in class activities by "sorting things out for themselves".

Doenau (1987) focussed on the mismatch between girls' expectations in mathematical problem solving and the teacher's expectations of the required outcome. He focussed on the research of Carss and Barnes (1980).

In year 8 mathematics classrooms in three coeducational schools, they made audio recordings of the discussions of pairs of boys and girls as they worked on mathematics problems. The tapes were analysed in terms of:

- mechanistic talk (reporting fact, procedures, checking)
- process talk (problem-solving strategies)
- semantic interpretive talk (interpreting terms and meanings in context)
- reading aloud or silently
- deviant (off task) talk
- no talk.

It was found that low-achieving pairs spoke very little or not at all about maths. In average achievement pairs, males spent more time on mechanistic talk, while average and above average females spent more time on process talk - which was counter productive since rewards were for getting the right answer and the more direct approach of males was, they considered, more likely to lead to that result.

Carss (1981) commented on the findings as follows:

"There are obvious differences in the way boys and girls learn and use mathematical vocabulary. The tendency for most books and many teachers to rely heavily on symbolic representation of mathematical ideas would appear to disadvantage girls at a crucial period in their mathematical development. Similarly, the tendency of most texts and teachers to give instruction on how to do a problem, rather than on why you do it that way, frustrates those who seek to understand the mathematics process. Such presentations do not cater for the differing learning mode of most girls." (p.36).

GEMS 1990:7 building on girls' preferences, would encourage teachers to:

- develop group and individual problem solving skills and strategies

- include open ended investigative problems where there is no single correct answer and encourage creative and diverse methods of tackling these.

- encourage and develop verbal communication skills in mathematics such as reading, writing, talking and listening.

Competitive Styles of Learning and "Fear of Success" in Girls:

There is also some suggestion that "fear of success" develop if girls are involved in competitive styles of learning and this is perceived by them as "aggressive unfeminine behaviour" (Burton 1986a:74). Consequently they may not wish to succeed in this type of atmosphere. Changing to a more collaborative teaching style could improve girls' performance in mathematics.

Learning Styles:

Owens (198`) found that girls show greater preference than boys for a cooperative mode of learning. Teachers of mathematics, especially males, are inclined to teach in a competitive style. Thus there is a mismatch between the learning preferences of girls and the style of teaching they meet in mathematics classrooms. Peterson and Fennema (1985) in a study that related to student-teacher interaction and achievement, found that girls' achievement was positively related to their involvement in cooperative learning activities.

Serialists/Holists: (Scott-Hodgetts 1986:74)

Tentatively suggested that boys' and girls' early experience and the expectations made of them, may result in more boys than girls adopting methods which are dependent on a willingness to take risks whilst girls are more inclined to be more cautious.

Girls' serialists tendencies reinforced in Primary School, may in part explain their downward trend in adolescence. By using a serialist strategy exclusively, girls hamper their long term mathematics development, since they are thrown by unfamiliar situations. Boys tend to be more successful maths learners in the long run since they are more versatile and have flexibility of choice between the different learning styles.

Schuard (1986) holds similar views to Scott-Hodgetts (1986) but focuses on the teacher's preferred teaching style and values. Primary teachers are predominantly female and "serialists".

"It would be mischievous to suggest that pupils who pay attention to teachers' traditional emphasis in primary maths give themselves a positive disadvantage for future success in mathematics, but evidence seems to point in this direction and girls seem more likely to follow the path".

GEMS (1990) building on the work of Foster (1989:32-34) suggest the following teaching methods that cater for the preferred learning styles of girls and encourage the building up of learning styles (other gendered). These methods also encourage boys to work in a collaborative way so important for the 1990's and the 21st century:

- make more extensive use of discussion methods, small group collaborative work and open ended investigation
- emphasise cooperation rather than competition.
- encourage girls to develop skills in risk taking through guessing, estimating, attempting partial solutions and using trial and error methods. (Risktaking/Cautiousness).
- cater for a variety of approaches to learning
- allow students some control over their own learning in the nature and timing of parts of their assessment tasks. (Locus of Control).

This section should be read in conjunction with Part II of the Report.

What can be done - with regard to teaching styles and learning styles:

1. Use a variety of teaching strategies to accommodate to preferred learning styles of boys and girls - building on strengths of each gender.
2. Link mathematics with other subject areas, popular with boys and girls. (Burton 1986a; Watson & Higgs 1989:241).
3. Avoid gender and race bias in real life applications - use of 'role reversal' strategies.
4. Think about the way you teach, to encourage boys to be cooperative and engage in collaborative work and girls to be more risk taking and develop an internal locus of control.
5. Use of imagery, which is particularly appropriate in teaching geometry. (Kent & Hedger 1980; Shuller 1983; ATM 1982).
   See also Shumway (1989:285) on the capabilities of graphics calculators.

6. The use of the computer in transforming mathematical topics and as a learning aid - may be introduced in an "evolutionary" way, for the especial comfort of teachers and girls. (Watson & Higgs 1989:241-243; Kelly 1989:251-256; Feldman 1989:245-249; Newhouse 1990 "Computer Education for Girls - in Part III of the Report).

7. Micro-computer as facilitator, illustrator and problem poser for constructivist Mathematics is an exciting prospect for 21st century mathematics. Research, however, shows a strong need to allay fears of girls who are beginning to perceive the computer as "masculine" together with every aspect of computer studies. (See Newhouse 1990 Computer Education for Girls).

F. Bias in teaching materials and textbooks that only portray boys and men as active and successful, and perpetuate the sex role stereotype in Mathematics:

Written materials are important in the Mathematics classroom especially in the context of alleviating bias due to gender, race and class. A necessary pre-condition of successful learning in this area is that materials should contain images to which pupils can relate and that are successful and active. In short, the subject should be presented in such a way that Mathematics is for everyone not just white middle-class boys.

"Authors of textbooks and other materials (including video, radio, computer software, wall displays, posters, worksheets) have considerable responsibility for the way messages they are trying to convey are presented; and also the effects and influence in pupils". (Girls into Mathematics, 1986:80).

Teachers need to counteract the written and illustrative gender bias displayed in commercially produced mathematical materials and the lack of visibility of girls and women in active, creative roles, by putting pressure on publishers to change their practices. (Sylvester 1979; Northam 1982; Buxton 1984; and GAMMA cited in Burton 1986a:81,98,99).

Creating Gender Inclusive Materials:

"It is the balance that matters and to achieve this girls must be 'seen' to actively be taking part in the mathematics and activities associated with it". (Burton 1986:81).

Awareness of Sex Role Stereotyping:

Mathematics teachers, in Britain, were surprised how much bias existed in materials (Burton 1986:84) such as fewer females overall, very few adult women, stereotyped roles of women, adult males portrayed outside the home as active bread winners, many girls behaving in passive ways, boys in roles displaying initiative, prowess and performance and names implying stereotypes.

Awareness of the Contexts:

Teachers need to develop an awareness of the contexts in which Mathematics is set.

"The applications of mathematics which are found in many textbooks and examination questions reflect activities associated with men more often than women" (Cockcroft Report 1982).

Thus confirming in many ways, maths can still be classified as a "Boy's Vocational subject" in spite of changes in the curriculum.

Graf and Riddell (1970); Eddowes, Sturgeon and Coates (1980) and Leder (1984) found that girls performed better where questions had a female context, whereas boys performed well in both traditional and female (equivalent) contexts. Smail (1984) recommends keeping the context "people free" without "dehumanizing".

Awareness of the Bias Inherent in resources, such as calculators, computers, software, toys and games - and their differential availability to boys and girls:

Teachers' awareness of the need to use apparatus in the constructivist Mathematics classroom of the 90's to develop confidence and assurance in all pupils. The APU 1981 (cited in Burton 1986:95) noted again that this behaviour and expertise with resources was the province of boys and could reinforce that "Mathematics is not for girls". Burton (1986:95) focussed on the use of calculators, computers, toys and games. Boys are more likely to have computers, calculators and construction games.

Walden & Walkerdine (1982) believed it was lack of opportunity and encouragement which leads to girls not playing with construction toys.

Straker (1986) found that boys are twice as likely to own a calculator, microcomputer and a digital watch than the girls.

Serbin (1978) found that young children are more likely to play with an opposite sex toy if a male teacher is nearby. Everley (1981) found that girls with Meccano showed more capability and greater productivity than boys and just as much interest, thus destroying a myth stereotyping the activity as "male".

Burton (1986:95) emphasised the importance of encouraging all pupils to become familiar and confident with microcomputers and expressed great concern with regard to girls' attitudes to computing in general and their use of the machines.

Awareness of Preponderance of Boys' Interests:

The teachers need to avoid perpetuating stereotypes that already exist (Burton 1986:87); Northam (1982) found a preponderance of supposed boys' interests at junior level and Clwyd County Council (1983) found:

- o the vast majority of mathematics questions mentioned males or male interests.

  "The implication is that men fill the world of work and finance. The only question with a reference to a woman placed her very low down on the earning scale". (Burton 1986:90).

- o a reflection of presumed higher status of male interest in mathematics, thus creating in the minds of so many people that they "may not consider themselves competent to use such an important tool". A subtle, almost intangible process of exclusion.

- o Teachers' awareness of the need to include Women's Contribution to Mathematics and recognize its implications for educating girls today.

  "I didn't know that there had ever been any women mathematicians" said one student. (Barnes, Plaister & Thomas 1984).

One of the most important factors discouraging girls from the study of mathematics is the way in which society has viewed it as a male domain.

"In fact in the past women made a number of contributions to the study of mathematics, though it has been argued that their work has to be systematically devalued because of their gender". (Perl 1978; Spender 1982; Leder 1984). Burton (1986:27)) provides a list of women mathematicians since the earliest middle-eastern civilizations. She states these women faced enormous obstacles in order to pursue their studies which indicates their commitment to mathematics and why relatively few women mathematicians have gained public recognition. Barnes et al (1984) also recognized the barriers to women's achievement in mathematics, including their own misgivings about their own performance.

"I have perseverance and intelligence but not genius. That spark from heaven is not granted to the (female) sex" said Mary Somerville, one of the greatest of all mathematicians, quoted in Burton 1986:28-29.

<u>Recent Curricula materials in Mathematics in Western Australia</u>.

Mathematics Development 2.3 (cited at Rockingham Senior High School) shows signs of gender inclusiveness.

<u>Gender Inclusive Materials, Resources and Textbooks</u> - What can be done?

It is recommended that teachers:

- o become aware of the remnants of past barriers to female mathematical achievement that remain today.
- o recognize that the problem is exacerbated by cultural and social class background.

- o avoid the use of sexist language and ensure equal representation of females and males in illustrations, explanations and examples (GEMS 1990:7).
- o when preparing their own materials "balance" the commercial impression of girls with dynamic active images of females - written in a warm, friendly style (GEMS 1990:7).
- o draw pupils' attention to commercially produced bias, encouraging them to reflect on what they have read and learned.
- o provide opportunities to discuss the roles of males and females from different cultures,
- o make opportunities for more collaborative mathematics (GEMS 1990:6)
- o reverse gender references to alert people to attitudes they did not think they had. (Langton & Snape 1984 cited in Burton 1986:84)
- o include examples of males and females in non-traditional. roles (GEMS 1990).
- o develop an awareness of sexist language, both as a classroom and staffroom topic (Spender 1989).
- o make the context meaningful to all, especially helping girls to relate to materials and "make it their own" since they do not perform as well in the "male context".
- o create environments that provide opportunities and encourage girls to "tinker" in male stereotyped play and to use computers and graphic calculators with confidence and assurance. Perhaps in girl only environments (Whyte 1986).
- o use of imagery particularly important in teaching geometry progressively introducing computer software and graphics calculators. (Kent and Hedger 1980; Shuller 1983; ATM 1982; cited in Burton 1986; Malone et al 1989).
- o include "Her story" of Mathematics (see Burton 1986) in the curriculum, to counter gender and race stereotyping and the restrictions it imposes on the motivation and life chances of individuals.
- o include reference to people and real world problems relating mathematics to human interests and concerns.

G. <u>Assessment</u> - bias in favour of boys' preferred learning styles and contexts of questions.

On average, girls are not so successful as boys in public examinations at 16+.

> "The results of the 3rd year assessment test frightened me. With few exceptions, the top half were boys and the bottom half were girls". (Binns 1982).

> A similar study in Mathematics tests, at 'O' and 'A' level found in most cases boys did significantly better than girls. (Eales 1986).

> Lynn Joffe and Derek Foxman (1986) found on a number of different topics boys perform significantly better than girls at both (age 11 and 15) on APU tests. "the main differences in performance are established at age 11", they concluded.

> However, Parker and Offer (1989) provides ample statistics to show how well girls performed in mathematics under the old Achievement Certificate in Western Australia when Mathematics was part of the compulsory core curriculum for boys and girls and examinations were part of school based assessments. This case raises questions about the "freedom" compulsory mathematics gives girls and the form of school based assessment. (Issacson 1986)

The way in which Maths is assessed and the strategies used to tackle assessment questions could also contribute to girls lower potential attainment:

Types of Assessment:

Girls are at more of a disadvantage in multiple choice tests than in more traditional open ended tests.

> "This consistent male advantage in objective test papers across the whole range of subjects ... males are generally at an advantage when educational levels are measured by objective tests rather than other forms of assessment ... such tests therefore tend to magnify an already existing male advantage". (Murphy (1978).

Examination Conditions:

Girls are actually disadvantaged by any sort of assessment carried out under examination conditions, Burton (1986a:109). For example, they are slower than boys, need to be sure they are right, and more susceptible to feelings of panic and anxiety as a result of test pressure and tension. Thus girls' performance in mathematics under exam conditions may not be the best indicator of their ability. Kindt and de Lange (1986).

Since 1982, in UK, there have been debates about new forms of assessment (Cockcroft Report 1982). Joffe and Foxman (1986) believe practical work may again disadvantage girls and problem solving which has relevance for girls may not appeal to boys. SMILE exams are being analysed by sex in UK.

Contextual Bias in Questions:

If there is to be assessment using 'Mathematics in context', mathematics teachers need to ensure that "everyday life" does not mean "every day life for a white male" otherwise the situation for girls and boys from the same cultural backgrounds will remain the same. (Burton 1986a:113).

Females take longer to solve problems set in a male context (Graf and Riddell 1972) and girls do not perform as well as boys on such questions (Eddowes et al 1980). Evidence from UK confirms that "male" contexts appears far more often than "female" contexts.

"The language of examinations tends to assume that examinees and the population are male with constant references to "he", "him", "man"". (Kant 1982). Strassberg-Rossenberg and Doulen (1985), in the USA, classified test items for male/female bias and looked for questions females or males found significantly harder. As may have been predicted males did better in contexts such as science, traditional male interests or skills, transport, communications, space and time relationship, political science and electricity. Females related to contexts such as cookery, clothing and personality characteristics. Clearly girls need to have more background knowledge in the physical sciences and technical courses to help them answer "male" context questions.

Strategies for girls in tackling Assessment:

Girls in a technological world will "still have to cope with assessments which disadvantage them". Changing the assessment procedure and contexts of questions is "one half of the story", "improving girls' strategies in tackling assessment is the other". (Burton 1986a:117).

Eddowes (1980) found that girls did not have such good examination strategies over all as boys: Females tend to "apply rules to recognized situations" whereas males "use more independent processes, often successful in more difficult questions". However, females who did identify the problem were more reliable in calculations than corresponding boys". Females were more likely to be thrown by unfamiliar contexts. Wood (1976) found that girls are far more likely to miss the final stage in a problem and relate it back to the problem set. That they are less likely to look back over the answer and ask "is this a sensible answer"?

Burton (1986a:119) found girls' examination strategies worse than boys:

- girls answer questions in the same order as they were written, whereas boys "give up" and return.

- more boys eliminated wrong options by informed guesses on multiple choice tests items.

- girls in making sense of a question "self talk"

- hardly used diagrams (imagery)

- females, as "Serialists" were more anxious about unfamiliar situations, whereas males as "Holists" were better on unfamiliar questions. Brown (1984) identified two systems of thought, one more appropriate to the humanities (contextual) and one more appropriate to the sciences.

  Females tend to prefer the "field dependent" approach to problem solving and males prefer a more "field independent" approach, resulting in a slower approach by females and a preoccupation with context rather than the heart of the problem.

What can be done to Eliminate Assessment Bias?

- o Need to ensure that all members of the Maths department are aware of a whole school policy with regard to Gender Equity (Burton 1986:122).

- o Need to inservice mathematics teachers in educational measurement, with gender equity in mind.

- o Teachers should ensure that they have the requisite skills for formulating, selecting and/or constructing multiple choice questions well (GEMS 1990:7).

- o develop the ability to write or select challenging open ended investigative problems.

- o carefully consider the contexts of problems set during the unit and for formal assessment.

- o work cooperatively and collaboratively in school and through wider networks to this end.

- o need to tackle assessment as part of an overall policy for equity throughout the teaching of mathematics (GEMS 1990:7).

- o need to note that the examination room is not the first place to startle people with thought provoking "role reversals".

- o need for change so that no pupil is disadvantaged either by type of assessment or by any bias in questions.

- o need to foster general positive attitudes of girls themselves in particular preparing for and tackling assessment questions.

- o need to improve girls' attitudes and expectations and help them to develop better learning strategies and exam technique, could also help girls to do justice in assessment.

  In particular:

  help girls develop better strategies in order to tackle conventional types of exams.

  reduce pressure and tension as much as possible

  ensure types of practical work equally relevant to boys and girls

  use and prepare students for oral work in the classroom - develop these skills for their oral testing.

  course profiles for each student
  (Burton 1986a:111-112).

  need to consciously broaden girls' experiences so that they can cope better with 'male' contexts.

need to use metacognitive processes to find out how they are tackling assessment questions of different types
need for over all strategies for tackling tests and examinations (Burton 1986a:120).

need for girls to be aware of their preferred "serialist", field dependent cognitive/learning styles, so that they learn to move to the essence of the problem more quickly, unless the problem is related to important social issues. (Boys may need to foster girls' preferred styles too).

INTERVENTION PROGRAMMES - What has been done?

"Plan to lift science and Maths teaching" (Button 1987).

"Teachers greater concern with the work of boys in mathematics - expressed subtly in a number of different ways illustrates the extent to which prevailing cultural stereotypes are reflected in classroom practices, which in turn further reinforce these beliefs. Intervention studies challenge the assumption that this vicious cycle can not be broken" Leder (1989:97).

The work of Chapline et al 1980; Moody and Linn 1986; Beauvais 1986; Burton 1986a; Berard and Huppertz 1987; Good and Brophy 1987; Doenau 1987; Lewis and Davies (GAMAST) 1986; Vasey 1989 and Barnes 1989 will be considered briefly.

Target - Pre-service Student Teachers - USA experience.

The Teacher Education and Mathematics (TEAM) project in New York, developed a model programme and instructional materials to increase the student teachers' confidence and skills in (1) Mathematics by reducing their mathematics anxiety; (2) developing skills in identifying sex bias in mathematics curriculum materials and teacher-pupil classroom interactions and (3) increasing their knowledge of mathematics concepts required in primary education. (Chapline et al 1981).

In the light of the recent GEMS (1990:8) statement related to Girls and Mathematics, we as a college would do well to initiate remedial mathematics units, including gender issues, for ECE, Primary and Secondary specialists.

Professional Development Packages for Teachers, Parents and Administrators:

Target - Professional Teachers in the USA.

Moody and Linn (1986) developed a teaching guide for mathematics teachers in the USA to foster sex equity in Maths. The need to gain competence in Mathematics skills and confidence in mathematical abilities is fostered by district and whole school programmes to increase student participation, motivation and achievement.

Target - Administrators, Teachers, Parents in School Districts in the USA:

Berard and Huppertz (1987) have produced a manual to increase equity awareness at the local school district level. The manual describes a model travelling equity resource display and provides instructions,

agendas and participant materials for a two day training workshop for administrators, which will enable them to inservice teachers and parents. The workshop focuses on Title IX, Women's History, Mathematics, Science and Computer equity.

A Valuable Resource for Mathematics Teachers concerned with Gender Equity developed in the USA:

Beauvais et al (1986) looked closely on the influences on sex equity in Mathematics achievement by summarizing the research and recommendations. The report focuses on:

- mathematics enrollment
- influences on mathematics participation
- predicting mathematics achievement
- sex differences in attitudes towards mathematics achievement
- visual-spatial skills
- parents, peers and significant others
- teachers
- classroom environment
- school structure
- testing
- advanced placement girls (ie. gifted)
- career aspirations and educational goals
- recommendations to teachers, parents and school personnel.

Classroom Interaction - Intervention Programme for Teachers: from the USA and Australian experience.

Good and Brophy (1987) believed feedback to teachers about classroom behaviour should be obtained systematically and reliably in three ways, feed back from older students, fellow teachers, and developing a conceptual framework to benefit their own performance. Doenau (1987) advocated a step by step approach to develop gradual awareness of teacher behaviour and student responses/initiations; confidence in monitoring, recording, analysing and finally putting findings into practice to modify teacher behaviour.

Packages developed in Australia for Action Research Programmes in Schools:

Target - Teachers and Parents:

GAMAST (1986) provides inservice materials to assist groups of teachers (Maths & Science) to:

- diversify teaching to include girls
- develop inclusive policy for their schools
- develop skills in implementing change
- plan programmes to start from the experience of girls

Parents are also encouraged to be involved and inserviced (Lewis and Davies 1986).

Inservicing of Teachers of Mathematics and Computing: (The UK experience)

"Girls into Mathematics" Package (Burton et al 1986) provides excellent inservicing for teachers of mathematics and computing (following the Ramsay 1982 model).

Burton (1986b) has, in addition, collected a series of valuable articles in "Girls into Maths Can Go", which is a valuable research supplement for this package.

Assumptions and Aims of the Pack:

1. Awareness of issues of equity is necessary when fighting sexism for when the teacher is in command of the facts, she/he can contend with adverse reactions if and when they occur. Reinforcing the key role of teachers in effecting change related to equitable treatment of boys and girls in the classroom.

2. Improving the situation for 52% of the school population - should affect the learning experiences of all pupils.

3. Active role of learners (teachers) is emphasised for both attitude change, knowledge acquisition related to gender and skills to counter invidious effects of sex stereotyping in school and the mathematics classroom.

   "Activities to work through, help you to turn ideas into experience and experience into practice" Burton (1986a).

4. Group discussion of teachers is essential since ultimately "through discussion of issues we will build up better rapport between boys and girls, leading to a better classroom climate" Burton (1986a).

5. Pack encourages teacher to do own research - collecting anecdotal evidence and sharing it with others.

   - to seek resonance with other people's experience and to sharpen own awareness, to give access to a broader range of options than simply automatic reaction. This small scale research should ideally be feedback to a "centre for mathematics for collation and later dissemination.

6. Links between Universities, employing bodies, schools and teachers provide valuable networks for enhancing the experiences of all students in school and support for teachers at the "chalk face".

Important to highlight that issues of gender are exacerbated by differences in race and culture which "could be no less pervasive than that of gender" (Burton 1986a:7).

Some evidence, in UK, that Afro-Caribbean girls perform better than other girls in maths and that Asian boys perform worse than other boys. (Educational Studies in Mathematics 14th November 1983:342 cited in Burton et al (1986a:17).

Dilemmas experienced by girls were in danger of being repeated in 'Computing' - partly due to lack of intrinsic interest in computers.

"The Computer and Mathematics" appendix is included because of real and apparent connections between math and computing:

(a) often maths and computing is a joint teaching responsibility

(b) most often used in maths, which could explain negative attitudes of girls towards computers, even through technology historically has only recently been introduced in schools.

However, (c) arguably micro-technology has a very influential effect on the teaching of constructivist mathematics, so strengthening links could have positive effect on both attitudes of girls to maths and computing. Girls need careful nurturing (Burton 1986a: Malone et al (eds) 1990).

Intervention Programmes in Mathematics for Girls and Women - Modifications to the Setting: (The Australian Experience)

The two intervention studies of Vasey (1989:98-104) and Barnes (1989:105-117) describe practical ways in which the setting for mathematics learning can be modified for greater equity for all.

1. The Family Maths Project, (FAMPA) was established in the ACT, in 1985 and runs parallel to and complements Participation and Equity Programmes (PEP) concerned with gaining greater participation and involvement of school communities in education and increasing the participation of girls in mathematics education (Vasey 1989).

In 1982, Meece and Eccles-Parsons wrote:

> "It is vital that parents and teachers become more sensitive to their own attitudes towards mathematics and avoid perpetuating stereotypic views of maths achievement or careers in the quantitative fields as inappropriate for girls or women" (Meece and Eccles-Parsons 1982:343).

The Family Maths Project (Australia) is "based on the belief that attitudes towards mathematics can be improved for children of all nationalities by encouraging the family to be a base for learning mathematical skills and for demonstrating the importance of mathematics" Varsey (1989:104).

Parent Involvement in the FAMPA Programme:

Parents are:

> "Conveyors of expectancies regarding their children's abilities (Eccles-Parsons et al 1982:320).

Research supports the assertion that attitudes and the expectations of both parents are important in the development of children's attitudes towards mathematics and their achievement levels especially for girls. (Stamp 1979; Wilhelm and Brooks 1980; Meece and Eccles-Parson 1982; Eccles-Parsons et al 1982; Graham & Roberts 1982; Graham 1985; Newhouse 1990:19-22).

The FAMPA programme in Canberra covers pre-school to Year 12, with special emphasis on the interfaces between preschool and K, Year 6 and Year 7, and Year 10 and Year 11.

Pre-schoolers are at a critical stage in the development of mathematical ability and attitudes. In order to counter social influences that are deleterious to this development, parents are very much involved in roster duty, fund raising and 'inservice course' to begin to maximize the benefits of the family unit as a base for learning.

Parents and children (3-8 years) establish a working relationship to achieve a common understanding of mathematics and its importance in today's society. Family Maths Libraries are being established to provide materials and activities which parents can borrow.
A Maths Centre was established in Canberra in 1977, based on a hands on problem solving approach to Mathematics learning.

Preferred Learning Styles and A New Setting for Mathematics - A Prototype Setting in the ACT for High Schools:

One of the initiatives in the FAMPA and PEP programmes was the establishment of a Mathematics laboratory in one high school originally designed to provide more practical, hands on problem solving experiences of every day mathematics for those students who are not achieving in high school mathematics. It is now used by all mathematics classes and will be a model for all other ACT high schools. (Vasey 1989:101).

Retention and Participation Rates in Year 11 and 12 in ACT Schools:

There is an 80% retention rate in Year 11 and 12 and 90% of continuing students pursue a Maths course.

FAMPA is aimed at Year 11 students doing accredited courses (non-tertiary entrance) and aims to foster interest and enjoyment of maths while maintaining career options. (Vasey 1989:101)

This is vital for girls who may be aiming at TAFE courses and apprenticeships (Towns 1985).

Encouraging Research Findings Related to FAMPA:

Initial follow up research into the attitudes of children at primary school indicates that FAMPA is "reaching those girls with poor attitudes to maths and giving them a more positive view of mathematics" (Vasey 1989:104).

Parents' confidence and their expressed feelings about their ability to help their children is sex related with its origins in their own childhood experiences of maths at primary school. FAMPA programmes can change the expressed attitudes of mothers and fathers towards primary school mathematics, which will have positive repercussions for their children.

2. Barnes (1989) "A Rescue Operation" aims to assist "women in tertiary" in achieving competence in Mathematics by their voluntarily attending a "Mathematics Learning Centre" at the University of Sydney. The centre works closely with various academic departments who can in turn make their students aware of this service particularly to overcome "maths anxiety" and "rediscover Mathematics" Barnes 1989:110).

The major aims of the centre are to:

- o develop their mathematics knowledge base
- o develop effective approaches to learning and studying maths not relying on "rote learning" but more meaningful problem solving approaches.
- o develop confidence in their ability to learn maths by positive talk, perseverance at tasks and risk taking when approaching new areas of maths; to minimize the development of "learned helplessness"; using questions to students advisedly, by encouragement of "group" problem solving for mutual support.
- o cater for particular mathematics difficulties (Barnes 1989:112).
- o Increase the visibility of competent female maths educators and tutors.

Feedback indicates that the centre has:

(a) prevented drop-outs and failures, and even enhanced their enjoyment and understanding of maths.

(b) Produced women who now wish to teach Mathematics who hopefully will be empathetic to the needs of girls in the future.

Barnes 1989:117 concludes:

"It is clearly impossible to separate initiatives to encourage girls in mathematics from non-sexist programmes in general - we need to develop whole school approaches to gender equity where girls, boys, teachers, parents and administrators deal with this crucial issue".

<u>WHERE TO FROM HERE</u>?

1. Compulsory Mathematics for Girls:

   Issacson (1986) pursuing this from a philosophical perspective believed that compulsory mathematics would indeed give girls greater freedom to choose from a wide range of occupations, thus broadening and enhancing their life chances. Parker and Offer (1989) provided ample statistics to show how well girls performed in Mathematics under the old Achievement Certificate in Western Australia, with its core education.

2. <u>Career Education - Girls' Perceptions of Mathematics for Future Employment</u>: (Jacobs 1978).

   "Information and interest are necessary components for creating the desire, which is an important element in the exercise of freedom" (Issacson 1986:227)

   Stereotyped views about careers must have implications for maths performance. The Insight Programme (Peacock and Skinkins 1983) in UK focussed on careers for girls in engineering.

   The EOC (1984) quote that "a positive choice at 13 has a positive effect for life". In the light of this catch phrase, two initiatives were implemented:

(i) Conference for Girls:

"Be a sumbody" for 12-14 year olds was initiated in UK, to expand awareness of the role of Mathematics as a critical filter into future employment activities. This conference was deliberately group centred, creative and challenging. It also showed the enjoyable aspects of maths and the range of options for which maths is needed (Burton 1986a:122).

(ii) Careers Fair:

In which girls meet women, in UK, who were in non-traditional jobs. (Burton & Townsend 1986 'Girl Friendly' Maths)

3. Redefining the Content, Context and Methodology will make it possible for girls to engage in Mathematics without the conflict caused by the "demands of double conformity" (Issacson 1989:239).

4. In theory and increasingly in practice we are beginning to humanize the discipline of Mathematics by "incorporating typically female concerns, modes of behaviour, insights and responses" - "considered necessary for a saner world". (Brown 1986; Issacson 1986:239).

5. "Girls need to study physics and technical subjects, (as well as mathematics), if they are to have positive freedom, that is, be in charge of their own lives as adults" (Issacson 1986:230).

(a) Mathematics and Technology are becoming more closely integrated requiring both skills in and positive attitudes towards computers and graphic calculators (See Malone et al (eds) 1989). It is a matter of concern that girls may be disadvantaged by failing to become competent in this area.

(b) 'Industrial Arts for Girls' - should it be compulsory? particularly in the light of facilitating spatial skills, autonomous behaviour, competence and confidence in traditional 'male' pursuit. (Catton 1985).

Curriculum adaptations in this area are discussed in Part 3 of this report (Newhouse 1990).

(c) Physics and Physical Science, maths related subjects - how to encourage this? - by relating content to a "female context" (Harding 1983; Garnet et al 1989)

Single sex grouping - year 11 Girls and Physics (Kent Street Senior High School, Perth WA. 1990)

(d) Maths its relationship with other subjects:

"If girls are encouraged to go into scientific or technological fields of study, their maths skills will improve. An improvement might be effected if the maths inherent in many subjects traditionally studied by girls is recognised as part of the formal curriculum". (Burton 1986a:20).

Mathematics Educators need to become increasingly aware of areas such as Home Economics, Human Biology and Biology where mathematics and Physics are an integral part of the curriculum - and provides a "feminine" environment to match preferred learning styles of girls. Differential valuing of such subject areas is a problem which needs to be overcome.

6. Single Sex Grouping in Mathematics - a perennial question - an advantage for girls? (Leder 1980; Binns 1982; Smith 1983; Mahoney 1985; Peterson & Fennema 1985; Burton and Townsend 1985; Eales 1986; Rowe 1988; Barnes 1989; Chang 1989; Leder 1989; Willis 1989).

7. Assessment Procedures - a matter of great importance for girls, in terms of learning styles, anxiety, timing of public examinations. (Murphy 1978; Cockcroft 1982; GEMS 1990:7; Kant 1982; ATM 1985; Strassberg-Rosenberg et al 1985; Kissane 1986.)

8. Awareness and attitude change is a vital consideration if gender equity is to become a reality (EOC 1990). Ways of effecting this are well presented in GAMAST (Lewis & Davies 1988). Lewis and Davies (1988) advocate evaluation of every aspect of action research related to gender equity and provide evaluation criteria in the Appendix of GAMAST.

9. Changing attitudes of Mathematics Educators, Mathematics Student Teachers and Professional Mathematics teacher with regard to the special mathematical educational needs of girls.

RECOMMENDATIONS - MATHEMATICS EDUCATION FOR GIRLS:
(to be read in conjunction with the AAMT recommendations)

It is recommended that mathematics education of girls be firmly Integrated with "Mathematics for the Year 2000": (Malone 1989 (ed) et al).

- with a focus on the development of mathematical thinking rather than the learning; such a focus on thinking processes will require appropriate evaluation techniques and assessment proforma.

- presenting mathematics as a human endeavour, rather than a "masculine" enterprise only - by including and valuing the past and present achievements of women and girls.

- incorporating applications of mathematics to important social issues, incorporating a feminine morality of 'caring' (Noddings 1984 and Gilligan 1989).

- emphasising the creative and imaginative appeal of mathematics, by consciously planning alternative teaching strategies; the use of graphic calculators and computer software; open ended investigative problems, where alternative strategies for their solution are encouraged.

- developing group and individual problem solving skills and strategies, where such processes are carefully monitored and may be assessed by teachers and pupils.

- o encouraging, developing carefully monitoring and evaluating verbal communication skills in mathematics such as reading, writing, talking and listening. Pupils should be encouraged to assess their own and group competence in this area. (ref GAMAST).

- o encouraging and developing visual skills in mathematics such as drawing, interpreting and visualizing diagrams, graphs and other symbolic representations. Evaluation of such skills should be progressively monitored for competence and special help given to girls in facilitating spatial skills and in the use of computers and graphic calculators as tools in this process.

<u>It is recommended that Mathematics Educators, Teachers at Pre-Primary, Primary, Secondary, Post-secondary and Student Mathematics Teachers</u>:

- o perceive the major aim of gender inclusiveness as permitting individuals (especially girls) to achieve their potential and maintain a positive self image and human dignity.

- o become aware of, and seek to eliminate any gender bias in their current practices.

- o immerse themselves in key literature such as <u>Burton</u> (1986b) <u>Girls into Maths Can Go</u>.

- o use models for achieving gender equity in the Mathematics Curriculum such as <u>Girls into Mathematics</u> (Burton 1986) <u>GAMAST</u> (Lewis and Davies 1988).

- o focus on their professional development, as an essential first step in planning and implementing such mathematics curricula in schools and tertiary institutions.

- o plan to implement gender inclusive maths curricula using an action research model (Whyte 1986).

- o examine blocks that inhibit the performance of females in mathematics classes, examinations and other problem solving situations with due regard to the research related to sex differences; cognitive and learning styles; spatial ability; mathematics achievement of young and adolescent girls; sex stereotyped beliefs, aspirations, expectations of girls in relation to mathematics anxiety, fear of success, fear of failure.

<u>Recommended Changes at Institutional and Systems Level</u>:

It is recommended that, at the Tertiary Institutional, Schools and Systems level:

- o There is an increase in the representation of women at all levels in Mathematics, mathematics education and leadership positions to encourage girls, as "achieving models" in a predominantly masculine domain and for future career options.

- o A balance of female and male teachers taking high level mathematics courses be encouraged to increase the number of female role models in the department.

- Career education for girls be closely integrated with mathematics education, which may require professional development for Mathematics teachers and counsellors in the school.

- Timetabling is given priority in ensuring girls are not blocked out of Mathematics options, nor subjects of particular interest to them.

- Administrators and counsellors are inserviced into the needs of women and girls particularly in mathematics.

- Schools and tertiary institutions take responsibility for informing parents and the community about the importance of girls' participation in mathematics as a "critical filter" to many occupations and careers, and to enhance the mathematical literacy of the society by:

  - inservicing parents and community members alerting them to the fact that girls can and do achieve well in mathematics to dispel sex role stereotyping.

  - providing parent - daughter career nights with information about non-traditional careers and role models of achieving people in these fields.

  - participate in inservice programmes at school related to mathematics taught, methods used, importance of mathematics and the special needs of girls.

  - by parents' active involvement in mathematics programmes, which is not only important for increasing their own mathematics competence and confidence, but enables them to help in their child's mathematics education. (FAMPA).

<u>Role of the Tertiary Institutiors</u>:

It is recommended that Mathematics departments in their education of teachers provide:

- pre-service education courses for teachers of all levels of mathematics

- provide professional development courses for teachers of mathematics, including those particularly related to gender issues

- provide support for mathematics teachers individually and collectively in their schools to establish networks between tertiary institutions and schools.

<u>In Particular, it Recommended that Mathematics Teachers are</u>:

- inserviced on selecting formulating and evaluating questions and problems, with regard to contexts that might marginalize or exclude girls, because they focus on masculine experiences.

- provided with information on selecting and using well constructed multiple choice questions, since poorly expressed questions or the total use of such questions can penalize girls; due to their preferred learning style, confidence and willingness to take risks.

- conscious of contexts of questions and the ways it may "delay" field dependent learning style people (often girls) in their solution of such problems.

- aware of the timing of major examinations, especially for girls at the zenith of their aspirational levels.

- skilled in the use of variety of contexts in which mathematical thinking can be developed and applied; yet are sensitively aware of the fact that, at the present time, the use of computers or graphic calculators may disadvantage or marginalize girls, especially those of different race, ethnicity or social class.

- introduced to intervention programmes such as FAMPA, which are valuable models of action research in a state system alerted to the fact that mathematics education may be considered to be life long; and that "intervention programmes" to overcome mathematics anxiety, promote skills and mathematical understanding can be made available to tertiary students from other faculties" (Ref Barnes 1989).

- made aware of and consciously reduce the sex role stereotyping and marginality of females in written materials, computer software and published materials by:

  modifying or incorporating curriculum content and alternative teaching strategies for gender inclusiveness.

  writing in a warm, friendly style, for inclusiveness.

  avoiding the use of sexist language and ensuring equal representation of females and males in illustrations, explanations and examples: both men and women being seen in active roles and non-traditional roles.

  including references to women's past and present contributions to Mathematics.

  incorporating a feminine philosophy by including references to people and real life (world) situations and relating mathematics to human interest and concern.

  encouraging students to critically evaluate any materials for gender inclusiveness.

- made aware of the important role of teachers in the classroom in overcoming cultural gendered expectations, reducing sex stereotyping, fostering realistic expectations and aspirations; and generally making the classroom gender-inclusive.

- inserviced in the analysis of classroom interaction in the mathematics classroom, with reference to differential teacher attention to boys and girls, distribution of high level cognitive questions and encouraging positive comments.

- aware of non-verbal communication which may convey 'hidden messages' especially to girls with regard to their perceived marginality, self esteem, confidence competence, belief in an ability to take risks and to achieve.

- able to encourage cooperation in the Mathematics classroom with a healthy degree of competition.

- able to discourage "learned helplessness" in girls and encourage risk-taking through guessing, estimating, attempting partial solutions and 'trial and error'.

- providing students with some control over their own learning through negotiation in the nature and timing of their assessment tasks.

- encourage when appropriate open class discussion on the issue of gender.

- actively encouraging students to evaluate the teachers and their own interaction in the classroom.

- Using a variety of teaching strategies that:

    - focus on student achievement, application to the real world and enhance interest and motivation

    - foster cooperation and group learning

    - enhance problem solving and creative solutions

    - show the creativeness and beauty of mathematics.

<u>It is recommended that for gender inclusiveness, mathematics educators ensure that assessment and evaluation in Mathematics</u>:

- is varied; including written, oral and practical tasks, with appropriate criteria for assessing such tasks (GAMAST 1988).

- includes projects, presentations, open-ended investigations, essays, take home tests and assignments, as well as assessments of speed and accuracy.

- provides students with the opportunity to work cooperatively and both teacher and pupils evaluate how effective the group and individuals were in achieving the objectives. (GAMAST 1988).

- includes extended and time restricted periods of time for completion of all types, in order to accommodate to preferred learning styles of boys and girls.

- ensures that external assessment is consistent with assessment modifications for gender inclusiveness.

- encourages students to reflect on what they have learned.

<u>REFERENCES - MATHEMATICS EDUCATION FOR GIRLS AND GENDER INCLUSIVE MATHEMATICS</u>:

ATM (1982), Geometric Images.

ATM (1985), Writing Notes in Assessment.

Barnes, M., Plaister, R., & Thomas, A. (1984), (eds), Girls Count in Maths and Science: A Handbook for Teachers, Mathematical Association of NSW, Sydney.

Barnes, M. (1988), (eds), Mathematics: A Barrier for Women? in Caine, B. et al. Crossing Boundaries, Allen and Unwin, Sydney.

Barnes, M. (1989), (eds), 'A Rescue Operation' in G.C. Leder and S.N. Sampson. Educating Girls: Practice and Research, pp. 105-117. Allen & Unwin, Australia.

Beauvais, K., et.al. (1986), Sex Equity and Math Achievement: A Summary of Research and Recommendations. Michigan State Dept of Education, Lansing.

Becker, J. (1981), 'Differential Treatment of Females and Males in Mathematics Classes', Journal for Research in Mathematics Education, Vol.12, pp.40-53.

Benbow, C. and Stanley, J. (1983), "Sex Differences in Mathematics reasoning ability: More Facts", Science, 222: pp.1029-31.

Berard, B.K., and Huppertz, N. (1987), 'A Model Program for Statewide Title IX Capacity Building', Northwest Regional Education Lab., Portland.

Binns, B. (1982), The Girls in my Tutor Group will not fail at Maths, in Burton L. 1986b.

Bondi, C. (1987), 'Girls and Mathematics : A Report of the Joint Mathematical Education Committee of the Royal Society and the Institute of Mathematics and its application' in Teaching Mathematics and its Applications, Vol.6, No.2, pp.58-62.

Brophy, J. and Good, T. (1970), Teacher-Child dyadic interaction. A manual for coding classroom behaviour in A. Simon and E. Boyer, (Eds) Mirrors for behaviour. An Anthology of classroom observation instruments 1970 Supplement, Vol A Philadelphia Pennsylvania Research for Better Schools.

Brophy, J. and Good, T. (1974), Teacher and Student Relationships: Causes and Consequences, Holt Rinehart & Winston, New York.

Brown, S.I. (1984), "The Logic of Problem Generation from Morality and Solving To De-posing and Rebellion" in L. Burton (ed) 1986, Girls into Maths Can Go. pp.196-222, Holt Rinehart & Winston, London.

Brinkworth, P. (1988), Conditions for Teacher and Curriculum Change. Submission to Theme Group 7, Sub-group 7.3, ICME-6, Budapest.

Burton, L., & Townsend, R, (1985), 'Girl Friendly Mathematics' in L Burton (1986), Girls into Maths Can Go, pp.187-195.

Burton, L., et.al. (1986a), (ed), Girls into Mathematics, The Open University Inner London Authority Course. Canbridge University Press, Canbridge.

Buerk, D. (1985), The Voices of Women Making Meaning in Mathematics in Journal of Education, 167(3).

Burton, L. (1986b) (ed), Girls into Maths Can Go, Holt Rinehart and Winston, London.

Button, J. (1987), 'Plan to lift science and maths teaching' The Age, October 24:p.3.
Buxton, L. (1981), Do you Panic about Mathematics: Coping with Maths Anxiety. Heinemann Educational Books.

Buxton, L. (1984), Mathematics for Everyman. Dent. UK.

Catton, J. (1985), cited in Whyte (1986), Girls in Science and Technology: the story of a Project. Routledge & Kegan Paul, London.

Chang, P.T., (1989), '21st Century Mathematics: Teacher Training and Remediation', Malone, J. (eds) (1989), The Mathematics Curriculum for the Year 2000.

Chapline, E.B., and Others (1980), Teacher Education and Mathematics Project. Final Report 1979-1980. City University of New York, Flushing, New York.

Chipman, S. & Wilson, D., (1985), 'Understanding Mathematics course enrolment and mathematics achievement: a synthesis of research' in S.F. Chipman, L.R. Brush and D.M. Wilson (eds) Women and Mathematics: Balancing the Equation, Lawrence Erlbaum and Associates, Hillsdale N.J. pp.275-328.

Clwyd County Council (1983), Equal Opportunities and the Secondary School Curriculum, Equal Opportunities Commission.

Cockcroft, W.H. (Chair) (1982), (The Cockcroft Report), Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools. HMSO.

Crawford, K.P. (1987), Simultaneous and Successive Processing, Executive Control and Social Experience: Individual Differences in Educational Achievement and Problem Solving in Mathematics. University of New England. Armadale, NSW. PhD Thesis

Cross (Chair), (19880), (The Cross Report), Final Report of the Commissioners Appointed to Enquire into the Elementary Education Acts England and Wales HMSO.

Day, N.A. (1987) "Factors associated with student choice of Mathematics. . Science and Technology", in Report of the Working Party on Education for Science and Technology. Improving the Science, Mathematics and Technology Educations Base in Victoria, Ministry of Education, Melbourne Victoria, Part 4:1-29.

DES, (1984), Statistics of School Leavers 1983 (Vol 2) HMSO.

DES, (1985), Mathematics from 5 to 16, (Curriculum Matters 3), HMSO.
Deekers, J. de Laeter, J., and Malone, J. (1986), Upper-Secondary Science and Mathematics Enrolment Patterns in Australia, 1970-1985. Science and Mathematics Education Centre Curtin University, Perth.

Deem, R. (1978), Women and Schooling, Routledge & Kegan Paul, London.

Doenau, S. (1987), Are Teachers Fair to Girls? School of Education MacQuarie University. pp.191-192.

Eales, A., (1986), "Girls and Mathematics at Oadby Beauchamp College, Leicester" in Burton 1986b).

Eccles-Parsons, J., Adler, T. and Kaczala, C. (1982), "Socialization of Achievement Attitudes and Beliefs: Parental Influences" Child Development, Vol 53, pp.310-21.

Eccles J and Blumenfeld, P. (1985), Classroom Experiences and Student Gender: Are there differences and do they matter? in L.C. Wilkinson and C.B. Marrett (eds) Gender Influences in Classroom Interaction, Academic Press, New York. pp.79-114.

Eddowes, M. (1983), Humble-pi :the Mathematics Education of Girls, Longmans for the Schools Council.

Eggleston, J., Galton, M. and Jones, M. (1976), Processes and Products of science teaching (Schools Council Research Studies) MacMillan Education.

EOC (1984), Subject options at school: a positive choice at 13 has a positive effect for life. EOC.

EOC (1990), Discrimination in Government Policies and Practices S.82, Report No.5 Second Review of the Provision of Public Education in Western Australia. Equal Opportunity Commission, Perth. June 1990.

Evans, T.D. (1982), "Being and Becoming: teachers' perceptions of Sex roles and actions towards their male and female pupils. British Journal of Sociology of Education, Vol.3, No.2, pp.127-43.

Eynard R. & Walkerdine, V. (1981), The Practice of Reason: Investigations into the teaching of mathematics in the early years of schooling Vol.2 Girls and Mathematics, Thomas Coram Research Unit, University of London.

Evans, T.D. (1989), 'Living Curricula' in G.C. Leder and S.N. Sampson (eds), Educating Girls: Practice and Research, pp.73-83.

Feldman, L. (1989), The Expansion of Mathematics Software Toward the Year 2000 in Malone J, et.al. (eds) The Mathematics Curriculum for the Year 2000. Curtin University WA.

Fennema, E. (1985), (ed), 'Explaining Sex Related Differences in Mathematics' - Theoretical Models Educational Studies in Mathematics, Vol.16, No.3, pp.303-20.

Fennema, E. and Peterson, P. (1985), Autonomous Learning Behaviour: A Possible explanation of gender related differences in mathematics in L.Wilkinson and C. Marrett (eds), Gender Influences in Classroom Interaction, Academic Press, New York. pp 17-35.

Fox, L.H., et al, (1980), Women and the Mathematical Mystique, John Hopkins University Press, Baltimore.

Foster, V. (1989), is Gender Inclusiveness Curriculum the Answer for Girls? in Leder, G. and Sampson, S.N. (eds), Educating Girls: Practice and Research, Allen & Unwin. Australia. (pp.32-34).

Galton, M., Simon, B. and Croll, P. (1980), Inside the Primary Classroom, Routledge and Kegan Paul.

Garnett, P., et al, (1989), A New Approach to Teaching Mechanics: or how to be a little cog in a big wheel. Paper presented at The Western Australian Science Education Conference.

GEMS, Gender Equity in Mathematics and Science, Vol.1, Issues 1-5, 1988-89, Woden, ACT.

GEMS (1990), A National Statement on Girls and Mathematics. The Australia Association of Mathematics Teachers Inc (AAMT) July.

Graf, R.G. & Riddell, J.C. (1972), Sex Differences in Problem Solving as a function of problem context. Journal of Educational Research, Vol.65, pp.451-2.

Good, T., Sikes, J., and Brophy, J. (1973) Effects of teacher sex and student sex on classroom interaction. Journal of Educational Psychology, Vol.656, pp.74-87.

Good, T. and Brophy, J. (1987) (4th ed), Looking into Classrooms, Harper & Row Publishers, New York.

Gore, D. and Roumagoux, D. (1983), Wait Time as a variable in sex related differences during fourth grade mathematics instruction. Journal of Educational Research 26, pp.273-275.

Graham, A, and Roberts, H. (1982), Sums for Mums, Open University, UK.

Graham, A. (1985), Help Your Child with Maths, Fontana UK.

Guidi, R.M. (1989), 'Curriculum Change in Brasilia' in Malone, J. et al, (eds), The Mathematics Curriculum for the Year 2000'. Curtin University, Perth WA.

Harding, J. (1983), Switched Off: the Science Education for Girls. Longman for School Council.

Hacker, S.L. (1983), Mathematication of Engineering: Limits on Women and the field. in Rothschild, J. (ed) Machina Ex Dea, Pergamon, London.

Haimo D.T., & Friedlander, K. (1989) Effecting Curriculum Change through the Introduction of Mathematics Applications in Malone et al (1989), (eds), Mathematics Curriculum for the Year 2000, Curtin University, Perth WA.

Hersee, J. (1989), 'Communication of Aims and Criteria for a New Mathematics Curriculum' in Malone, J. et al, (1989), The Mathematics Curriculum for the Year 2000, Curtin University, Perth, WA.

Issacson, Z. (1982), Gender and Mathematics in England and Wales in International Review of Gender and Mathematics, ERIC.

Issacson Z. (1986), Freedom and Girls' Education: A Philosophical Discussion with Particular Reference to Mathematics in Burton (1986b) (ed), Girls into Maths Can Go, pp.223-240.

IlEA (1984), Equal Opportunities for Girls and Boys in Primary School Mathematics, ILEA Learning Resources Branch.

Jacobs, J. E. (1978), Perspectives on Women and Mathematics, ERIC Clearing house for Science, Maths and Env. Ed. Colombus, Ohio.

Joffe, L. (1983), "Is it your attitude that matters?" GAMMA Newsletter, No.4:7-11.

Joffe, L. & Foxman, D. (1986), Attitudes and Sex Differences: Some APU findings in Burton (1986b) (eds).

Johnstone, B. (1984), Technology: must the girls keep losing out. The Times, 6th November.

Kant, L. (1982), Are examinations up to the mark? Secondary Education Journal, Vol.12, No.2, pp.8-10, June.

Kelly, A. (1982), Gender Roles at Home and School, in Burton 1986(b).

Kelly, B. (1989), Embedding Computer Science in a New Mathematics Curriculum in Malone, J. et al, (eds), The Mathematics Curriculum for the Year 2000, Curtin University, Perth, WA.

Kent,D. and Hedger, K. (1980) 'Growing Tall' in Educational Studies in Mathematics. Vol.11, pp.137-79.

Kent Street Senior High School (1990), Upper School Physics for Girls.

Kissane, B. (1986), 'Selection of Mathematically Talented Students' Educational Studies in Mathematics, Vol.17, pp.221-41.

Leder, G.C. (1980), 'Bright Girls, Mathematics and Fear of Success". Educational Studies in Mathematics, 11, pp.411-22.

Leder, G.C. (1987), "Teacher-student interaction: A Case Study". Educational Studies in Mathematics, 18 pp.255-272.

Leder, G.C. (1988), "Teacher-student interactions: the Mathematics Classroom. Unicorn, 14.2. pp.107-111.

Leder, G.C. (1989), Do Girls Count in Mathematics? in G.C., Leder and S.N. Sampson, (eds), Educating Girls: Practice and Research, Allen and Unwin, Australia, pp.84-97.

Lewis, S. and Davies, A. (1988), GAMAST Professional Development Manual: Gender Equity in Mathematics and Science. A Project of National Significance funded by Commonwealth Schools Commission. Published by CDC, Woden, ACT.

Long, M.J. (1989), "Educating Mathematics Teacher Leaders", in Malone, J. et.al. (1989), The Mathematics Curriculum Towards the Year 2000.

Mahoney, P. (1985), Schools for the Boys?, Hutchinson, London.

Malone, J., Burkhardt, H., Kertel, C. (1989), (eds), The Mathematics Curriculum: Towards the Year 2000. Content, Technology, Teachers, Dynamics. Collected Papers on this theme for the 6th International Congress on Mathematical Education, Budapest, Hungary, 1988. Published by Curtin University, WA.

McDermott, M. (1983), 'The Impact of Classroom Interaction Patterns on Students' Achievement - Related Beliefs and Behaviours'. Paper, presented at the Biennial Meeting of the Society for Research in Child Development. Detroit.

Meece, J.L. and Eccles-Parsons, J. (1982), Sex Differences in Math Achievement: Toward a Model of Academic Choice. Psychological Bulletin, Vol.91, No.2, pp.324-48.

Millman, V. and Weiner, G. (1985), Sex Differentiation in School - is there really a problem? Longmans for the Schools Council.

Moody, C.D., Linn, E., (1986), Fostering Sex Equity in Maths. Michigan University. USA.

Moore, D. and Smith, P. (1980), "Teacher Questions: Frequency and Distribution in a Sample of Papua New Guinea High Schools" Australian Journal of Education, Vol.24, pp.315-17.

Murphy, R.J.L. (1978), Sex Differences in Objective Test Performance. Report of Investigation carried out by the research unit of the Associated Examining Board.

Newhouse, L.P. (1990), Gender Equity :Retrospect and Prospect, with Recommendations for the School of Education, Part 1 and 2. WA College of Advanced Education, Perth.

Part 1 - Sex Differences: Spatial Ability pp.16-18
: Mathematics Ability pp.18-20
: Achievement pp.20-22.

See in particular

Part 2 - Bias in Materials and use of Resources
Classroom Interaction
Learning Styles - implications for Teaching
Strategies and Evaluation
Career Education.

Part 3 - See also Science Education for Girls
Computer Education for Girls
Industrial Arts for Girls.

Owens, L. (1981) 'The Cooperative, competitive and Individualized learning preferences of primary and secondary teachers in Sydney' Paper presented at the Annual Conference of the Australian Association for Research in Education, Adelaide.

Parker, L.H. and Offer, J.A. (1989), In favour of Compulsory Science in G.C. Leder and S.N. Sampson (eds) Educating Girls :Practice and Research. pp.118-127. Allen & Unwin Australia.

Pateman, N.A., (1989), Teaching Mathematics - a Tantalizing Enterprise - on the nature of Mathematics and Mathematics Teaching. Deakin University Press.

Paynter, M. (1986), Gender and Unit Choice in Maths and Science. Kent Street Senior High School, Perth WA.
Perl, T. (1978), Math Equals: Biographies of Women Mathematicians and Related Activities. Addison Wesley.

Peacock, S. & Shinskin (1983), Review of the "Insight Programme" designed to encourage Girls to be Engineers. Engineering Industry Board.

Person to Person : Finding Out
: Starting Points
: Kids Talk
: Video Tape. Booklets and Video tape
Audio Visual Education Branch
Education Department of Western Australia 1986.

Peterson, P. and Fennema, E. (1985), Effective Teaching for Girls and Boys: The Same or Different? in D.C. Berlinger and B.V. Rosenshine (eds), Talks to Teachers, Random House, New York.

Prince, M.H. (1989), 'Mathematics Curriculum Development Through Partnership with Schools', Malone et al (eds) (1989) pp.379-386.

Ramsay, E. (1983), "Language, Politics and Sexism in the Classroom" Education News, March.

Reyes L.H. (1984), Mathematics Classroom Processes. Paper presented at the 5th International Congress on Mathematics Education. Adelaide Australia.

Reynolds, P. (1989), 'Curriculum Towards 2000, A National Curriculum: The Teacher's Friend or Foe in Malone J, et al, (eds), The Mathematics Curriculum for the Year 2000. Curtin University, WA.

Ridgeway, J. Crass M. & Mack, in Burkhardt and Ridgway (1989), The Dynamics of Planned Curriculum Change in Malone et al, (eds), The Mathematics Curriculum for the Year 2000.

Rowe, K.J. (1988) 'Single Sex and Mixed Sex Classes the Effects of Class Type, Student Achievement Confidence and Participation in Mathematics' Australian Journal of Education, Vol.32, No.2, pp.180-202.

Rowe M.B. (1974a) "Wait time and rewards as instrumental variables, their influence on language, logic and fate control : Part one - wait time. Journal of Research in Science Teaching, Vol.11 pp.81-94.

Rowe, M.B. (1974b) 'Relation of Wait time and rewards to the development of language, logic and fate control : Part two - rewards. Journal of Research in Science Teaching. Vol.11, pp.291-308.

Russell, S. (1983), Factors Influencing the Choice of Advanced level Mathematics by Boys and Girls. Centre for Studies in Science Education. University of Leeds.

Schools Council (1983), Reducing Sex Differentiation in School, Newsletter 4, March.

Scott-Hodgetts (1986), Girls and Mathematics : The Negative Implications of Success in Burton L. (1986b) Girls into Maths Can Go. pp.61-76.

Sells, L. (1973), "High School Mathematics as a critical filter in the job market" in Developing Opportunities for Minorities in Graduate Education. Proceedings of the Conference on Minority Graduate Education at the University of California Berkeley May.

Shuard, H. (1986), The Relative Attainments of Girls and Boys in Mathematics in the primary years in Burton 1986b.

Shuller, (1983), Working with Images, Maths Teaching, Vol. 104. pp.38-41, Sept 1983.

Smail, B. (1984), Girl-Friendly Science: Avoiding Sex Bias in the Curriculum. Longmans for the Schools Council.

Smith, M. and Mathew, V. (1984), Your Choice at 13+. Hobbs Press for the Careers Research and Advisory Centre.

Smith, S. (1983), "Single Sex-Setting : A Possible Solution" : The Text of a Lecture given at a Conference in Sheffield, July 1982. cited in Burton (1986a).

Spender, D. (1980), Man-made Language. Routledge and Kegan Paul.

Spender, D. (1982a), Invisible Women: the Schooling Scandal, Writers and Reader.

Spender, D. (1982b), Women's Ideas and What Men have done to them. Ark Paperbacks.

Strassberg-Rosenberg, B. and Donlen, T. (1985), Content influences on sex differences in performance and aptitude tests' Paper presented at the Annual Meeting of National Council for Measurements in Education, Washington USA.

Stamp, P. (1979), 'Girls and Mathematics: Parental Variables, British Journal of Educational Psychology, Vol. 49, pp.39-50.

Steffe, L.P. (1989), Principles of Mathematics Curricula Design - a Constructivist Perspective. University of Georgia USA, cited in Malone, J. et al. (1989), Mathematics Curriculum for the Year 2000. Curtin University, Perth WA.

Swan, M. (Chair) (1985), The Swann Report: Education for all Report of the Committee of Inquiry into the Education of children from Ethnic Minority Groups. HMSO.

Taylor, H. (1986), Experience with a primary school implementing an equal opportunity enquiry in Burton, (1986b).

Thomas, F.H. (1983), An Investigation in the Relative Effects of two Methods of Teaching Geometry Mathematical Education for Teaching. Vol.14, No.2, October pp.19-29.

Thomas, J. (1989), A Professional Model for the Support of Teacher Change". Ministry of Education, Victoria, Australia, cited in Malone, J. et al, (eds) (1989), The Mathematics Curriculum for the Year 2000.

Tobias, S, (1978), Overcoming Math Anxiety, WW Norton & Co. Inc., New York.

Torok, T. (1989), "Computers in the Hungarian Curriculum" in Malone, J. et al, (1989), The Mathematics Curriculum for the Year 2000.

Tobin, K. (1987), "The Role of Wait Time in Higher Cognitive Level Learning". Review of Educational Research, Vol. 57, pp.69-95.

Towns, D. (1985), The Responsibility to Educate Girls for a Technologically Oriented Society. Equal Opportunity Unit. Education Department, Deakin University Press, Victoria.

Vasey, J. (1989), "The Family Mathematics Project (FAMPA) in G.C. Leder and S.N. Sampson. Educating Girls: Practice and Research. pp.98-104. Allen & Unwin, Australia.

Walden, R. & Walkerdine, V. (1982), Girls & Mathematics: The Early Years. London Institute of Education, Bedford Way Papers.

Walden, R. and Walkerdine, V. (1985), Girls and Mathematics from Primary to Secondary Schooling. Institute of Education, London University, Bedford Way. Paper No.24.

Walkerdine, V. (1989), Counting Girls Out. Virago, London.

Ward, R. (1983), 'Waster Potential' TES. 4th Nov.

Ward, R. (1986), 'Girls and Technology' in Burton, (1986b).

Watson, F.R. and Higgo, J.R., (1989), School Mathematics in the Year 2000 - the impact of the Micro-computer in Malone, J. et al, (eds), The Mathematics Curriculum for the Year 2000.

Weiner, G. (1985), Just a Bunch of Girls. O.U. Press.

Willis, S. (1989), Real Girls Don't Do Maths: Gender and the Construction of Privilege, Deakin University Press.

Whyte, J. (1985), Gender, Science & Technology, Inservice Handbook. SCDC. Published in Longman's Resources Unit.

Zaslavsky, C. (1990), Will Technology come first in Mathematics? in Malone, J. et al, 1990. pp.315-318.

SCIENCE EDUCATION FOR GIRLS - Towards a Gender Inclusive Science Curriculum.

Presage:

"When teachers become aware of the complexity required for a curriculum to be an effective agent for educating girls, in the same way as our present curriculum has been designed and redesigned over the last century to be an effective agent in educating boys, a large number of changes immediately become possible" (Foster 1989:38).

Creating an Affirmative Environment for Girls in Science:

School and Community Level:

1. As educators we need to recognize that current curriculum change at best is stage 3, where women are regarded as a disadvantaged, subordinate group. (Schuster and Van Dyne 1984 cited in Foster 1989).

2. Many young women in Australia are still finding it difficult to determine a career path for themselves and experiencing an "uneasy compromise" with regard to family and career choices (Poole and Beswick 1989).

   Much research has been directed towards the relationship between the economy and the unsuitability of the education for girls in science and technological subjects in "tapping their ability" for future careers in these fields. It is now considered as a critical political issue in Australia which must be resolved if our country is to have a productive technological future. (See Part 2 of this report).

   Career education for girls is thus perceived as essential for equity, either as a separate stream or an integral part of the science curriculum. Girls need: science teachers who are warm, positive, empathetic to girls and their life situation to develop high aspirations and goal setting (Butler-Kahle 1985); women as occupational role models to foster science career commitments (Stake 1981; Stake and Granger 1978; Whyte 1986; Butler-Kahle 1985); and assertiveness training to increase levels of confidence and self esteem, which it has been shown enhances career aspirations. (Foster 1989).

   Here in Australia, girls are described "as a largely untapped reservoir of scientific talent" (Button 1987:3).

3. There is a great need to enhance Australian Girls' aspirations, expectations and feelings of self-worth. To this end, there has been a focus on effecting conscious structural changes in school communities around Australia. Valuable action research is happening in Tasmania, with its cooperative school clusters (Fitzgibbon 1989); rural high schools in Queensland, purposefully enhancing girls' expectations (Martinez et al 1989) and through empowerment of school communities in the "living curricula" of Primary schools in Victoria (Evans 1989).

All these projects are tackling the problem holistically at the "whole school", "inter school" and "wider community" level, where gender equity policies and programmes are implemented within an ethos of mutual support, professional and personal net-working; and where evaluative research findings are disseminated to encourage and edify other parts of the country in the vital need for change in the education of girls generally. Such "whole school" policies and programmes are essential, if changes are to be effective at the science curricula level.

4. In Australia, it is increasingly evident from the research that we can neither ethically ignore the issue of gender nor fail to take positive action where the education of all young people is concerned. At the surface level, it is possible for educators to look closely at the many facets of both the formal and hidden curriculum and to be actively involved in making provisions more gender inclusive; to reduce harmful effects of sex role stereotyping; and to create images that show women and girls in a more positive light. (See Part 2 of this report).

5. At a much deeper level, gender concerns have also raised the issue of 'Knowledge and Control'. A relationship so expertly analysed in the 1970's by Bourdieu (1967) and Young (1971) particularly with regard to prestigious knowledge being available only to the elite in any society, hence maintaining the status quo in social class differentiation.

It is urgent in the 1990's to address the same dilemma in relation to gender. Historically and in contemporary times, girls and women have been and are excluded because of the pervasive 'masculine' nature of prestigious disciplines, such as Physical Science, Mathematics and technological subjects.

This has very much limited the access, even the desirability of girls and women to gain access, to elite "masculine" knowledge.

> "Science is power, so science is masculine" (Wallsgrove 1980).

Over the past twenty-two years, women have questioned the belief that science is "neutral, objective and value-free" (Bleier 1986:4). Women are now bringing a "feminine" balance into the nature of scientific knowledge itself, with its caring, people oriented, philosophy, morality and ideology and a concern for the creative, positive use of science for humankind and the care of the world environment. (Mares 1989:103-109; Thompson 1987b; Cross 1989).

6. Evidence from a Western Australian EOC (1989) report on State School teachers' attitudes towards "specifically catering for the special educational needs of girls" found 47% of females and 55% of males responded in the negative, with unsolicited comments ranging from highly negative to a lack of awareness of a problem.

Professional development is therefore essential as a "parallel curriculum" for teachers, administrators, parents and community members, if changes in the curriculum, especially in the 'masculine' disciplines, are to be perceived as valid and for the benefit of all who have been marginalized because of gender, race, ethnicity and social class. (Hildebrand 1989:14-15).

7. Much research has been generated in the area of "Gender Bias in written resources used in school and society". Interaction between men and women; and teachers, boys and girls in the classroom; and preferred learning styles of girls as it affects the gaining of knowledge, skills, problem solving, creativity and assessment in all subject areas. (See Part 2 of this report).

8. There is a need to look closely at the historical perspective of equality of opportunity and to regard this phase of our curriculum development in Australian Schools as a crucial "redefinition of the situation" in moving toward equity for all children and young people by taking full account of gender, race, ethnicity and social class for the 1990's and into the 21st century.

9. At the Systemic Level, there are initiatives to implement the Australian Science Teachers Association Policy for Girls and Women in Science Education (1987).

10. Networks of Innovators need to be supported by Ministries of Education (eg. McClintock Collective & Victorian Ministry of Education).

11. Systems can help in upgrading of qualifications in physical science, especially for women (Hildebrand 1989:15).

12. Resources for innovation in Gender Equity such as videos, posters, booklets can be produced and funded centrally. So too speakers specializing in the area. (eg. Ministry of Education, Perth).

13. The Invaluable Role of CSIRO in achieving the ASTA's recommendations in the Policy on Girls and Women in Science Education (1987).

- presenting science and technology as an activity appropriate for both females and males
- providing information and support material on women in science
- providing time release for women to act as role models at schools
- providing female students with work experience
- establishing a network of EEO contact officers across the organization to support women in the work force and,
- through CSIRO's EEO officer investigating, evaluating and reporting on the Organization's policies and practices towards women. (Kingsland 1989:48).

SITUATIONAL ANALYSIS

Science & Technology in Australia and the Need for Human Resources: Societal need at two levels (equally valuable)

(a) The Societal Need for Women in Non-traditional trades:

Troy (1990:16) stated that the number of women in non-traditional trades had trebled in the past five years - but women in this category represent only 3.1% of WA apprentices. Of 14,148 in WA, only 445 are women in trades other than hairdressing.

(b) The Societal Need for Scientists, Mathematics and Technologists of Calibre is expressed in the following statement:

"In a period of unprecedentedly rapid technological change Australia has a great deal of catching up to do. We are starting from a long way behind. Physics, Chemistry and Mathematics especially in application will be essential elements for a more technologically competent, independent and expert oriented Australia ..." (Barry Jones, Minister for Science 10 March 1987).

At the higher education level, the Commonwealth had already given priority, in the allocation of new student places in Universities and Colleges, to science and technology (Senator Susan Ryan, Minister for Education, News release 10 November 1986).

Yet by 1989, universities were still unable to attract young people to this area, particularly young women ... judging by this appeal in a university prospectus.

"... the physical sciences, mathematics and computing courses have not yet utilized the available intellectual capacity of many females who are potentially excellent scientists and mathematicians. We encourage young women seriously to consider the career opportunities in these areas". (Curtin University Prospectus 1989:2).

Cross cultural studies by Ware and Lee (1988:594) and Ethington and Wolfle (1988) show similar concerns.

"The demand for qualified scientists and engineers will not abate, and in fact may increase as we move into the 1990's and the 21st century. Clearly one way of ensuring that future needs for scientific talent will be met is to find ways of encouraging more young women to choose college majors and subsequent careers in the sciences". Ware and Lee (1988:594)

Observations by Whyte (1986) in her appraisal of the GIST project and the life chances of women are as pertinent to Australia in the 1990's as they were in UK in the early 1980's.

1. She focuses on the wider issue of masculine power and dominance in the field of science and technology and its effect on maintaining the status quo. "The virtual exclusion of the female sex from the most powerful sources of social, economic and technological change has profound implications for the power and position of women in general". (Whyte 1986:16).

2. Whyte alerts us to:
"The 'gender spectrum' of school subjects arts, languages, home economics subjects for girls, mathematics, physics and technical subjects for boys" - which not only reflects labour market decisions but reconstructs them "fitting boys and girls into their corresponding positions in the male or female labour market" Whyte (1986).

3. Whyte (1986) alludes to one of the crucial determinants of sex segregation in the labour market which is the "different qualifications with which girls and boys leave school, and, in particular, girls lack of technical and scientific qualifications, this deprives women of the means to enter a large range of occupations and confines them to the lowest paid and least secure jobs and sections in the economy".

4. Whyte used statistics gathered from the DES Survey (1973) to show that only 71% of girls compared to 90% of boys were offered the chance to take physics in fourth and fifth years (lower school). But the sex differences in choosing the subject were much greater only 17% of girls who were offered the choice took physics compared with 52% of the boys. The same pattern, in a milder form showed up in Chemistry and the reverse was true in biology, the "girls' science".

   Clearly "the entry of women into scientific and technological careers is blocked by girls' avoidance of options in physical science and technology at secondary school" (See DES Education Survey 21).

Sharma and Meighan (1980) and Towns (1985) in analysing female life chances in UK and Australia demonstrated that occupations and careers are effectively reduced to six main possibilities namely teaching (primary) nursing, catering, office work, retail employment and hairdressing.

<u>The Scene in Western Australia, with regard to Mathematics, Science and Technology subjects taken by girls and their subsequent achievements in the TEE examinations</u> (1985-1989).

<u>Mathematics</u> - "a critical filter" for careers in science and technology (Sells 1982).

	Maths I		**Maths II**		**Maths III**		**Maths IV**	
	Male	Female	Male	Female	Male	Female	M/F	
1989	4076	4032	1321	593	1308	587	-	-
1988	3820	3815	1430	550	1418	549	-	-
1987	3413	3430	1354	580	1350	576	-	-
1986	2959	3199	1317	531	1316	532	16	30
1985	2681	2792	1402	624	1399	626	1109	1578

(TAE & TEE (1985-89)

The analysis of candidates by sex indicates that the majority of girls studying mathematics were pursuing a middle status Mathematics I course. Fewer girls than boys were studying Mathematics II and III, which are prerequisites for prestigious university studies, including Engineering.

Computer Studies - knowledge and skills required for the 21st century.

	Male	Female
1989	314	143
1988	187	108

(TAE & TEE 1988-89)

Twice as many boys as girls were involved in Computer Studies at a higher level in 1989. Computer literacy is essential for the 21st century.

Accounting & Economics

Statistics indicate girls' involvement in these areas has increased over the past 5 years and are increasingly popular pursuits.

	Accounting		**Economics**	
	Male	Female	Male	Female
1989	1621	1739	2520	1896
1988	1566	1671	2383	1754
1987	1427	1419	2138	1589
1986	1308	1299	1876	1359
1985	1733	1364	1949	1415

Physics

There are still many more boys than girls pursuing Physics in upper school. Giving some indication of the perceived "masculine" nature of the subject by girls.

	Male	Female
1989	2360	996
1988	2391	932
1987	2210	891
1986	2181	878
1985	2345	1067

Chemistry

The trend in Chemistry, is similar to Physics though "milder" and less extreme. Boys still dominate the area.

	Male	Female
1989	2196	1493
1988	2243	1458
1987	2067	1304
1986	1995	1172
1985	2193	1399

Physical Science and Geology

Neither subject has much appeal for boys and girls though there is still a greater representation of boys than girls

	Physical Science		Geology	
	Male	Female	Male	Female
1989	441	318	116	21
1988	439	322	86	34
1987	486	357	78	13
1986	453	347	104	11
1985	435	336	147	15

Biology and Human Biology

Only in Biology and especially Human Biology did the girls exceed the numbers of boys, though the latter too were well represented. This is traditionally regarded as a "feminine" science.

	Biology		Human Biology	
	Male	Female	Male	Female
1989	1266	1577	1587	4302
1988	1441	1547	1674	4441
1987	1508	1736	1387	3824
1986	1544	1757	1292	3655
1985	1818	2460	1248	3249

Post Script: It is very important to have statistics of this type available, especially to find out where the interests of girls and boys lie and to monitor trends accordingly. Of particular interest, is the fact that Home Economics, formerly a TAE subject, is no longer regarded as a possible pre-requisite for Tertiary study. In 1985, 770 girls and 24 boys were pursuing this subject at TAE level.

It is an integrated subject area, with a predominantly feminine philosophy and encompasses mathematics, the sciences, the arts, sociology, developmental psychology, a belief in aesthetic beauty, the use of computer skills and skills required for homemaking and traditional feminine pursuits. Its value as a valid pursuit of excellence needs to be considered in the light of a more balanced philosophy for humankind (Sher 1989 cited in Littleford 1989:280; Thompson 1987; Willis in GEN September 1990).

NEEDS ASSESSMENT

The Quality of Girls' achievement in Mathematics and Science

The research of Parker (1986) showed that in Western Australia between 1976 and 1983 girls were achieving well over a wide range of subjects in lower school including Mathematics.

In Mathematics II and III in which girls were outnumbered, there was no significant difference in the quality of the maths results. In Maths I, the middle range course, girls earned significantly better results and in Mathematics IV there had been no significant difference between girls and boys in the quality of results. This qualitative evaluation showed that girls' high achievement was sustainable at Upper School level in all subjects, except Physics.

In 1987, Parker and Offer (in Leder and Sampson 1989:120) analysed the achievement of Year 10 girls, in Western Australia, in the four core areas of English, Mathematics, Social Studies and Science and found over the period 1972-1986 girls' achievement relative to the boys increased noticeably in all four areas. (Figures 10.1 - 10.4 in Leder and Sampson 1989:121-124). Of most interest was the increasingly high achievement of girls in science. This trend was significant, as studies in other comparable countries, consistently identified boys as the high achievers.

In Western Australia the girls and boys were exposed to the same amount of science (instructional time) and the same kind of science (content), other studies (Fennema and Sherman 1987) perceived superiority in boys' results due to their doing "more science" and "different science".

Parker and Offer (1987a) contended that if qualitative and quantitative differences were removed, as in the old Achievement Certificate, sex differences in science achievement disappeared. Under the current lower school curriculum structure in Western Australia, science is not compulsory "which is not conducive to universal scientific and technological literacy" (Parker and Offer 1989:125).

At upper school level, it is suggested that 20% of students choose to do no science, the majority of whom are female. The academic upper school science curricula is not catering for the wide range of needs, aspirations and abilities of those who do participate at this level. Secondly, there is a polarization, due to the subject centred structuring of the content, where girls pursue biological sciences and boys gravitate towards the physical sciences. (Parker and Offer 1987 Figure 10.5).

Thus, Parker and Offer (1989:126) conclude "if girls and boys continue with science, each sex in reality is acquainted with only half the scientific world". They suggest that upper school secondary science should be reorganized to make the study of a multi-disciplinary gender inclusive science curriculum compulsory for all students for one-sixth of the total study programme.

This proposal of Parker and Offer (1989) has significance for all girls whether they are planning continuing education in the tertiary sector, TAFE or in trades and apprenticeships. It would ensure literacy in science and technology, widen career options and validate a gender-inclusive science curriculum for entrance to tertiary and TAFE institutions.

A valuable line of quantitative research by de Laeter, Malone and Dekkers (1989:23) also highlights the need to restructure the upper school science curriculum because of the rapidly increasing female retention rate. In their opinion many girls find traditional single discipline science, especially physics and chemistry, "beyond their capabilities" which may block out their future life chances.

de Laeter et al (1989) evaluated the popularity of various alternative upper school science programmes currently operating in Australia and make proposals very much in line with Parker and Offer (1989:127). Involvement in such courses would hopefully encourage talented young people to pursue careers that will help the country stage an economic recovery based on technological developments (de Laeter et al (1989:25).

Qualitative and Quantitative Research into the Participation and Achievement of women at the Tertiary Level

In 1988, just over half the students in higher education were women and the number of tertiary students has doubled over the past 15 years. What is causing concern is that the number of physics graduates has remained constant and the number of chemistry students has only risen by 34% from 1968-1988 (Stern 1989).

Females are opting to study chemistry in increasing numbers (de Laeter 1989:29) and it is perhaps significant that up to 35% of students now enrolling in Chemical Engineering are females (de Laeter 1989:32; Newhouse C.K. 1989:91) and 10% of new starters in engineering over all.

Female engineers now earn more than their proportionate share of prizes and scholarships and they are presently getting more job offers. Newhouse lists some of the key characteristics for potential engineers, which encompass masculine and feminine attributes:

- interested and capable in mathematics and science
- enjoy logical reasoning and systematic argument
- have a practical bent
- show imagination and curiosity
- appreciate aesthetic beauty
- like to work in a team, and,
- want to contribute to society. (Newhouse 1989:91)

As science curriculum developers, we would do well to focus our attention on the "product" required for the 1990's and 21st century for our technological world. The outcome would be a transformation of the science, mathematics and technological curricula in schools to meet the needs of both society and all the individuals who pursue the topics.

The Needs of Girls - transforming IMAGES of Science and Scientists

A transformation of the curriculum would require creating positive images of science and scientists in the physical sciences especially.

Head and Carre (1974) were part of the significant UK science teachers education project of the 1970's. Their book called Through the Eyes of the Pupil encapsulates their image of science, its methodology; the difficulties of girls doing pure science; their attitudes that "physics was beyond their reach"; the increasing interest of some girls in chemistry triggered by its application to problems in the modern world.

All the formal definitions of a scientist were from boys, one in particular has significance for its gender inclusiveness

> "a scientist, is a man or lady, who has brains, but most important of all that person has to have imagination" (boy 13) (Head & Carre 1974:67).

Girls find science more difficult to study than the arts and social science. They do not find the present structure of the pure physical sciences intrinsically motivating, interesting, relevant to their needs or enjoyable.

The "masculine" image of science is also deeply marginalizing for girls. (Head and Carre 1974; Sleet and Stern 1980; Shannon, Sleet and Stern 1982; Kelly 1985; Cross 1989;)

Female scientists themselves hold deeply depressing images of themselves in the "laboratory" setting. Standish (1982:13) identifies five ways in which women currently have careers in science by:

- becoming an invaluable support worker
- being a "super male" or "surrogate male"
- marrying one's mentor
- working in animate rather than inanimate science
- forming a collective support group.

She describes the difficulties facing women in one of the most male-dominated of human enterprises.

She claims that "Reductionist, individualized science creates an environment poorly structured to meet their (females') intellectual and emotional needs" (Standish 1982:14).

Cross (1989) warns science teachers in consequence of this that "the next and future generations of scientists, technologists and engineers will largely be the products of science education in our primary and secondary schools" ... he continues "we can no longer pretend that what we teach and the way we teach does not carry ideological messages".

... "as science teachers we are extremely influential and perhaps in powerful positions to encourage change ..."

... "it is the ideology of science itself that we must begin to challenge". (Cross 1989:42).

<u>Conclusions from qualitative and quantitative Research (1985-1989) with regard to Upper School Science in the Future and Meeting the needs of all students</u>

A. <u>The Changing Pattern of Science enrolments as indicators for change in Upper School Science</u>

According to de Laeter et al (1989:31-33), selection of subjects for upper school study is influenced by the interplay of four major factors especially for girls:

(1) Increase in the number of school science units where too much choice may be deleterious to girls' career choices; entry to certain tertiary studies or chances of apprenticeship (Parker and Offer 1989:118)

(2) Relative difficulty of Pure Science and its perceived and real masculine nature (Kelly 1985; Pike 1989:80)

(3) Interest and enjoyment of Science. For females biology is most interesting. Physics and Chemistry need drastic revisions in all aspects of their curricula to intrigue girls towards further study. (Leggett 1989:76)

(4) Career relevance of a Science unit (Sleet and Stern 1980 cited in de Laeter et al 1989; Leggett 1989:76; Stocklmayer 1989:77).

B. Other variables of significance which influence wise selection of Upper School Study and future careers in science and technology:

(1) Rejection of misguided views of the differential science achievement in lower school science of boys and girls given that there are no qualitative or quantitative differences in their science education (Young and Fraser 1989:105-109; Parker & Offer 1989:120-125).

(2) Peer group pressures in Year 10 may need countering, especially for girls wishing to pursue traditional "male" subjects such as science, mathematics and technology. (de Laeter et al 1989:32).

(3) Advise of teachers and counsellors is of paramount importance to girls to counter cultural gendered expectations and invidious sex role stereotyping of adult roles and career options. Inservicing to raise awareness of issues concerning participation and achievement of girls in science and mathematics is essential (Lewis and Davies 1988 (GAMAST); Lendon 1989:78 (GEMS); Bates 1989:81 (GES); Mullins-Gunst & Simonelli 1989:81; Baker 1989:99).

(4) Academic relevance and difficulty of upper school subjects need careful monitoring and adaptation to curriculum materials and processes is vital to balance masculine/feminine perspectives especially in science and technology (Beruldsen 1989:56; Villiers 1989:61; Peck & Dick 1989:65; James 1989:72; McClintock Collective 1989:72; Rennie 1989:74.

(5) Changing nature of Year 12 population (numbers) and dramatic shift in numbers of females leading to wide range of academic ability and interests, will be a real challenge for designing appropriate curricula for the 1990's particularly in science and technology (de Laeter et al 1989:32) to help the nation's "literacy in science and technology" (Parker and Offer 1989).

(6) Female retention has been fostered in 1989 by:

(a) The feminist movement world-wide (1968-1989) which has helped females to realize occupational and career horizons can be widened and has, as a consequence, created more female role models in non-traditional careers.

(b) Affirmative action programmes have led girls to take up Science careers and in the field of engineering and technology. (Kingsland 1989:45; Dangerfield 1989:50; Newhouse 1989:90).

(c) Better conditions for females to study science are evident particularly in Victoria and Western Australia (Deekers and de Laeter 1985; McClintock Collective 1989:128; Hildebrand 1989:7).

(d) The added encouragement of government agencies; CSIRO (Kingsland 1989:45) tertiary institutions (Fraser 1989:86-87); and professions and professionals (Newhouse 1989:91).

(e) A growing belief that girls and women are important to science (Parker & Offer (1989); Cross (1989).

C. Significant for Science and Technology in Australia - Is Girls' Tertiary Level Selection

(1) Females opting to study chemistry in increasing numbers and up to one third enrolling in Chemical Engineering are females (de Laeter et al 1989).

(2) Need for more females to enrol in engineering and science courses. There is a dearth of able people. Many of these people are opting for commerce, economics, business studies, medicine and law.

(3) The particular needs, aspirations and interests of females must be catered for by alternative science units in schools in all states (de Laeter 1989:32)

(4) Positive support for women in traditional male areas is vital (Meikle 1989:87).

D. Need for Good Role Models to Assist Females Pursuing Science and Technological Careers

(1) Encouraging talented females to take up pure science teaching, would act as excellent role models for adolescent girls. (Stake and Granger 1978; Butler Kahle 1985; Whyte 1986; de Laeter et al 1989)

(2) Make female scientists and engineers visible in magazines, journals and participating in school programmes. (McPherson 1989:117; Parker (Ed) 1989:113; Apelt 1989:98; Kingsland 1989:45; Pike 1989:80; Lynam 1989:82).

(3) Curricula with an Australian flavour, to include contribution to science by Australian women and Aboriginals (Payget 1989:95; Burfitt 1988:31-37; Bindon 1988:16-21).

E. Curriculum Development at all Levels of Education

(1) Leadership role of universities, industry and commerce is evident in parts of UK, America and Australia where they work closely with primary and secondary educators. This has led to joint development of curricula, including resource materials in schools. (See ASTJ Aug 1989; Groves 1989:85).

(2) Dominant position now occupied by females at Year 12 provides an unparalleled opportunity to harness their interest in science, both as part of our culture and as a career goal in the future. (Parker and Offer 1989:113; Lendon 1989:78; Groves 1989:85).

(3) Need for a national curriculum to consider the changing nature of the upper school population by involving education, industry, professional associations, State and Federal Governments, including women (de Laeter et al 1989).

(4) Evaluation of the "State of the Art", nationally and States to monitor both qualitatively and quantitatively through yearly reports and modifications to numbers in data banks. (Commonwealth of Australia 1988).

Male Hierarchies in the Structure and Organization of the School and in Science Departments - barriers to change in schools.

Friere believed education ... is "always either a tool for oppression or liberation" (cited in Henry et al 1989:274).

"Females found that they were consistently at odds with and mis-recognized by the "official" value system of school and its curriculum ... disadvantaged by a school system where processes and curriculum consistently operated to penalize them" (Henry et al 1989).

It is evident that gender equity can not be accomplished without a significant change in the structure of male/female dominance relations as well as schooling itself.

Spender commented in 1982,
"Females are significantly under represented in the senior positions of schools, and this affects the boys and girls attitudes to the capabilities of females" - This issue was taken up again in 1985.

"Measures should be taken to feminize school hierarchies to ensure women participate fully with men in decision making aspects in schools "Girls and Tomorrow" (1985:10).

This is in reality difficult to accomplish. Sampson (1986, 1987) suggests that a complex system of practices in Australian schools produces long term inequalities in hierarchical positions in schools, highlighted by her 1984 research into aspirations for promotion within schools in all states thus creating a "Catch 22" situation for women teachers. Clarricoates (1980) had earlier pointed out that:

"Teachers operate within gender expectations not only in their personal and familial roles, but in their professional capacity too ... they, for example, reinforce sex role stereotyping by expecting and tolerating different standards of behaviour from boys or girls".

Delamont (1980) emphasised the need for action research on attitude change on the grounds that only teachers committed to changing sex role relationships in schools are likely to be able to shift pupils' attitudes and then only if they are skilful in their approach.

The GIST action research framework allowed some new analysis of the barriers to change in schools (Whyte 1986). The GIST action research generated a "problem solving attitude to change which in the long run could liberate both teachers and pupils from the shackles of conventional thinking". (Kelly in Whyte 1986:270).

Evans (1989) believes that "it is imperative for us to reflect critically on the parts we all play in the 'living curricula' of school communities "not only should principals, heads of departments, teachers and parents do this, but "we should encourage our children to be critical both of the gender structures that surround them and of the gender relations they are constructing for themselves".

Whyte (1986) emphasized two essentials in effecting gender equity in science and technology.

"If the ethos of the school broadly supports social change, it is easier for teachers to work with a (gender equity) project" in science and technology, and "within a department, change was more likely if a group of teachers worked together to promote the aims of a (gender equity) project" under the leadership of a hardworking sympathetic head of science. Whyte (1986:227).

Heads of Science Departments need to look closely at organizational practices and consider the following issues and traditional practices (Hildebrand 1989:14-15)

- the maintenance of science as a compulsory component of the curriculum until beyond the school leaving age. (Parker & Offer 1989; Klainin 1989. (See also Current Issues in Science Section - In Favour of Compulsory Science pp117-118)
- the removal of gender stereotyping of time table options (eg Physics with Literature)
- setting up of single sex classes for some aspects of science (eg Physics)
- "Where the critical mass of girls was "higher than 15%-30% girls were perceived as able to achieve and the subject was seen as "gender neutral".
- The minimisation of pre-requisites; which act as "critical" filters and barriers and provision of alternative pathways in upper school courses.
- the allocation of staff to classes in a non traditional way. eg. Year 12 Physics taught by a woman, junior science by a man.

- Assistance with upgrading of qualifications for upper school physical sciences.

Causal Factors in Girls' Underachievement in Science - Dispelling the Myths

A book edited by Kelly (1981) has already become an indispensable classic for those who wish to understand the range of explanations for sex differences in science achievement.

1. Spatial and Mechanical Ability of Girls

   The GIST action research in UK has strongly indicated (Smail 1983; Whyte 1986:105-118) that demonstrated sex differences in spatial competence are unlikely to be innate but have an acquired component. "As this is the main plank of the genetic deficit argument, it is thereby considerably weakened" (Whyte 1986:260).

   They demonstrated that spatial/mechanical ability may be altered as a result of concrete experiences which the school could conceivably offer as part of their intervention strategies:

   "The marked improvement in girls' scores is strongly suggestive that the group of skills associated with spatial ability may be acquired, at least in part, through first hand practical experience of appropriate activities such as those offered in a craft, design and technology course" (Smail 1983 cited in Whyte 1986:109).

2. Early socialization

   Whyte (1986) showed girls had participated more in biological activities and boys were more likely to be involved in physical science, inventions, science magazines, talking and scientific discoveries (the latter rather uncommon in both sexes). The largest sex difference was in "Tinkering" activities for which Whyte advocated compensatory play sessions (Whyte 1986 Chapter 8).

3. Prevailing Social Norms, Attitudes

   As determinants of girls' beliefs, opinions and choices concerning science and sex roles.

   Kelly et al (1982) found parents' aspirations for their children in school were "remarkably egalitarian" but that there were strong divisions along sex lines outside school.

   Research into effects of mothers' attitudes upon daughters has shown that mothers who work outside the home are more likely to have daughters in active careers particularly in non-traditional fields (Harvey and Klein 1989; Hoffman 1974 cited in Whyte 1986:19).

4. Teacher and Parental Expectations and Science - Comparative Research Findings - UK

   Whyte (1986:106) believes we "intuitively accept" an intellectual difference between the sexes.

"The problem (then) is neither that girls cannot do science, nor that they do not want to, but that they are covertly discouraged by all those around them" (Whyte 1986:260; Curran 1980 cited in Whyte 1986).

"Physics teachers working in GIST schools were especially prone to remark that girls 'just can't do maths' and so are unsuitable material for 'O' and 'A' level Physics".

When the effects of additional opportunities of boys for experiencing Mathematics are allowed for (such as Physics and technical drawing) the sex difference, according to Sharma and Meighan (1980) largely disappears.

Togo

Biraimah K C (1980) examined a government secondary school in Lome, Togo and obtained a clearer understanding of the school's ability to affect female role expectations. She focussed on students' internalization of teacher attitudes, classroom interaction messages, implicit school authority structures and the girls' stated educational and career expectations.

USA

Morse and Handley (1982) in their early research into self concept and perceptions of gender role identities as pivotal variables which either constrained or supported early adolescent's interests and achievement in science, identified the influences of significant others (parent, teacher, peers) as antecedents positively and negatively depending on their support.

USSR

Comparative studies, for example by Walford (1983), highlighted similar concern in USSR for sex differences in enrolment, text book bias, classroom interaction, jobs (both type and pay) by considering family, society and factors stemming from the educational organization/process.

5. Pupil Attitudes 11-14 years

Whyte (1986:20). At 11, girls seem to enjoy school more and just as many gave science as their favourite subject.

6. "Self-Confidence" Differential

Despite the fact that at 11 years, girls are doing better than boys in school, more boys than girls claimed to be "above average". Whyte (1986:20).

7. Masculine Image of Science and the Double Conformity bind for Girls

"Perhaps the greatest discouragement is the masculine image of science and technology, in the sense that masculine characteristics are supposed to be desirable for success in the areas and the vast majority of existing scientists and technologists seem to be men" Whyte (1986:20).

"For adolescent girls, in the process of defining their femininity the image of the scientist is in conflict with society's ideal of womanhood" (Whyte 1986:20).

8. Boys' Stereotyped Attitudes Concerning Science and Sex Roles and its Effects on Girls

In the GIST project three questionnaires explored children's opinions of science and sex roles. "The most important finding was that boys are more traditionally minded and more stereotyped than girls about both". Whyte (1986:110).

These results indicate the importance of dealing with boys' stereotyped attitudes towards science and sex roles and anticipating the likely effects of their prejudices on girls' attitudes and choices. Boys perceived science as a 'male domain', thus "learning science is more important for boys than girls" and girls who want to be scientists are a "bit peculiar".

Kelly and Smail (1983) declare that a sex neutral attitude would perceive science as "open, beneficial and pleasurable". Girls are more aware of the social benefits of science, they think scientists care for people and money given to Science is well spent. However they perceived science as "a very difficult subject"; "only for brainy people" and "did not expect to be good at it".

9. Girls' Choice of Physical Science in Upper School

According to Whyte (1986) these would be girls who had been involved in physical science and technical crafts; had high cognitive ability and who were least stereotyped in both home and school experiences. Girls who opted to continue in Physical Science performed on average slightly better than boys. "There is a confidence barrier for girls and only the more able persist in physical science" (Whyte 1986:215).

Conclusion

Cultural gender expectations of any society are incorporated into the personalities of parents, teachers, administrators and pupils alike. The science laboratory is a "microcosm of society" with an ingrained masculine bias. It is therefore imperative that we change the nature of science; the environment; and the invidious stereotyping that excludes and marginalizes women and girls from science in the home, at school and in the work force.

THE EFFECTS OF AN INTERVENTION PROGRAMME IN MAKING SCIENCE MORE "GIRL FRIENDLY" - GIST (1979-1984)

Preamble:

I have included this section which is devoted to the GIST action research programme, because I believe it contains all the elements discussed theoretically over the years with regard to science education for girls. It has shown how dedicated tertiary consultants and teachers can work together to effect change in science education that is gender inclusive and which also began to change the "nature of science" itself in schools. Many of these findings have been adopted or affirmed by Australian

educators and there is ample evidence of this in the Australian Science Teachers Journal August 1989.

The great enthusiasm (or lesser negativism) of the "action children", both girls and boys, towards science suggests that girls will want to do science if they are not turned off by the subject's presentation as irrelevant and unduly "masculine" (Whyte 1986:260).

"The GIST experience generated many ideas about making science more "girl friendly: and as Whyte (1986:90) says "this has possibly been the project's most important outcome".

General Findings:

1. Social Application and Usefulness of Science:

   Girls are more interested and motivated to study science if they learn something of its useful and beneficial social applications (Ormerod 1971, 1973).

   Smail (1984) showed how this could be achieved in the normal school science curriculum and produced a source book from her practical experience in the GIST project.

2. The Importance of Professional Development of Teachers in Detecting Gender Bias and Understanding the Nature of Science:

   In the GIST project (1979-84), the science text-books and work-sheets were examined for sex bias in the teacher workshops:

   (a) far more pictures of boys and men
   (b) content clearly aimed at boys
   (c) where women appeared - stereotyped roles
   showed this to be "the most elementary facet of the masculine image of science"
   (d) "Science materials often written as if the value of understanding science is already taken for granted" - too few links with social, technological and human applications of science.
   Social implications need to be presented integrally with the body of science knowledge to meet girls' "wider social and humanitarian concerns".

3. The Need to Link Science with Career Benefits and Intrinsic Interests of all Students:

   Science may not be perfect for boys and many may take science as an "expected option with clear career related benefits". (Whyte 1986:91) Teachers may need to take account of students' other interests to make science more enjoyable.

4. The Process of Science Teaching and Learning is also Discouraging to Girls - because it ignores preferred learning styles:

   Galton (1981) in his study of science teachers found that their preferred teaching styles were "inadvertently antagonistic to girls' full participation in the learning process". (Whyte 1986:91).

Whyte (1986:91) showed, through careful observation, how social interactions in labs and workshops "edge girls out of science" (Whyte 1986:25-38).

5. Making Science more "girl-friendly" in the Classroom:

(a) the materials and examples used by the teacher build on girls' as much as boys' interests (Whyte 1986:92).

(b) the teaching approach stresses the social and human applications of science in everyday life.

(c) girls are constantly and actively involved in first hand practical experience which will help them to a concrete understanding of scientific processes, and the teacher's management of the classroom ensures girls participate at least as much as the boys.

(d) Science is for girls too - children know, because they have been explicitly told that science is a subject for girls, at least as much as boys; are expected to do well, and the atmosphere of the school is supportive to girls' choice of physical science.

6. Modifying the Context, Content and Methodology to make Physical Science more Acceptable to Girls:

"Girl friendly science builds on girls' known interests, so that half of the class is not automatically excluded by implication" (Whyte (1986:93).

(a) Whyte (1986:93) found that both sexes at 11 years were extremely interested in the human body and how it worked. She and colleagues also collected data on "demotivating" topics for boys and girls and determined how human biology could be used as a motivating starter for Physical sciences.

(b) "Our innovation was to put application first before any theory ... whenever relevance to home life could be spelled out, girls' interest was captured (Smail 1984:36).

(c) Involving Community role models - there was the tremendous value of incorporating in GIST, the VISTA intervention where women in Science and technology presented their work to boys and girls in schools.

VISTA women successfully incorporated Smail's techniques to present science and its application to their occupations in a "girl-friendly" way, that was not antagonistic to boys. (Smail 1984:93-97).

7. Relating Science to Everyday Life:

Butler-Kahle (1983) in her American study of science teachers who were very successful in encouraging girls to do science, identified a common feature of their ability to relate science to every day life. These teachers were also highly competent and experienced and good science teachers in the "general sense".

8. <u>Socio-Political Issues</u> such as the impact of science on the environment seemed to be of especial interest to girls. Smail (1984:96) believed it was a reflection of their "initial pre-disposition to be people-oriented rather than "thing-oriented" and "evidence of their greater maturing and social responsibility" in early adolescence than boys.

   Smail (1984) exploited this interest by helping staff in one school to redraft an existing unit on 'Science and the Environment' (Whyte 1986:96).

9. <u>Hands on Experience - "Science by doing"</u>

   Girl-friendly science "should provide visual or physical, but especially first hand experiences which will help children understand scientific processes, with girls participating at least as much as boys". (Whyte 1986:97)

   The VISTA women in the GIST project (1979-84) took in some visual demonstration of their work and the handling of physical objects created enjoyable and productive sessions especially, in 1981, with 11 or 12 year olds. (Whyte 1986 97-99).

10. <u>The Need for documentation and Feedback on Findings in the Context of "action research"</u>

   For example:

   (a) GIST observers, teachers and VISTA women commented on "the way boys' reactions dominated the visits" and gave them a heightened awareness of the girls' comparative invisibility and reticence.

   (b) Experiencing the satisfaction and enjoyment of science at first-hand and the chance to get involved in experimental work was evident in both boys and girls.

   This evidence then affirms earlier research findings. Bulter-Kahle (1983) pointed to the dramatic superiority of "successful" teachers in their getting girls to use science materials".

   (c) The HMI Report <u>Girls and Science</u> (1980:16) drew attention to the "high value girls placed on practical work" and its correlation to high levels of interest and later positive attitudes to lab work.

11. <u>The Need for Direct Encouragement</u>

   Bone (1983) reported that girls' choice of sciences in all girls' grammar schools in UK was a consequence of a school ethos which positively valued female scientific achievement plus an encouraging laboratory environment in which girls could then thrive.

Encouragement is correlated to teachers' attitudes and beliefs and the atmosphere created in the laboratory. Whyte (1986:100) found that:

"Girls need more than implicit encouragement if they are to choose to continue with science".

12. What do we change in the boys' behaviour in the laboratory? : a delicate task for the teacher

Boys "edge girls out". Whyte (1986:26-30), after four years of visiting the eight (8) GIST Schools, revealed several themes of gender differentiation namely:

a the sexes constantly divide and are divided at school
b boys dominate classroom discussion
c boys insist on more teacher attention
d boys and teachers "masculinize" the lesson content in science and crafts
e boys "hog" resources
f girls "fetch and carry" for boys

a. The conformity of girls divides and limits their quality interaction with the Science Teacher

"Girls' greater conscientiousness in presenting neat and accurate work is generally noticed, but teachers are less aware that girls are also conscientious in their adherence to unwritten rules of classroom organization: queueing politely in line, waiting till the teacher sees her hand up. The boisterous demanding boys seem to be the more attractive pupils and teachers often without realizing it, respond to boys' enthusiasm and forget the quieter girls". (Whyte 1986:31)

b. Boys dominate class discussion and

c. Insist on more teacher attention

Galton (1981) in a large study of science teachers where staff were categorized according to "the number and nature of questions directed to pupils by the teacher" found the Problem Solving approach was most popular, distinguished by a relatively high degree of teacher questions combined with relatively greater use of teacher statements.

"Girls in mixed classes are apparently self conscious about speaking up at all, while boys, in contrast, revel in the limelight, happily if wrongly, guessing at answers to questions and probably learning a good deal in the process" (Whyte 1986:30).

Girls "prefer to offer answers only if they are confident they are correct. Samuel (1981:254).

This showed that teaching strategies needed to be adapted to accommodate to preferred learning styles of girls as well as boys.

d. Creating a 'masculine' climate in the laboratory

Unconsciously teachers may gear their teaching to the boys, setting a masculine context from the start:

"Masculine references and examples presumably come more readily to the mind of male teachers" (Whyte 1986:32).

"The tendency is helped along by the fact that science textbooks, too, assume a male audience and masculine interest" ... "Science is "really" for boys, which is held more strongly for boys (Whyte 1986:32). Those boys in the GIST sample were significantly more likely than girls to believe that "girls who want to be scientists are a bit peculiar" and "learning science is more important for boys than girls".

"The masculinization of science is forcefully underlined in the way boys succeed in turning every aspect of the learning process into a macho endeavour" (Whyte 1986:32) ... "even in Home Economics rooms - the boys put mixers on high speed - "Danger Men at Work - Dominance", thrill of potential danger - thus the girls intimidated, become onlookers.

e. Boys hog Resources

Whyte, colleagues and teachers observed the following over a four year period:

(i) Boys on the whole are keener to mess about with machines, equipment and materials, boys assert their right to first use.

(ii) Boys are pushier and seem to regard scientific or technical resources as rightfully theirs. Girls for their part become unwilling to enter into an undignified scrabble for equipment. (Whyte 1986:34)

(iii) Boys dominance of resources often gives the appearance that the boys are working more quickly and efficiently. (Whyte 1986:35)

(iv) Girls progressively opted out of the physical, practical activities. They concentrated on neat presentation of work and dependence on the teacher. Teachers, often interpreted girls' dependence and timidity as "poor motivation". (Whyte 1986:35)

(v) Girls stayed close to the teacher (ref Early Socialization in the Classroom (Serbin 1981) - teachers only spoke to girls quietly when near him/her, but would shout across to boys).

(vi) Different approaches to the task. Boys often approached the task by "trial and error" immediately; girls tended to discuss the process, follow rules and set up the apparatus accurately 1st time - two approaches to science - the former taken as the norm and one right way. (Whyte 1986:36).

f. <u>Girls "Fetch & Carry"</u>

(i) Teachers talk of difficulty of getting boys to be orderly and tidy and contrasting it with the neatness and diligence of girls. Girls often did "tidying up", regular jobs as expectation of girls. (Whyte 1986:37)

(ii) Gender decisions can make girls and boys a negative reference group for one another. (Whyte 1986:37).

(iii) Girls "lose out" in science and technology partly because they don't gain a proper foothold in the subjects (Whyte 1986:38) especially when they are in the laboratory setting.

13. <u>Teachers as transformative educators and Androgynous Managers in the Successful GIST Action Schools</u>

"The incorporation of more material on the social implications and social benefits of science, the construction of syllabi around student interest and the inclusion of topics and examples appealing to both sexes were all innovations likely to improve the learning of science for all pupils, and not just girls" (Whyte 1986:101).

Whyte (1986) found boys' attitudes, both to science and to sex roles were more rigid and stereotyped than girls, ... but boys as well as girls' attitudes were liberalized to a greater extent in the "action research" schools than in the control schools, during the GIST project (1979-84) ... where "teachers gave direct, explicit encouragement to girls in class and who made it clear that they were aware of existing bias against females in science". (Whyte 1986:101).

<u>TOWARDS GENDER INCLUSIVE CURRICULUM IN SCIENCE AND TECHNOLOGY</u>

<u>Science Content, Context and Methodology</u>

There is a need to redefine:

"the Content, Context and Methodology to make it possible for women to engage in masculine subjects, without the conflicts that arise from the "demands of double conformity". There is a need to humanize the discipline of science by incorporating typically "female concerns, modes of behaviour, insights and responses considered necessary for a saner world" (insights from Issacson 1986:239).

Gender Inclusive Curriculum has been defined by Rennie and Mottier (1989:18) as:

"Curriculum which in its content, language and methods gives as much value and validity to the knowledge and experiences of girls and women as that given to boys and men"

I plan to focus on "Science for Girls", so that it may be incorporated into an integrated plan for "gender inclusiveness" in Science and Technology:

1. Bias in teaching materials, books and other resources and increased visibility of achieving women scientists and girls in active roles. (pp89-95)

2. Preferred learning styles and science educators with implications for:

   A. Physical Environment (p96)

   B. Matching teaching styles in Science with Preferred Learning Styles. (p96)

   C. Matching learning styles with preferred modes of learning (p97)

   D. Learning styles and implications for quality interaction in the science laboratory - particularly concerned with the Affective and Cognitive Style components. (pp98-101)

   E. (i) Learning styles and single sex grouping and mixed sex grouping in Science. (pp101-105)

      (ii) Special concern: Career Education for Girls in Science and Related Technology. (pp105-110)

   F. (i) Preferred learning styles and implications for models of teaching and teaching strategies for a gender inclusive science curriculum. (pp110-117)

      (ii) Current issues in Science for Gender Inclusiveness on the Australian scene to promote "Girl Friendly" Science 1990

         (a) In favour of Compulsory Science
         (b) The Nature of Science, integration of a feminist philosophy and knowledge (pp117-122)

   G. Learning styles, Assessment and Evaluation in Science (pp122-129)

3. Professional Development of Teachers in Science and Technology - mutual dependence of teachers in Maths, Science, Industrial Arts, Computing and Home Economics. (pp129-134)

4. Recommendations. (pp135-138)

5. References. (pp138-154)

1. SCIENCE FOR GIRLS: BIAS IN TEACHING MATERIALS, BOOKS AND OTHER RESOURCES

Cultural Gender Expectations and Science Content

"Resource materials are a major source of unintended teaching about women and sex roles". Most texts used in schools "either omit women or present traditional stereotypes, particularly in Maths, Science and History" (Henry et al 1989:151).

Early investigators were concerned with the role of science text book images in reproducing gender divisions in society (Walford 1983) Taylor (1979) found:

"references to females were few, references to active females even fewer and references to females in scientific activities virtually non-existent".

Cox (in Lowe 1989) points out that "even apparently neutral subjects have built in gender bias".

"Teaching often conveys to pupils that men are the initiators, active agents and subjects of human life" (Stanworth 1981:16).

Most (resources and textbooks) seem based on the assumption that the normal human being is male ... where girls and women are represented they tend to be white middle class in submissive inactive roles"., (Cox in Lowe 1989:149)

Even in the most contemporary science materials when women and girls do appear they are shown in sex stereotyped roles which serve to emphasis their marginal and subordinate position in Science.

"Textbooks for physics and chemistry, particularly those aimed at the 11-16 age range, have become more attractively presented in the last few years, with more drawings, more photographs, more colour, however there is an over all bias in illustrations of about four to one in favour of male characters" qualitatively enhanced by "putting the women in traditional and inferior situations" ... "women looking amazed or frightened or simply doing silly things". (Samuel in Whyld 1983).

Smail (1984) found that in two science schemes, 'Nuffield Combined Science' and "Science for the 70's" that the "implicit assumption in many of the booklets was that the reader would be male, although the schemes were designed for use in mixed classes in lower secondary years" and there was often the "implication that <u>only</u> boys really become scientists" (Smail 1984:42-43).

In the revised "Science for the 70's" renamed "Science 2000" in 1980, Smail observed it began" men and women who study science" but in illustrations males still outnumbered females by 3:1, males were portrayed as active whilst the image of females was still in limiting domestic roles. Smail (1984) helped GIST teachers to produce alternative worksheets and a series of drawings of girls active in the laboratory.

Because girls tend to be more person centred, they were most "put off" science when it was taught" as if it were devoid of any human relevance at all ... science and technology affect every aspect of our lives. It is imperative therefore that we educate teachers and parents to counter the gender stereotypes and dehumanized images depicted in science, maths and technological resources if we are to truly included girls and women and their balancing contributions to science. (insight from Whyte 1986:59).

Further girls' educational choices, career choices and aspirations will be significantly and negatively affected by the content of many readers and texts in use in our schools today. (insights from Gilbert et al 1987:5).

State of the Art in Western Australia with regard to Eliminating Sex Bias and Gender Inclusiveness in Resources

The Education department in Western Australia in 1980 issued a policy statement asserting that "it is essential that courses and materials should be examined for sexist bias and steps taken to counter this bias ... effort is being made to ensure that Departmental publications are non-sexist. Teachers are requested to take the same approach to all materials produced in schools ... and when commercial materials are produced for use in schools".

Several years later the booklet A Fair Say (1987) was published by the Ministry of Education in Western Australia to give teachers guide-lines in making language free of bias for race, culture and gender. The Curriculum Development Centre has a number of curriculum projects nearing completion.

A publication by Lewis and Davies (1988), which stemmed from the Girls and Maths and Science Teaching (GAMAST) project, includes a set of inservice materials for both teachers and parents, with one section devoted to the issue of gender bias in textbooks. The McClintock Collective has been a powerful caring force in Victoria since 1983, through foundation members like Hildebrand (1989:7). They have been working in the struggle for gender inclusiveness since the mid seventies.

Teacher Skills in Countering Gender Bias and the Lack of Positive Visibility of Girls and Women in Resources

Rennie and Mottier (1989) have written a definitive article on developing gender inclusive resources for Science teaching and they believe that the greatest concern in 1989 "is not simply the matter of unequal representation of the sexes, but concern that science and technology are presented not as human activity, but as a male activity, and thus create a barrier to the participation of females. Further the sex stereotyped roles depicted by the persons illustrated not only limit females to a narrow range of roles but they also limit the activities thought to be appropriate for men". Rennie and Mottier (1989:18).

Mottier (1987a & b) has constructed all encompassing guide-lines concerning sex equity in teaching materials for science, technology, history and languages and detailed in Rennie and Mottier (1989:20-22). These are straightforward, unambiguous and easily applied by teachers.

Rennie (1989) has adeptly reviewed the 'state of the art' in science education in Australia and disappointingly affirms that there has been little evidence of change. Rennie reviewed the research since 1970's. Scott 1980 summarized research during the 1970's and found little evidence

of change, science textbooks were of particular concern; Taylor (1979) found ample evidence of bias in language, illustrations and activities in British physics books and five years later Smail (1984) noted little improvement.

Detailed analyses of Chemistry books by Heikkinen (1978) in America and Mullins-Gunst (1985) in Australia found males outnumbered females in photographs and illustrations by 5:1. Males took varied and active roles; females took conservative, passive and assistant roles.

Neither researchers found evidence of change over the years. Ives (1984) reviewed 22 Australian textbooks and found Biology books had the most equitable representation of 3 males to one female; chemistry and general science textbook ratio male to female was 5:1; and it was 8.6:1 for physics.

An Example of Analysis of Science Texts

Rennie and Mottier (1989:18-19) analysed illustrations and photographs in Books 1, 2 and 3 of a general science text published in 1984 and 1985, they found well over 300 illustrations in each book, of the 10% which included whole people, two thirds were male.

In the 94 photographs the ratio of males to females was 2.4:1 considerably less than Ives (1984) reported for general science books. The balance of boys to girls in active or passive activity was almost identical but the most disturbing fact was ratio of actively involved adult males to females being 6.6:1.

The Packaging of Science

Kelly 1985 has described gender bias in science textbooks as the "packaging" of science as masculine, which tends to exclude females from participation in Chemistry and Physics in particular. de Laeter, Malone and Deekers' (1989:23-33) enrolment trends affirm this trend. Taylor (1987:278 in an analysis of sexist bias in physics textbooks, pointed out its effect on Science Teachers' precepts of girls and physics:

> "Not showing girls as active, inquiring individuals can only work against the desire of science teachers for more participation and interest by girls in their subject".

Need for Visibility of Women in Science Teaching Materials - "Beyond Marie Curie"

Foster's women (1989:34) believe their learning will be facilitated "by the inclusion and visibility of women's history, culture and knowledge".

Perhaps most disturbing is that women scientists perceive the only ways of pursuing and surviving in careers in science is by:

- becoming an invaluable support worker
- being a "super male"
- marrying one's mentor
- working in animate rather than inanimate science (not Pure Physics and Chemistry), and,
- forming a collective support group

(Standish 1982 cited in Cross 1989:39).

Thus textbooks, journals, materials require evidence of women as scientists and engineers, today and evidence of past contributions of women brought to the notice of girls and boys in the 1990 classroom. (Annas et al 1986; Alic 1986; Parker 1989:113; McPherson 1989:117; Burfitt 1988:31-37).

Same Age Peers - girls achieving in Science

I believe it is also useful for girls to perceive female peers who are achievers in science in the local press. (Hilbert A (1990) "She's in her Element" The Times September 18).

"Science in the home" should not be denigrated. Science teachers in the "pure sciences" should become increasingly aware of the science involved in "Home Economics" and link their science to achievements of women in this area of scientific knowledge. Nor should Science Fiction be ignored as a way of knowing future predictions and notions of equal partnership between men and women.

Advice to Teachers of Science

1. Set yourselves the challenge of identifying and eliminating gender bias from your subject area - this requires awareness training, a knowledge of research findings and skills in modifying texts and worksheets (Smail 1984; Rennie & Mottier 1989).

2. Include women's achievements alongside men's historic events (Burfitt 1988).

3. Develop check-lists to measure gender inclusiveness in texts. (Rennie and Mottier 1989).

4. Look closely at the construction of knowledge and the constraints of language. Beware that these operate out of a particular ideology. This ideology endorses White Middle and Upper class males ..." (Cox in Lowe 1989).

Curriculum Innovations in Science in Australia

1. Curriculum Materials and Resources (Human & Material)

   (a) Science Units - Lee Whisson's Woodside Unit on Energy is gender-inclusive, pictorially with diagrams and images

   (b) The Curriculum Corporation of Australia funded by the Federal Government is to commission new books meeting guidelines, as part of the Girls in Schools Programme (1989).

   (c) Connor (1990) has completed an introductory science book which encapsulates both feminist philosophy and practice in science (Smail 1984; Kelly 1985; Whyte 1986). Scientific knowledge is integrated, for example, the principles of Physics are exemplified in Biology, Geology, in the home and in great scientific discoveries. Photographs present girls as "active" scientists; science in the home is valued and related experiments are widely used. There is a valuing of literacy in science and books viewed as "storehouses of knowledge" and sources of investigation.

History of measurement is included. Assessment is competency- based with self assessment exercises. A book that would bring science alive to both boys and girls.

2. Curriculum Innovations

Innovative units in lower school physics: making mechanics more "contextually" understanding to girls is a break through at St Hilda's Girls' School in Perth. (Rennie, Garnett, et al 1989).

3. Australian Science Teachers Journal August 1989.

Special issue Gender Inclusive Science and Technology Education. An Engineer's viewpoint (1989:113) and a scientist's viewpoint (1989:117) both females, provide role models so imperative for inclusion in Gender Inclusive Science Curricula.

4. Displaying the posters, EOC has produced featuring women scientists (Kelly 1985:149).

5. Resources for Science teachers. Smail (1984) has produced worksheets on women's contributions to science and audio visual material available for schools, teachers, parents and pupils. Burfitt (1988) has written on the contributions of women in the development of Australian science.

6. CSIRO Women in Science Project as live role models for 15-16 year old girls.

Production of "Anyone for Science" support material and the double Helix Science Club's quarterly magazine.

Video cassette "Women in Science".

Professional Development/Pre-service Education of Science Teachers with regard to Developing awareness of Gender bias in Resources, and the skills and Volition to Counter its effect.

1. Awareness Training

"Studying the images of males and females in science textbooks is certainly an effective consciousness raising exercise for teachers who may never previously have considered the question" (Kelly (1985:149).

Whyte (1986:59) found women teachers much more definite in their findings and more impressed by the evidence of bias than men, to change the attitudes of men teachers may be a challenge in the male dominated science environment.

2. Countering the hard cold male scientist image

As part of the GIST action research, VISTA was developed and "was intended to counter the hard, cold male scientist and to suggest that femininity and scientific or technical competence are not necessarily mutually exclusive" (Whyte 1986:21).

This semester, we initially asked our students to "Draw a Scientist" (Lewis and Davies et al 1988) and they were able to discover in the safety of small groups how stereotyped their views of a scientist were. Predominantly they portrayed a lone male, slightly mad and bespectacled boffin - though some women did produce robotic lone figures and one women student depicted a female student producing the perfect male from a flask. (Newhouse & Cullen (1990) Notes on EDU 2400).

3. Applying the "Inclusiveness Criterion" (gender, race and ethnicity):

   (a) Resources include texts, resource books, videos, computer simulations and posters

   (b) Sexist language and positive active women and girls - identified.

   (c) Are experiences, learning styles and contributions of women and girls equally valued?

   (d) Use check-lists for analysing resources for gender bias as valid evaluating instruments (Hildebrand 1985; Lewis & Davies 1988; Rennie & Mottier 1989)

   (e) Detecting bias in materials and resources is to be regarded as a valid starting point for the whole gender inclusive process (Hildebrand 1989:11).

PREFERRED LEARNING STYLES AND SCIENCE EDUCATION

Introduction

"Learning style describes a student in terms of those educational conditions under which she/he is most likely to learn" (Hunt cited in Davidson 1981:642). Learning style indicates how a student learns and likes to learn. The style of the individual student reflects "personality development, motivation, genetic coding and adaptation to the environment" (Keefe 1988).

This section should be read in conjunction with Part 2 of this report on Learning Styles.

1. Sex differences have been identified in cognitive style for example, reflective/impulsive dimension (Kagan 1969) and Field dependent/Field independent dimension (Witkin 1974).

   "This difference in perception suggests a more general difference in personality and in subject interests" (Sutherland 1981:88).

2. Differences in physical preferences and differences in social emotional states conducive to learning have increasingly become the focus of attention in science education (Sjoberg 1989). Acknowledging different learning styles of girls may involve "time to think in contextual problem solving" and "relating to the reality of women, by borrowing teaching strategies from the arts".

The Girls' and Tomorrow Report (1984:36) emphasised that in general: "Teacher sensitivity to the particular needs and learning styles of boys and girls is essential".

3. "The content of the curriculum, particularly in the areas of mathematical, scientific and technological subjects and the climate of the classroom learning environment needs to be modified to be less male defined and inclined more to the learning styles preferred by women" (Foster 1989:33-34).

4. We may in the 21st century make extended use of Learning Style Profiles, acknowledging the unique constellations in cognitive style, affective and physiological factors (Keefe 1988).

A. Learning Styles, Science and the Physical Environment: creating a comfortable setting where all students want to be.

Hildebrand (1989:9) began in her school by introducing colour, plants; people posters (including women in scientific careers)*; information related to scientific jobs and pre-requisite courses; every day objects on show that related to "current science" being studied and a "Science in the News" notice board.

Students were even encouraged to tie-dye and paint designs on their lab-coats to move away from the "sterile, lone scientist" syndrome of masculine science. Table groupings were formed to encourage cooperative student learning and activity.

*(Women in Science 1988).

This is affirmed by Foster's Women (1989:34) who believed that their learning was facilitated by:

"Attention to the physical environment and other details which make women feel secure".

B. Matching Teaching Styles in Science with Preferred Learning Styles

"Along with the changed curriculum, we need to develop gender inclusive teaching practices that cater to a variety of learning styles, make use of cooperative and collaborative activities, encourage the development of meaning through discussion and give students some control over their own learning". (Barnes 1989:117).

Eggleston et al (1976) investigated the "Processes and Products of Science teaching" and identified 3 key teaching styles namely:

Style 1 : "Problem solvers", where the initiative was held by the teacher, who by questioning challenged the pupils to observe, speculate and solve problems.

Style 2 : "The Informers" - presented a non-practical fact acquiring image, and

Style 3 : "The Enquirers" used pupil centred enquiry methods.

Style 1 and 2 produced a competitive environment, whilst Style 3 encouraged and created a collaborative learning environment, based on mutual respect. The researchers found that Style 1 was popular with the boys, but not so with the girls. More than half the male teachers used Style 1.

Style 3 was most effective in maintaining girls' liking for science and was used more by women than any other style. Jan Harding (1983) explained this preference in the following way:

"It seems that Style 3 in removing public interaction with the teacher - may enable girls to participate more fully in the class activity, sorting things out for themselves".

The Work of Spender 1980; 1982, supports the reluctance of girls and women to be involved in public questioning and interaction.

Allen's (1987) work with undergraduates, affirms that "communication apprehension" and "communication avoidance" of female students had the effect of their learning less and feeling worse about themselves.

Foster's women (1989:34) needed in their learning to experience "being taken seriously, which by contributing to confidence and self esteem, increased learning potential and "the absence of the concept of failure".

C. Matching Learning Styles with Preferred Modes of Learning

Harpole (1987) indicated that Grade 10 & 11 male chemistry students preferred situations that involved numbers and logic, computing and solving mathematics problems and benefitted from course work that was logically and clearly organized and assignments that were meaningful. Female chemistry students tended to need laboratory activities in which they could work with people and help each other. It was suggested that planning of different types of laboratory activities for males and females may enhance lab skills and consideration should be given to the structure of instructional procedures with females being allowed to set their own objectives and males given more logical well-defined instructional procedures.

This suggestion for females is very much in line with the preferences of Foster's women (1989:34) in facilitating their learning:

"where possible setting one's own learning agenda by negotiation"

"group work featuring cooperation, sharing negotiation, trust, consensus, acceptance of difference and opportunity to speak freely."

"the sharing of information, knowledge and skills".

D. Preferred Learning Style (Cognitive and Affective Components) and Implications for Quality Interaction in the Science Laboratory

This section should be read in conjunction with the General Findings related to Classroom Interaction and Gender Equity in Part 2 of the report.

"Teachers' greater concern with the work of boys - expressed subtly in a number of different ways - illustrates the extent to which prevailing cultural stereotypes are reflected in classroom practices, which in turn further reinforce these beliefs". Leder (1989:97)

Boys emerge as "dominant and important" while girls remain "peripheral, unimportant and invisible" (Spender (in Ramsay 1981:11).

Intervention strategies challenge the assumption that this vicious cycle can not be broken. There is in Australia a "Plan to lift Science and Maths Teaching" The Age October 24, 1987, page 3.

Kelly (1985) in her definitive paper on the masculine nature of science stated that it is: "constructed by two main mechanisms namely boy oriented packaging and classroom interaction whereby gender is recontextualized" Kelly (1985:149).

Kalia (1986) looked at the power of language, which is especially pertinent in a masculine area of study like Science, to show how it affects girls' perceptions of self, their capabilities, confidence and self esteem as potential scientists:

"Since language uses us as much as we use language, it both reflects and affects the way we think, sexist language vents, spreads and reinforces sex role stereotypes on the psychological level. Our opinions on any given matter are generally shaped by the way in which the original facts were presented to us, and if our initial information about something is always couched in solely negative or positive terms, we are likely to perceive the phenomena accordingly" (Kalia 1986).

A research focussing on Science teachers clearly showed that "there are classroom behaviours and inter-actions whereby elements of masculinity and femininity developed out of out-of-school contexts are transformed in such a way as to establish science as a male preserve" (Kelly 1985).

Science teachers more than in any other field need to be able to analyse their own expectations, attitudes, values and belief systems for "sex role stereotyping" and to actively monitor and correct the resulting erroneous interactive behaviour in the classroom - both verbal and non-verbal.

It is important for Science Educators to be aware how they specifically contribute to "marginalizing" girls in the Science laboratory. The "Classroom Interaction and Gender Equity" section in Part 2 of this report provides a comprehensive review of the research on teachers', girls' and boys' behaviour in the classroom.

(i) Research has shown that science teachers are biased in favour of boys and can influence girls' achievements in that way" (Rowell 1971; Spear 1984,87 cited in Leder & Sampson 1989:140).

(ii) "praise and encouragement" are 3 times as likely to be given to a boy rather than a girl. (Spender 1982:55).

(iii) "The teachers were found to give more information to boys in the form of longer direction and more conversation" (Whyld 1983).

(iv) "Boys are usually attention seekers and have more management problems. Lessons are geared to "boys' interests" so that they do not become disruptive and girls' contributions may be given scant attention in order not to lose the boys' attention" Cox (in Lowe 1989:155).

(v) Tobin (1987) has focussed his attention on "wait time and engaging students and its effects on student achievement in science. He affirms much of the "femininist" research of the past 22 years.

(vi) The dilemma of Gifted girls: Dr Sampson has suggested that girls are "relatively unsuccessful in maths and science due to "attitudes of teachers who spend more time with boys than girls, the attitude of boys who practice dominance behaviour over girls; and a male oriented curriculum" and "hence we fail to identify and nurture excellence in this half of the student population".

(vii) "It is clear that many other girls, more thin-skinned or with less determination, fail to get so far even when they have the necessary abilities (Whyte 1986:54).

<u>STRATEGIES FOR PROMOTING GENDER EQUITABLE INTERACTION IN THE SCIENCE LABORATORY</u>

1. Pre-service Unit and/or Inservicing of Science teachers

(a) Awareness of the gender agenda in classroom interaction and recognizing the prejudice we bring into the classroom (Foster 1987:137; Lewis and Davies 1988; Newhouse 1990:Part 2).

(b) Owning the problem, by attending to equity in verbal and non-verbal communication (Dobry 1986)

(c) Focus on the cultural gendered expectations of teachers which have "a high profile in research into gender equity, especially related to the classroom and career aspirations" (Good & Brophy 1987:153).

This is best achieved by:

(i) Student empowerment, especially in science, by actively countering denigrating teacher expectation effects. (Stanworth 1981; Good & Brophy 1987:144 & 583-587)

Students therefore need workshops to:

- o create an awareness of the "Gender Agenda" (Evans 1989)
- o develop their ability to evaluate interactions and gender bias (Calabrese 1984; Johnson and Hall 1984)
- o be able to use evaluation schedules with regard to the way their science courses deal with women (after O'Barr 1988).

(ii) Male and female science teachers being good role models, in and out of the laboratory.

(iii) Developing positive, encouraging and warm relationships with all students, irrespective of gender, race, ethnicity or social class, is essential to change attitudes (Granger 1987 in Leder 1989:37)

(iv) There is a need for more females in Upper School Physical Science as achieving role models for girls.

(v) Interaction with visiting achieving women scientists in the school laboratories (CSIRO Women Kingsland 1989:45-49).

(d) Careful monitoring and improvement of interactive behaviour in the classroom:

(i) Consciousness of the marginalizing effect of teacher questioning on girls, which limits the development of higher order cognitive processes. (Eggleston, Galton & Jones 1976).

(ii) Distribution of and level of questions to boys and girls. (Hildebrand 1989:9).

(iii) Clarity of explanations, countering sexist language (Hildebrand 1989:10).

(iv) Countering "learned helplessness" of girls in practical activities, by encouraging them to set up and complete experiments themselves.

(v) Monitoring and countering boys' dominance of talk, time and space in the laboratory. (Doenau 1987; Cooper 1987; Mahoney 1985).

(vi) Ensuring active participation of all students in the laboratory, in terms of quality and quantity (Sadkar and Sadkar 1985; 1988) Encouraging girls particularly to "tinker" "to compensate for past experiences which impinge on learning" (Hildebrand 1989:11).

(e) Grouping in the laboratory:

(i) teachers of science need to carefully consider the issues related to cross-sex and single sex grouping in the science laboratory. (See E. - expanded discussion related to "Single sex grouping versus mixed sex grouping" (Foster 1989:32-34; Parker 1976; Kent Street Senior High School)

(ii) Evaluation of group processes is essential (Lewis & Davies 1988). GAMAST includes evaluation by students, teachers and self-evaluation.

(f) Inservicing parents with regard to the intellectual, emotional and career needs of girls in science and technology (Lewis & Davies 1988).

E.(i) Learning Styles of Girls, Achievement, Personal Development and Single Sex Grouping vs Mixed Sex Groupings in Science

The Problem

"Lacking appropriate prior studies in Maths and Science, many girls are ill-equipped for entry to much post school training and education" (Girls & Tomorrow 1985:3)

Co-Educational Setting

"If one is concerned that in growing up boys and girls should learn to communicate with each other as equals and to define themselves in relation to each other", then co-education is preferable (Girls, School and Society 1975:64).

There is a significant dilemma in such a preference, mainly the behaviour of adolescent boys (Mahoney 1985; Sampson 1989:139-143). If one focuses on boys' behaviour in this type of setting, schools may be perceived as "microcosms of society in which they exist" (Boudreau et al 1986:124). Cox noted that "central to boys' adolescent behaviour seems to be their need to be "masculine" and to prove it" (cited in Lowe 1989:153). Coeducational Schools need to address the male chauvinism of boys, as a 'whole school' policy and to take deliberate action, or adolescents will follow along a path that is considered "natural for the two sexes" Sjoberg (1989).

Partly, as a consequence of boys' behaviour in co-educational schools. Girls "limit themselves, regardless of individual abilities" (Leder & Sampson 1989:2) and have "to seem to be less brilliant and less ambitious than boys". Doherty and Culver 1976 (cited in Calvert 1978:32).

Single Sex Settings for Masculine Subject Areas

Cox (in Lowe 1989:152) found that boys have advantages in both co-educational sex-segregated schools - whereas girls are likely to go into "unstereotypical subjects" in girls' schools, "here subjects can be separated from gender, and achievement can improve considerably". (Pratt et al 1984).

Conclusion: Practices for Science in the Early 1990

There was clear evidence from GIST 1976-84 in labs and workshops that boys "edge" girls out of science and technology which they "regard as male territory". Girls' only clubs were organized as an intervention strategy, however many teachers felt this was positive discrimination" unfair to boys and not part of the coed ethos" ....

"It occurred to no one but us that the proper parallel would be to compensate boys with special lessons in cookery or social skills ... laughingly dismissed. (Whyte 1986:144-145)

At "Moss Green" School we did in fact initiate:

"Biological activities" for boys and,
"Fischer-Technik and Lego" for Girls" (Whyte 1986:144-145).

Dale's Classic Study of relative benefits of mixed or single sex education. (Dale 1969, 71, 74). Mixed schools were "happier" more "natural" and "lifé like" - and boys benefited in academic terms from the presence of girls in the school - but as Whyte (1986:13) observed "it did not occur to anyone at the time to ask if the implication was that girls suffered academically from the presence of Boys in mixed schools".

Girls in single sex schools see physics and chemistry as less masculine than girls in mixed schools (Ormerod 1975; Vockell and Lobanc 1981).

Research suggests girls work better in single sex classes in maths and science classes (Lawrence 1984).

Jan Harding's study for the Nuffield Foundation (Harding 1981) showed that girls in girls' schools were considerably more successful in science than girls in mixed schools of the same selectivity.

Single sex schools also seem to give girls a consistent, if small, advantage in physics achievement (Bone 1983; Steedman 1983) and it is possible that single sex classes in mixed school may have the same effect (Rhydderch 1982; Wilce 1983) ... "since they will no longer be subject in classroom interaction to the "boys' bravado and disdain for girls to be transformed into superior competence in Science". Kelly (1985:151).

Growing evidence of mixed sex schools that subject choice is more polarized in mixed schools and girls are more likely to continue with a study of physical science in an all-girls school (especially a selective grammar school). Whyte (1986:13).

Harvey and Staples (1986) examined the attitudes of 3rd year pupils in mixed and single sex schools in England, to chemistry, physics, biology and to school, and argued there was a case for separating students by sex for studying some subjects.

Love and Wild (1989) conducted a case study on the relative performance of girls and boys in chemistry in lower school science in a school committed to the GIST project and to the notion of compulsory science throughout the secondary curriculum. Girls in the single sex class performed well in the first year, but concentration and retention problems led to a general decline in performance. The researchers suggested girls might have achieved better in the public examination had they entered a year earlier. Boys in the single sex group proved to be low in cooperation and performance due to poor discipline and motivation. The mixed group of the most able boys and girls followed the expected pattern of male domination but no serious problems.

Several schools in S.A. have used single sex classes in science to increase girls' participation and confidence. Career workshops for girls from Year 8 upwards are provided in some schools. N.B. Negotiated salary allocations for the education of girls is provided for. (Pike 1989:80 Project Officer Biology/Chemistry SA).

Klainin et al (1989) found that girls in single sex schools in Thailand are the best performers in upper school physics.

A satisfactory compromise at present appears to be in the organization of single sex grouping for girls in science on the following grounds:

(a) "Positive discrimination is necessary to increase the number of women in male-dominated fields and positions of power. Not only is this important in equalizing the outcomes of education but also in ending the "perpetual cycle of depressed expectations and aspirations for females" (Stewart, Brown, Parker & Sherwood 1981:44).

(b) Single-sex settings for girls in Science may well be environments which "affirm girls' identities as individuals". (Stewart et al 1981:52) and contain essential specific features of educational practice that are women focussed (Weiner 1985 cited in Foster 1989:29; Sampson 1989:142-143).

(c)(i) Freedom from discipline problems in mixed classes, largely from dominant and aggressive boys. (Sampson 1989)

(ii) More teacher attention and help, less noise, freedom from boys' inhibiting effect on girls, and boys' confidence which may be intimidating, to "enable them to genuinely reach their full potential". (Lawrence 1984; Weiner 1985; Foster 1989:29; Polding 1989:21-26; Leder & Sampson 1989:139).

(d) Provides a setting and an opportunity to widen girls' horizons, without denigrating the traditional roles of women, (Weiner 1985 in Foster 1989:29) and can include "herstory" of science (Burfitt 1988).

(e) Encourages girls to do "masculine subjects", in an environment that frees girls from boys' attitudes, behaviour in science which produces "an unpleasant predicament for girls". Sampson (in Leder & Sampson 1989:10).

(f) Science, in mixed classes, has problems with resource distribution with the boys being more "hands-on" oriented and where most experiments and analysis are carried out by the male members of the class. In single sex classes girls are not competing with boys for classroom equipment. (Polding 1989:21-26).

(g) Objectives in single sex settings can be presented so that girls can easily relate to everyday settings (Polding 1986:21-26).

(h) It is a way of establishing school girls' and women's groups to provide support for female pupils and members of staff (Weiner 1985).

(i) There have been successes and precedents in establishing the single-sex setting of science for girls:

Whyte (1986:150-153) in the GIST action research found that there were improved chances of girls opting for Physics and especially at 'Moss Green' School girls were more positive towards Science.

Polding (1986:21-26) to improve the under-representation of girls in Upper School physical sciences, established a single sex class for a Year 10 science unit which was specifically related to the preferred learning style of girls. Kent Street Senior High School in Western Australia have initiated a Year 11 Physics class for girls where Curtin University lecturers, WACAE Science Education Lecturers and SCITECH are working cooperatively in this innovative action research with teachers. (1990).

Conclusion

At stage 3 in the paradigm for Curriculum change advocated by Schuster and Van Dyne (cited by Foster 1989:28) where women are a "disadvantaged, subordinate group", the single sex setting in high school in the highly masculine subject area of Physical Science is most appropriate at this time. To be set apart at times is valued by girls and women. We do need to be cautious that what we present to girls is not "second class" in terms of the quality of scientists we produce.

Hacker and Rogers (1982) found in their research that all-girl science classes were confined to lower order intellectual activities, while by contrast all male classes were extended and encouraged to engage in higher order intellectual activities. (Henry et al 1988)

Nor do we want brighter boys to suffer in "all boys classes" where Whyte (1986:149) found that they were "held back because of the poor discipline in all boys' groups. It is a situation that requires careful monitoring balancing the advantages of mixed groups in socializing boys towards "perceived equal status with girls" and that of single sex groups of girls

in building up their confidence, and enhanced aspirations of future life chances in science related careers.

Food for Thought:

Mixed or single sex grouping at Primary Level?

Whilst single sex grouping in the high school may be appropriate at this time, we do need to increase the competence and confidence of women teachers at primary level in the teaching of science to both boys and girls (Kirkwood 1989).

Rennie, Parker and Hutchinson (1985) conducted an inservice programme to facilitate a non-sexist approach to the teaching of science in primary schools. "The project found that teachers reported increased confidence, knowledge and skills in teaching electricity and changes in their awareness of the problems of girls in science". Their children's attitudes were less sex stereotyped and participation in mixed sex grouping was more equitable for girls, which bodes well for high school days.

Clearly "professional development" of teachers is a key area in "action research" in changing attitudes and effecting change in making science more gender inclusive and hopefully where they can orchestrate science education for the benefit of all students. (Kirkwood 1989:79).

E.(ii) SPECIAL CONCERN: CAREER EDUCATION FOR GIRLS IN SCIENCE AND RELATED TECHNOLOGY

> "More than a century of compulsory schooling has not produced equally valuable outcomes in girls and boys. The occupations to which they have gravitated in recent decades generally offer only part-time employment, that is when jobs are available and girls education does not normally fit them to enter other growing areas of employment" (Sampson 1989:1).

Career Education is a vital parallel "curriculum" for girls in schools and should be part of a whole school policy where administrators, guidance officers and teachers are all involved in this important endeavour in increasing the life chances of girls.

"Positive Discrimination in favour of women or blacks or inner city poor in educational and occupational selection is meant to compensate for inequalities of "condition", which would otherwise make a nonsense of equality of opportunity". (Mann M, (1983:112).

"There is a sense in which girls are less free than boys to take up certain school and career options and possibly also a sense in which boys are less free than girls to reject such options". (Isaacson (1986:225).

"Jobs for the Girls" is a major concern world-wide (Dick 1987).

1. The Problems in current Career Education for Girls

   (a) Counsellors' Aspirations and Expectations of Girls

"Australian girls have received biased advise and that careers advisers often have their own views about what sorts of occupations are suitable for girls" Gray (1984:7).

(b) Girls' Aspirational Levels Ebbing at 17-18 Years Old

Kfir (1988) found that Afro-Asian Israeli girls without dropping out of school "slow down" their own status attainment, even more than Euro-American girls, at 17 years to 18 years, giving their counterpart Afro-Asian boys significant advantage in achievement and objective ability.

Boys also have the added advantage of pursuing a technological track with wider choice, but the girls were "locked into" an academic track. Boys particularly Euro-Americans had an advantage in occupational aspirations at all ages and in educational aspirations for the future. Parker and Offer (1989) would support the need to deliberately enhance girls' aspirations to expand their life chances.

2. Girls' Lack of Awareness of the Importance of Mathematics as a "Critical Filter" for jobs and careers in science and technology (Sells 1982).

(a) "The usefulness of maths for career choices is extremely important for the higher paid scientific fields, such as physics, economics, chemistry and engineering". (Wilson K. and Boldizar, J. 1990:63).

(b) "45% of boys meet tertiary requirements with at least general maths, less than 20% of girls do so" (Henry, et al 1989:171).

Counselling out of class and in the context of maths, science and technology classes is vital.

3. Lack of Awareness of the Limited Life chances of Girls and Women, without mathematics, science and technological skills (Issacson 1986).

In 1987, over 54% of all women workers were in only two occupational groups those of clerks and salespersons. (Leder et.al. 1989:2).

4. Perpetuating the "powerlessness of women through their non-involvement in science and mathematics

"Some are concerned that women will have less power in the community because they do not have access to the empowering male domains of mathematics and science". Willis (1989).

5. <u>The double bind of "anti-school" girls, compared to "anti-school" boys and how to change girls' attitudes to science and technological education</u>

When "anti school "boys enter manual work their masculinity is affirmed and gives them status; "whilst anti school" girls either have to reject the traditional female role giving positive identity to successfully complete school or leave school and get a job that gives them low pay and low status". (Henry 1988:156-57).

6. <u>Attention to Marriage seems to Limit the Horizons of many girls</u>, so that their occupational future means less to them than maintenance of relationships. Cox (in Lowe 1989:47).

7. <u>Girls inability to "see beyond marriage"</u>

"When you consider your career, think about the future beyond the next few years .... do not consider marriage or a career, consider both ..." (Lyne-Brown 1973).

Stake (1981) has shown how educators can be very influential in fostering higher occupational goals and self confidence in female students (cited in Foster 1989:35). The persistence of the dilemma for girls is affirmed in the research and individual case studies of Poole and Beswick (1989:12-25). Chisholm & Holland (1986) have also worked on the problem of occupational choice and report on their curriculum development project.

8. <u>The Lack of Female Role Models in Non-traditional occupations and Scientific/Technological Careers</u>

There are undoubted limitations on the career aspirations of girls in the lack of female role models in male dominated positions and occupations such as the trade skills. (Calvert 1978:38).

Occupational role models are an important ingredient of a supportive atmosphere and influential ... in promoting career motivation (in girls) ... simply having a women teacher in the classroom was shown to be not enough" (Foster 1989:37).

Whyte (1986) did much to promote the inclusion of men and women in non-traditional occupations in the GIST programme in UK. In Australia, there are programmes that actively encourage upper primary to lower secondary to move towards science-related careers though live role models, historical role models and contemporary role models. (Mullins-Gunst and Simonelli (1989:83). (COMETS) provides seeding grants; also Australian Chemical Industries Council; and Australian Neuroscience Society. In parallel, there are in Western Australian programmes that actively encourage "girls as scientists and are part of school based Equity projects. (Lymon 1989:82).

9. The difficulty of linking school choices to future careers in science and technology

Ware and Lee (1988) and Ethington and Wolfle (1988) writing from an American perspective, assume that other factors both social and personal, besides subject competence, affect females' choice of science majors. Intervention strategies used here are primarily early intervention career counselling and subject guidance with strong parent involvement to change attitudes to "science as a career for girls" (See the early work of Berryman 1983,85).

In Victoria, programmes like Maths and Science Incentive Grant (MASIG) link in with technical work experience and careers counselling. This latter ensures early intervention with girls and parents and is an initiative of the Department of Labour (Groves 1989:85).

Lymon (1989) in describing the Western Australian Science and Technology programme highlights the need for:

- the formation of "Girls in Maths, Science and Technology" reference group to collate initiatives in this area, which includes:
  - Policy Consultants-Maths, Science Technology and gender equity
  - Curriculum project teams
  - teachers
  - district office personnel
  - tertiary institution representatives (Lymon 1989:82).
- Continuing monitoring of participation and access of girls in Secondary Education, particularly physical sciences. (Lymon 1989:82; deLaeter, et.al. 1989:23-33)
- Continuing focus on curriculum reform for example GAMAST, McClintock Collective and DEET. (Lymon 1989:82)
- Professional development of teachers (Lymon 1989:82).

10. The lack of skills, awareness and experience of Women Science teachers in meeting the particular needs of girls

There is a need for career development of Women Science Teachers for competency (Kirkwood (1989:79) and as valuable role models in the science settings for boys and girls at the primary levels and in lower and upper school science courses. (Rennie et.al 1985).

"Career motivation can be fostered by women teachers and role models who are perceived by students as vital, interesting and empathetic" (Foster 1989:37).

11. The Need for In-service Programmes for Men in Administration, Counselling and Science Teaching who lack awareness of the needs of girls in science and for encouraging career opportunities in Science and Technology. It is important that men too learn to counter invidious sex role stereotyping that inhibits their own

personality and intellectual development and, in turn, damages the ability of girls, particularly, to reach their potential in school science.

12. The Lack of Valuing their own worth as Women with regard to contributing to Society's economy and its development

This is exacerbated by Society's low valuing of women and "women's work"

A Society which wastes a substantial proportion of its human potential limits its own development and creates costs for itself - women have the potential to contribute to the economy" (Porter 1986). Initiatives in this area focus on re-educating the community - for example the WISNET exhibition. (Rainworth 1989:88).

13. The Problem of Stereotyping for Girls' School subjects and careers is well illustrated by "science (particularly physical science), mathematics and computing. Many girls consider these subjects to be in the male domain and in conflict with their own femininity - or stereotyped views of female roles. These stereotypes have created the expectation for girls to make family needs, not paid work, their priority. As a consequence many girls do not see a need for these subjects. They therefore tend to choose subjects that are based more on interest than on the need for credentials" (Willis 1989).

Intervention Strategies - linking subject choice with future careers.

"Information and interest are necessary components for creating the desire which is an important element in the exercise of freedom" (Issacson 1986:227).

(a) Issacson (1986) cites Peacock and Skinkins (1983) and their Insight Programme as a valuable means of focussing girls' attention on careers for girls in Education.

(b) Video recordings, like "Are Girls Calculating?" help to counter conflicts that limit girls' life chances, by presenting a true picture of the employment situation for girls in Western Australia. The use of achieving role models in non-traditional trades, occupations and careers is a highly effective mode of social learning (CSIRO Women Kingsland 1989).

(c) The South Australian Education Department 1989 in response to Senator Ryan's Position Paper 'Girls in Science' (1987) have developed a publication Access to Science, with four support papers namely:

The Masculine Image of Science

The Content of the Science Curriculum
Classroom Methods & Assessment
Girls in Science - School to Work!
(South Australia)

(d) Hildebrand (1989:10-11) "Activities which fit into the science curriculum, yet are aspects of career education are now available" (eg. Fraser 1982; Gianello 1988, PEP 1987a, 1987b & 1987c; Mullins Gunst and Simonelli 1989:83).

Linking Science and Careers with COMETS

Mullins-Gunst and Simonelli (1989:83-84) are concerned with linking science and careers through COMETS (Career Oriented Modules to Explore Topics in Science).

COMETS encourages all students, but especially girls to consider science related careers. COMETS sells science's usefulness in a whole range of careers and encourages students to keep their options open by continuing to study science and mathematics. At the heart of COMETS are the three uses of role models; live role models from every profession and occupation that uses science; historical role models and everyday women working in science related careers. This approach is very much affirmed by the pioneer work of Whyte (1986) in UK.

F.(i) PREFERRED LEARNING STYLES AND IMPLICATIONS FOR MODELS OF TEACHING AND STRATEGIES OF TEACHING TO PROMOTE LEARNING IN A GENDER INCLUSIVE SCIENCE CURRICULUM

Introduction

(a) There has increasing been an emphasis over the past few years on models of teaching with a "human dignity" outcome. (Joyce & Weil 1980).

For example:

Group Investigation Model - blending the goal of academic inquiry, social interaction and social process learning eg. cooperative learning (Charles 1989; Hildebrand 1989:14, Fraser 1982; Joyce & Weil 1980:239)

Role Playing Model - analysis of personal values and behaviour, strategies for solving interpersonal (personal) problems and empathy eg. Role Playing & Drama (Joyce & Weil 1980:258; Hildebrand 1989:13).

Jurisprudential Inquiry Model - nourishes the values of pluralism, exploring issues (Joyce & Weil 1980:274).

Laboratory Training Model - to improve interpersonal relationships. (Joyce & Weil 1980:292).

Social Inquiry Model - how to reflect on significant social issues (Joyce & Weil 1980:322).

Assertiveness Training Model - express oneself confidently in a social situation, resulting in self control and personal strength (Joyce & Weil 1980:425) eg. Personal Development Programmes (Hildebrand 1989:15).

Values Clarification Model (Hildebrand 1989:13).

(b) Mastery Learning - managing instruction so that the curriculum and the laboratory will enable all students to have "optimal time, good instruction, be induced to persevere and receive assistance in understanding". eg. Negotiated Curriculum (Roe 1988; Hildebrand 1989; Joyce and Weil 1980:446)

(c) Models of Teaching that enhance productive thought and creativity in Science where boys and girls are encouraged to be "scientists" rather than simply reproductively, "doing science". (Roe 1988; Hildebrand 1989; Jones & Newhouse 1982, 83).

A Need for Science Teachers to Interact and Cooperate with other Subject Colleagues and Recognize their role in Fostering Gender Equity

English Teachers

(1) Creative and Process Writing Skills
(2) Science Fiction as a source of future possibilities in life, science and technology
(3) Women in literature.

Social Science Teachers

In America, Social Science teachers play an important role in "Law related Education" including affirmative action; Role Playing historical events displaying inequities of women; Sex equity Issues; Professional inservicing in Project Equity; Sex Equity and Non traditional career orientation for elementary students. (Simms 1980; Tabor 1986; Malcolm 1985a&b; Cancellier et.al. 1986' Dudley-Smith et.al. 1984; Giese et.al. 1987; Middleton 1987).

Industrial Arts

Catton (1985) established the important role of Industrial Arts in developing skills in woodwork, metalwork and technical drawing for girls - particularly successful in single sex classes and clubs.

Home Economics

Science has much too learn from the integrated curriculum, prevailing feminine philosophy, morality and ideology. (Thompson 1987a & b)

Innovative Strategies in Science for Gender Inclusiveness and for Girls

Between 1988 and 1989, there has been a growing international debate concerning gender and science technology (Harding, Hildebrand, Klainin 1988 and concern for improving both Primary and Secondary Science; Career Education; and Technology in schools. (The McClintock Collective 1989:128-138).

Many of the teaching strategies for girls in Science, Mathematics and Technology, which were seeded in the innovative action research programmes of Whyte (GIST) (1983) and Barnes, Plaister and Thomas (1984) and gifted science education programmes of the early 1980's (Jones & Newhouse 1981. 1983). These strategies refined by Australian educators have proven to facilitate meaningful learning in science for both sexes (Hildebrand 1989:12).

o Developing positive attitudes of girls (in years 8-11) to science through creative writing, poems, art, jokes (fun) and imaginative creation. (Stocklmayer 1989:77).

Social Context Consideration This strategy has resulted in breaking down polarized subject divisions, so that the organizing framework becomes thematic and problem solving (Hildebrand 1989:10).

For example, in a strategy where "Advertising" became the organizing centre, Villiers (1989:61-64) focussed on the social and personal issues of being a female in our society. The strategy addressed the analysis of advertisements and underlying societal values of women; the science of products; social and cultural context; and self concept of women.

o Enhancing the Status of Women Scientists, Encouraging Girls as Scientists and Changing Science Teachers attitudes to 'Women in Science' by the active involvement of CSIRO women, employed in science and technical areas, through school seminars involving boys, girls and their science teachers.

(a) "The project is changing the perceptions of 15-16 year old students around the country by giving them the opportunity to discuss daily life in scientific research, the contribution that Australian scientific research is making to the community and other aspects of science that interest the students" Kingsland (1989:45).

... at one school, the first visits (of CSIRO women) led "directly to an increase in girls taking senior physics from 0% to 35% and from 11% to 50% in senior chemistry" and in another school "there was a considerable shift in girls' enrolments to the physical sciences" (Kingsland 1989:48).

(b) Breaking down the barriers with students and science teachers alike "The teachers ask just as many questions as students and mainly about my personal life, how I get on as a women in the science work environment ... rather than my scientific research work" (Tompkins cited in Kingsland 1989:45).

(c) Jan Harding (1987) highlighted the importance of demonstrating practical positive outcomes of science to girls, since "girls tend to opt to take the subject because of the beneficial results that science can produce" (Kingsland 1989:47).

This has led to the establishment of the Double Helix Science Club and the CSIRO National Network of seven Science Education Centres for boys and girls - and meeting the needs of both successfully.

o Role Model Programmes

According to Hildebrand (1989:10) "Many role model programmes are mushrooming across the country."

Harding (1986), from work done in the UK, has established that the best models are "those closest in age, one step ahead on the scientific ladder and closest to home". She instances:

- o primary students and lower secondary students running science activities in "Science in School" week
- o lower secondary students and Upper School Science students with cross-age tutoring schemes, Girls' science clubs, mentor schemes.
- o TAFE involvement in primary science (Perth 1990)
- o Community members, parents, engineers, pharmacists, non-traditional career people.
- o Work Experience in non-traditional areas to mix with "models on the job".
- o Values Clarification Strategy

"Science is socially constructed by its practitioners and therefore cannot be value free and totally objective". Hildebrand (1989:13) affirmed by Cross 1989:38 .

Objectives

(a) being confident enough to state opinions
(b) explaining value positions
(c) making decisions
(d) examining alternative viewpoints
(e) choosing a position from alternatives
(f) Challenging value positions
(g) Confronting values conflicts
(h) Acting on values.

Hildebrand (1989) recommends the use of Values Clarification exercises provided by Groves 1987(b); Simon et al 1978; Clarity Collective 1983; Edwards 1985; Gianello 1988; and her own "Liver Transplant Committee" that incorporates role play, values clarification, cooperative learning and creative writing, as an extension activity: (adapted from Hyman (1977:127-131) by Hildebrand (1989:70-72).

- o Tinkering to compensate for Differential Early Childhood Socialization

To develop knowledge and skills in mechanical and electronic areas, competence in the use of tools and machines (Gianello 1988; Groves 1987a and Dick 1987. Catton, (cited in Whyte 1986) looks at the role of Industrial Arts in developing these capabilities and for enhancing spatial skills, which are transferable to science and mathematics.

- o Integrating Aspects of Career Education into the Science Curriculum

(Fraser 1982; Gianello 1988; PEP 1987 a,b,c; Mullins-Gunst and Simonelli 1989).

Hildebrand (1989:10) highlights the "Metals at Work" unit in Gianello (1988) as "a good example of a package of activities which provide opportunities for students to explore career awareness, self perception and decision making skills in an integrated unit of work".

- <u>Integrating Science Education with "the Home" Context</u>

Equally important is the linking of Female experience with science, particularly in Physical Science, for both boys and girls. "Home" science applications need to be enhanced and valued by the whole community; and girls require as many linkages with their "home experiences" as possible for "inclusiveness" and enhancing their learning in Science (Hart 1987; Garnett et al 1989). Science in Home Economics should be valued and links consciously made by Science teachers. (Newhouse 1990).

- <u>Interest-Based Strategies in Science</u>

Manthorpe (1982) and Walford (1983a) expressed reservations about the development of science curricula around girls' interests. Kelly (1985) believes that it will produce a more feminine science for everyone, with a "concern for people".

Smail (1984) successfully developed approaches to traditional topics in physics and chemistry which took early adolescent girls' interests in youth culture and human biology as the starting point.

Villiers (1989:61-64) adopts this approach in Chemistry, by focussing initially on advertisements found in teenage magazines, which raise issues of interest to girls.

- <u>Science for Girls and Computers</u>

Clearly, there is a need to develop positive attitudes and interest in the use of computers (See Computer Education for Girls).

A project in a Perth Girls' School involved the use of the computer and a Griffin Microsat Satellite System. The girls were progressively "inserviced" in the use of the Microsat System and the Apple Computer, and finally developed the confidence to receive weather pictures directly from satellites. It was found that the girls were much enthused by this hands on experience of science and technology. It is planned that every student will participate in the reception of weather satellite usages as part of the normal science programme. (Rennie R. (1989:74-75).

- <u>Negotiated Curriculum - a Constructivist Approach to Science Learning</u>

"where possible setting one's own learning agenda by negotiation"
Foster's Women's Preferred Learning Style (1989:34).

According to Hildebrand (1989:10) and Roe (1988), within guidelines set by the teacher, content, processes and products can be negotiated to make a topic or course more challenging, worthwhile and exciting for individuals, small groups and the whole class to study. Essentially "goals, tasks, processes, timelines, products

and assessment techniques are negotiated and clarified at the beginning of the topic, which creates increased motivation and involvement in the students' own learning". (Roe 1988)

It is interesting to note that Negotiated Curriculum was very much in evidence in school based extension programmes for the Gifted in the early eighties. (Jones & Newhouse 1981, 83 & 84).

- Creativity in Science fostering "productive" scientists in the making, taking care that both boys and girls are nourished (Sampson 1989).

Borrowing Strategies from the Arts

- Stocklmayer (1989:77) used the art, English and poetry expertise of girls in the science laboratory, creatively "starting where they are best".

- Creative Writing also aids the clarification of ideas and can be a powerful learning device. (Hildebrand) 1989:12).

  "Currently we use report and re-count genres; fantasy and futuristic genres are possibilities, argumentative genre is sometimes used; poetry, scripts, journals, newspaper articles, advertisements, songs and conversations allow students to explore concepts through writing".

- Role play and drama:

  "Many ideas, objects and processes in science can not be seen with the eye, nor directly experienced with any of the other senses" ... it is appropriate then to act it out and enjoy themselves to grasp concepts and clarify scientific processes. (Hildebrand 1989:12-13; James 1989:72).

  Students can also be encouraged in role play imagining themselves in another time, place or situation. (Hildebrand 1989:70; Speedy 1989:73; James 1989:72; Goodings 1987:15).

- Cooperative learning to develop perceptions of shared responsibility and creative enhancement of participants.

  This approach is valued by Foster's Women (1989:34) and "a technique which empowers students by recognizing the importance of shared work" (Hildebrand 1989:14) ... and can also be used in an expert group context, such as professional development of teachers, administrators, counsellors and parents, (Peck and Dick 1989:65-69; Lewis and Davies 1989). Fraser (1982) provides cooperative learning strategies from 'The EQUALS' materials (USA). Charles (1989) believes cooperative learning strategies enhance classroom management.

  Cooperative learning also facilitates the creative process and outcomes so clearly demonstrated with the gifted and space research. (Clark 1988).

o Scientific Problem Solving and Creativity

Research shows that: Compared to males, females expressed less confidence in their scientific and problem solving abilities and reported less frequent participation in curricular and extra curricular science activities. (Matyas 1984).

Beckham et al (1988) have investigated problem context and sex role type in trying to detect sex differences in Problem-solving. Hansot and Tyack (1988) have written an interesting article on "thinking institutionally".

Intervention Strategies: Clearly practical innovations by Groves (1987) and Hart (1987) have actively encouraged creative problem-solving in girls, using the contexts that they are familiar with and enjoy. Both researchers emphasis pupil self-assessment of attitudes, confidence, competence and achievement.

Leggett et al (1989:76) ran extracurricular 'Fun with Physics' workshops for Year 11 and 12 at Curtin University. Cooperation between the teachers and lecturers was emphasised. There was a range of activities, including skill learning, manipulation, creative projects and a visit to SCITECH. Students left with a sense of achievement, a broader view of Physics, increased confidence and interest.

Comment: Gender inclusive science educators and teachers would do well to review the innovative strategies developed for the gifted between 1970 and 1989, since there are many parallels.

HOW TO GET STARTED IN SCIENCE EDUCATION IN YOUR INSTITUTION: CURRICULUM INNOVATIONS IN SCIENCE IN AUSTRALIA RELATED TO GENDER-INCLUSIVE CURRICULUM AND SOURCES OF INSPIRATION

The Australian Science Teachers Journal August 1989 provides up-to-date descriptions of Gender Inclusive Science and Technology Education in Australia. The Articles collectively would provide any school and science staff with a sound start to Gender Inclusive Science curriculum planning, implementation and evaluation.

GEMS (Gender Equity in Maths and Science) 1989 - is a professional development magazine, which provides articles about the full spectrum of curriculum innovations, including teaching strategies and units of study with a gender inclusive emphasis.

GAMAST (compiled by Lewis & Davies 1988) provides the science teacher with frameworks for designing programmes of work in Science that not only map out the content, but include the most appropriate strategies to use. (Lewis and Davies 1988 : Worksheets 76-83, eg. Theme "Pollution").

This professional development package aims to use a cooperative learning strategy so that groups of science teachers may share ideas and consequently enhance and support the creative gender-inclusive science curriculum that results.

Dangerfield (1989:50-55) of C.D.C. 'Engaging Science, a Science, Technology and Society Project aimed at Junior High School. It is hoped that groups of teachers, in association with their STA, will produce units for additional topics based on the model provided.

The PHRED Project

Beruldson (1989:56-64) discusses the implementation of Year 11 Physics, which gives due consideration of individual differences in abilities, talent and interests, that students bring to science. A concept of different "intelligences" aptly researched by Sternberg and His Triarchic Theory (Trotter 1986:16) is applied by this teacher in 'Physics for Real Education".

The PHRED project "utilized the talent of a group of writers from South Australia and a reference group with representation from each state who provided input on their Physics Curriculum, the main issues confronting girls' learning in science, and the structure, content and pedagogy that encouraged girls to do physics" ... to attract both sexes, accommodate to their interests and use their talents. (Beruldsen 1989:57).

F.(ii) Current Issues in Science for Gender Inclusiveness on The Australian Scene to Promote "Girl Friendly" Science 1990

In addition to "single sex classes in science, discussed in an earlier section there are two further issues namely 'Compulsory Science for Girls' and 'The Nature of Science'.

(a) In favour of Compulsory Science - to widen life chances of girls.

"Girls need to study physics, mathematics and technical subjects if they are to have positive freedom" that is in charge of their own lives as adults. (Issacson 1986:230).

Parker and Offer (1989) proposed that more consideration be given to compulsory science for girls in Western Australia which is affirmed by cross-cultural action research in Thailand ....

"there is no doubt that the existence of choice in the curricula organization of schooling does enable existing societal attitude to invade the process of learning" Klainin (1989:111).

Klainin et al (1989) found that girls and boys in Thailand participate equally in the senior secondary levels of schooling. They presented "for the first time a national system in which girls are both participating and achieving in Physics education equally with boys" ... 'put simply if girls are in physics classes some of them will learn. If they are not there they cannot learn. Thailand has them there and they are learning as least as well as the boys" (Klainin 1989:111). and in Norway ...

Sjoberg (1989:37) argues that "subject choices should be positioned so that important possibilities are not shut off at an early age. A common core curriculum and science for all seem to be important to promote equality between the sexes" which supports the views of Skog (1983) from findings in Norwegian High Schools.

Thus, as part of the "Girls in School Programme", The Curriculum Cooperation of Australia, which is funded by the Federal Government, plans compulsory technology classes for secondary school girls and single sex classes in Mathematics as two further measures to encourage interest in previously male dominated areas. (West Australian 1989).

(b) The Nature of Science: A Practical School Level Perspective

Alison Kelly (1985) argues succinctly that science is masculine and the masculinity of science is often considered the prime reason why girls tend to avoid the subject at school. Science, she considered is masculine in at least four senses, "namely, in terms of numbers - who studies science at school, who teaches it, who is recognized as a scientist. Secondly there is the packaging of science, the way it is presented, the examples and applications that are stressed. Thirdly, there are classroom behaviours and interactions whereby elements of masculinity and femininity developed in out of school contexts are transformed in such a way as to establish science as a male preserve; and finally there is the suggestion that the type of thinking commonly labelled scientific embodies an intrinsically masculine world view".

Creating a Gender Inclusive Science Education

It seems at present that curricula in science are being modified by dedicated science educators and science teachers in Australia in terms of trying to increase numbers of girls into the area; countering the gender bias and visibility of women in the packaging of science; taking cognisance of science teachers' language and interaction patterns in the classroom; attending to learning styles, when selecting teaching strategies and evaluation procedures; and increasing the visibility of achieving women scientists in science classes.

However, there has been very little philosophical, moral or ideological discourse between men and women as equal partners in the pursuit of science. Nor has there been a deep commitment by the majority of male science teachers and science educators in the mainstream to look closely at women's history, culture, knowledge and achievements in the field of science. Only very recently have there been concerted efforts by men and women to look towards a new philosophy of education. (Newhouse 1990 (Part 1):56-80).

I would argue that to be truly gender inclusive, science, as a masculine body of knowledge, requires the integration of a feminist ideology, morality and philosophy together with knowledge constructed from a feminine perspective.

THE FEMINIST PERSPECTIVE OF SCIENCE

1. Value System of Science

"Science is now the embodiment of values currently esteemed as male and masculine and is not feminine or female, nor are women or female values wanted" Spender (1981:239).

In support of this statement, Clark (1988) noted in recent times the lack of acknowledgement of achievements of women scientists by peers. (Newhouse 1990 Part 1:22).

2. Predominant Thinking in Science

Gray (1984) believes that real equity can not be achieved until the value system of society acknowledges the worth of feminine qualities of thinking, "such as creativity and intuition, as much as the masculine qualities of logical analytical thinking". Certainly the achieving gifted scientists exhibited both qualities of thought to be truly creative (Newhouse 1990:Part 1:22-23). Littleford (1989) highlighted the limiting effects of traditional philosophy on scientific discovery ... despite great scientists acknowledging the need for the holistic in pursuit of real discovery (Newhouse 1990:Part 1:70).

3. Social and Human Concerns and Issues as the Essence of Feminine Philosophy in Science

Salner (1985) argues that gender bias exists at the philosophical foundations of knowledge and inquiry. She challenges the ideology that empirical science is the only acceptable stance towards the generation of knowledge.

Willis (1989) holds the view that the lack of concern for the social and human condition in science and related areas is continuing to bind these subjects in a totally masculine perspective, the philosophy of which espouses power and dominance.

"Maths, science and computing curricula tend to emphasise the experiences, concerns and interests stereotypically associated with masculinity and rarely are mathematics and science (and computing) embedded in social and human concerns and issues" Willis (1989).

Barnes (1989) continues: ... these social and human concerns and issues "reflect the female tendency to view the world and a lack of these tend to exclude female interest. A change in curriculum that presents these subjects as human endeavour, with application to important social issues; including valuing the interests and achievements of women and girls; and emphasising the creative and imaginative appeal of mathematics and the physical sciences".

Once these changes begin to be incorporated into the school curricula, then there will be an acknowledgement that society is beginning to value a feminine philosophy with its caring, hopeful morality and to construct knowledge from a balanced masculine and feminine perspective and ideological stand point.

"Is it too much to hope that a gender inclusive science education might eventually change the practice of science to one that is socially responsible?" (Hildebrand 1989:16).

4. Learned Science from a Feminist Perspective

Mares (1989:103-109) has compiled a bibliography of scientific works from a feminist perspective. Bleier (1986) "attempts to extend our visions towards a science that is different, better, feminist and emancipating" (Mares 1989:104). Bleier writes convincingly about the prevailing masculine philosophy that continues to dominate the pursuit of knowledge and truth in science.

It is vital that men read feminist perspectives of science to gain insight into their own construction of knowledge.

5. Challenging the assumption that science is "neutral, objective and value free" from a Feminist Perspective

"There is hardly a significant area of science, however remote from gender or race or other social issues, that does not engender wildly differing opinions, intense passions, irrational responses, and personal antagonisms. And, furthermore, I would maintain that most scientists would not be happy in their work nor would science have accomplished so much as it has in understanding natural phenomena and applying the knowledge to social uses were these passions and drives absent from the laboratory.

The problem is that, more often than not, these passions and commitments have more to do with drives for personal power than with the pursuit of the truths of nature. And when the questions being investigated have important social implications about the "nature" of women, the commitment is to the social status quo rather than to a disinterested and unemotional consideration of the range of possible interpretations of a body of observations. That is, scientists, like the majority of men in our society, have a personal stake in a system and ideology that reinforces belief in the biological inferiority of women and, thus, justify women's subordination position within the home and the laboratory.

...Yet scientists ... still maintain that what they do in their laboratory is neutral, objective and value-free; and that their differences of opinions, emotions and drives are objective - based on rational differences in techniques or interpretations - all quite separate from who they are as people." (Bleier 1986:4)

The Value of Philosophical Discourse in Pursuit of Truth and Knowledge in Science

Three articles in the Australian Science Teachers Journal August 1989, have been written from a male perspective which challenges the masculine philosophy undergirding science, not only in regard to our belief and value system, but in the very practice of science and its outcomes in our world today.

Roger Cross (1989:38-44) writes "the challenge is for science teachers to work for a science that has as its objective the creation of a sustainable world involving human beings in partnership". Cross (1989:39) addresses the problem of creating equality in a flawed system:

"It is the ideology of science itself that we must begin to challenge ... to assert oneself powerfully (in the Physical Sciences) as a woman is impossible" (Overfield cited in Cross 1989:42).

Cross (1989:39-42) enters the debate of 'holistic versus reductionist' science by absorbing himself in the common philosophy held by both feminist scientists and those men and women who belong or belonged to the 'Social Responsibility of Science movement' (See References, Cross 1989:43).

"All too often it is claimed that we have accepted explanations (in science) which are derived from the isolation of the parts from the whole" (Cross 1989:40).

"The failure of science to accept the limitations of the scientific paradigm has led to many environmental and technological disasters we confront today" ... we fail to ask the questions beyond "is it the truth?" to include "is it beautiful?" "is it morally improving?" "does it lead to a perception of the good?" (Sivin 1982 cited in Cross 1989). Cross (1989:43) advocates student empowerment by exhorting all science teachers to help them to:

- understand the nature of subject they are studying in terms of its structure and ideology. To appreciate that the ways in which science is structured presently has consequences for us all.

- examine the past and present critiques of the methods and values of science in order that they can take action to counter prevailing attitudes which are not in accord with the rapid development of equality and equity.

- develop a vision for a sustainable society with the aid of a science that is holistic and serves all people.

Sjoberg (1989:34-37) looks at the way science has legitimized the opinions that "women seem to be naturally suited for work that has low esteem and low pay" and who are to be "dominated and oppressed". In his research he focusses on "person-oriented" cognitive style and draws on the collaborative findings of Kvande (1984) and Skog (1983, 1987) with regard to feminine values and perceptions of reality.

He concludes that "it should be considered as problematic that people recruited in technology seem to be people, who are not oriented to other people", which is much in line with feminist philosophy.

He believes more girls recruited into technology may enhance people orientation and be less inclined to cultivate individuals who are too single minded and concerned only with political and personal power. Like Cross (1989), he advocates presenting science in schools as an activity concerned with "people's needs and deeds" and connected with "a real societal context", where the problems of individuals and society at large have relevance for science and technology (Sjoberg 1989:37).

Kingsland (1989:45-49) is the manager of CSIRO Education Programs, who perceives the great importance of CSIRO women, working in scientific and technical fields, in promoting gender inclusive science in the schools.

> "The image of scientists as male can be countered by taking women scientists into schools to talk about their work" (Smail 1982).

The hope of CSIRO is "to encourage women to take up positions in science where they can have an influence on science, such as developing a more cooperative approach and promoting a concern for the social implication of research". The CSIRO project is having a "significant impact on those stereotypes and attitudes about women in the field of science which are no longer (and never were) significant. (Kingsland 1989:49).

Clearly, his interaction with achieving CSIRO scientists and technologists and insight gained from the research and philosophical beliefs of women such as Armstrong 1987; Harding 1987; Spear 1984; Spender 1982; and Willis 1989; must have influenced his orientation to adopting a more feminist philosophy of science himself.

Physics - the "least person oriented" science of all

A new Physics curriculum is currently being developed in Western Australia and will hopefully encompass a balanced masculine/feminine philosophy morality and ideology so that we develop as Beruldsen (1989:56) says "Physics for Real Education" which will "attract students of both sexes" and will not de-emphasise certain skills which happen to be "those which girls tend to possess and enjoy: and "critical to real learning" ... "putting these skills back into Physics will not only encourage girls but improve the quality of physics for all by encouraging "an understanding of the real nature of the subject".

Certainly, the recent Ross Lecture by John de Laeter (1990) on Models in Physics reflected both a balanced masculine/feminine philosophy and a real sense of collaboration between men and women scientists both past and present.

The theme of this years "Australian Science in Schools Week" is "environment" which reflects a "feminine philosophy in relation to creating a "sustainable biosphere" (Cross 1989).

G. LEARNING STYLES, ASSESSMENT AND EVALUATION IN SCIENCE

What the experts say about Science Teachers, Teaching and Evaluation

"USA students performance in Math and Science could be highly improved by a more systematic approach to Math and Science teaching. Students due to the late start in studying these subject areas and their too rapid progression drives students, especially women and minorities, from optional maths and sciences courses". (Nappi 1990:79).

Parker (1984) overviewed the question of why so few girls pursued the physical sciences and outlined some possible explanations and suggestions about the way teachers might change the situation.

Smail (1985), in UK, described the results of a four year action research project (GIST) and investigated reasons for girls' under-achievement in science and technology and tested "teacher-developed strategies" for change. The project recognized the need for science and technology teachers to become "action researchers" in their laboratories and workshops for effective change towards "Girl-Friendly" Science and Technology.

Putting these Ideas into Action, Aids to Success for Gender Inclusive Science Curricula

Lewis and Davies (1988) have taken such suggestions and transformed them into a Professional Development package to assist the school, science and maths departments, Career Educators and Counsellors, and teachers to systematically plan, implement and evaluate (formative, diagnostic and summative) as "action researchers" to make these subjects "Girl Friendly".

Evaluation in the Broadest Sense: Major Considerations by Science Educators

(a) Research, Evaluation and the adequacy of the use of the Print (1987) and Wlodkowski (1982) models in the Curriculum Development for Girls.

(b) Evaluation and Equity (Harvey & Klein 1989; Klein et al 1985)

(c) Models, Check-lists and Guide-lines to evaluate Equity

(d) Major modifications for an Effective Curriculum for Girls (Newhouse 1990:Part2:9-10)

(e) Adopting an "action research" model (Whyte 1986), which requires stringent evaluation of all aspects of the science curriculum with a focus on input, process and output (Newhouse 1990:Part 2:10).

(f) Foci for Change in the Curriculum. (Newhouse 1990:Part2:29-34)

(g) Read the extended deliberation of Evaluation and Assessment in Mathematics, since the same dilemmas for girls apply in Science, particularly Physical Sciences (Newhouse Part 3 (1990) Mathematics Curriculum for Girls - Evaluation).

Evaluation at the School Level

Particularly in Terms of:

(1) Policy and programmes related to promoting gender equity in the school. (Lewis and Davies 1988: Worksheet 65:2). The importance of using an Action Research Planner (Lewis and Davies 1988: Case Study 9).

(2) Consideration for school organization and promotional positions that reflect an active concern for "changed structures" to promote gender equity

(3) Administrative support, especially the Principal and Deputy Principals, for changes in the curriculum to promote gender equity to be monitored. (Lewis & Davies 1988: Worksheet 66 'Roles')

(4) A need for Performance indicators for annual evaluation related to Equity. (Porter 1987; Harvey & Klein 1989) (See Newhouse 1990: Part 1:1-17 and Part 2:10).

(5) Monitoring collaboration between department in promoting gender equity.

(6) An annual report with submissions from each subject department in the school to evaluate gender equity initiatives in the school and to disseminate information to interested parties, including teachers, parents, administrators, counsellors, professional associations, state and federal education centres for promoting gender equity. (adapted from Jones & Newhouse 1984).

Evaluation in the Science Department

(1) Staff structure in science requires monitoring for gender equity and monitoring the visibility of women teachers in Upper School science and coordinator roles.

(2) Evaluating the current policy and programmes for promoting gender equity - (Years 8-12) and modifying in the light of experience, current research and state/national policies on the education of girls. (Lewis and Davies 1988:17)

(3) Monitoring the need for inservice programmes for new staff. (Lewis and Davies 1988:GAMAST and Case Study 119 "Designing Workshops")

(4) Providing support for teachers, especially women, to further their science qualifications especially in Physical Science (Kirkwood 1989:79).

(5) Monitor current attitudes and collaborative efforts of the department towards promoting gender equity. (Lewis and Davies 1988: Case Study 117-119).

(6) Head of department to gather information from staff with regard to "gender inclusive curriculum innovations" in their laboratory situations, excursions, community and industrial assistance (especially human resources).

(7) Submission of participation and retention rates of girls in science, maths, computer education and industrial arts in Year 10, 11 and 12. (Ref Girls Education Strategy NSW 1989).

(8) Classroom Data Collection - Strategies for Science teachers initiating Gender Inclusive Curriculum, eg:

Survey Questionnaires
Interview
Check-list
Journals and Diaries
Creative Writing
Videos, tapes, photographs
Drawings
followed by analysis.

(Lewis & Davies 1988:A27).

(9) Planning for Special Science Events. (Lewis & Davies 1988 : Case Study 89)

Evaluation in the Laboratory Setting for Gender Equity

(1) Self Assessment of personal values and beliefs in relation to promoting gender-equity in the laboratory (Newhouse 1990:Part 2:33)

(2) Self-assessment regarding a knowledge of the underlying philosophy of Science and feminist perception of Scientific Knowledge (Newhouse 1990: Part 1:66-80, Part 2:26, Part 3 The Nature of Science).

(3) Realistic assessment of professional needs and skills required to promote gender equity in the laboratory. (Lewis and Davies 1988 eg. Inclusive Curriculum Check-list).

(4) Assessment of teaching resources for gender bias and lack of visibility of women and girls. (Lewis & Davies 1988:12) (see Newhouse 1990: Part 3 pp 88-95

(5) Assessment of Classroom Interaction and Gender bias. (See Newhouse 1990; Part 3 pages 98-101) (Lewis and Davies 1988:Case Study 46-47 Videoing a Class to explore class interaction and tally sheet).

(6) Assessment of Teaching-learning strategies in promoting learning of all students in a gender-inclusive environment. (Lewis and Davies 1988 Worksheets 57-59).

(7) Assessment of Group Processes by teacher, the group(s) and individuals. (Lewis and Davies 1988 Case Study 101-106).

(8) Evaluation of the efficacy of assessment of students in the laboratory, where equity and excellence are prime considerations. (Lewis & Davies 1988: Stages in Learning a New Skill W.Sheet 107).

(9) Evaluation of visits by achieving women scientists, non-traditional career people, conferences, work experience, special science days. (Lewis & Davies 1988)

(10) Parent-Daughter Evening (Lewis & Davies 1988: Case Study 137)

(11) Realistic assessment of careers for boys and girls (Lewis & Davies 1988; Michael & Michelle)

(12) Career Development (Lewis & Davies 1988: Case Study 120-137).

<u>Evaluation of Students in the Science Setting</u>

<u>Assessment in Gender Inclusive Science - questions to ask</u>

<u>Will assessment be</u>:

integrated?
non-competitive?
by peers?
incorporating student goals?
through self-evaluation?

(From check-list for including women and girls Davies & Lewis 1988:A-59)

<u>Class Profiles</u>

Barnes, Plaister and Thomas (1984) produced class profiles focussing on Sex of Pupil, Knowledge, Confidence, Ability, Level of Responsiveness, Level of Attention Seeking, others, admitting:

"I know least the average, undemanding girl" (See also Lewis and Davies 1988:A-39 'Remembering about Girls in Science' Teacher Check-list).

Data Collection in the Classroom by the Teacher

'Draw a Scientist'

A useful exercise to establish the level of sex role stereotyping evident in a student's perception of a scientist (Lewis and Davies 1988:5 and Worksheet A-24).

Early Socialization Check-list

Personal data collection and for raising student awareness of early socialization with regard to play interests, toys, social interaction, expectations and values of parents for their future life chances as boys and girls (Lewis & Davies 1989:Worksheets).

Designing Check Lists for Including girls (Quantitative evaluation) (Lewis and Davies 1988:8)

Keeping a Journal or Diary for Qualitative Formative Evaluation (Lewis and Davies 1988:9)

To contribute to final report, particularly useful for "affective"/volitional assessment.

Negotiated Curriculum in Science

1. Linking Learning and Assessment:
   Goal based assessment (Lewis and Davies 1988 - Worksheet 59)

2. Contracting by Student:

   (Student Record Sheet - Negotiated Curriculum includes work requirements, goals, due date, signatures, student and teacher comments. (Lewis & Davies 1989:Case Study 61).

3. Formative and Diagnostic:

   Evaluation by the teacher (Lewis and Davies 1988 : Worksheet 57 includes Work Comments, corrective comments. grades given. average grades, science skills of the student.

4. Goal-Based Assessment by the Student
   (Lewis and Davies 1988 - Worksheet 59).

   Student's assessment of Goals, Tasks, who worked with whom, successes, how things could have been better achieved, "I learnt", plus any illustrations. Also include peer and group assessment, where appropriate. (Lewis and Davies 1988 : Case Study 64).

5. Cooperative Learning may be Incorporated into Negotiated Curriculum

   Hence teacher, peer and group assessment is essential. (Lewis and Davies 1988:29-33 and Case Studies 101-106 are Check-lists for assessment by teacher, group, self - both formative and summative).

   (a) Teacher
       (i) Quantitative - Lewis & Davies (1988), and

(ii) Qualitative comments in an anecdotal journal are invaluable for intervention and professional development, for example:

"Patience of boys with other boys in problem solving - did not allow the same degree of thinking space to a girl later "helped" - hardly allowed any touching of "resources" - solved problem - allowing hardly any active part by girl" (IlEA 1984)

6. Skills Test in Science - Teacher assessment emphasising knowledge, application, process and "List, draw, describe, practical setting up and working through experiment" (Lewis and Davies 1988 : Worksheet 58).

7. Negotiation of Final Assessment

The most suitable form of assessment may be negotiated with the students, but to be inclusive of the skills of all students should include:

- A practical test

- A formal test containing a balance of:
  - descriptive questions
  - written answer question which ask the student to solve a problem.
  - mathematical questions to be used in moderation

Creativity in Science - initially incorporated into the science curriculum for girls to improve their attitudes to science. Creative products were especially encouraged in lower school science for girls, for example.

creative poems, art, essays - "not just addressing social and historical issues", but "can provide for exercises with chemical formulae, biological pattern or physical principles". Stocklmayer (1989:77).

Assessment of the Creative Process and Product

(a). Imaginative Writing:

Groves (1984) provides a Check-list on what to look for in an imaginative essay - namely originality, effort, understanding of science concepts, degree of scientific consistency, personalization. (Lewis and Davies 1988:A-80).

(b) Dramatic Science

Inspired by Einstein's experience with regard to synthesizing his Theory of Relativity, students are encouraged to plan and act out models of scientific phenomena. After the performance they check-list:

How valid is our dramatic model?
How does it compare with the text book model?
Which is most useful?
Why do we use scientific models?
Are any models a true representation of a scientific concept?

(From McClintock Collective Getting into Gear in Lewis and Davis 1988: Worksheet 72)

Evaluation of a Unit of Study

Assessment should occur throughout a unit, including student self assessment. One needs to be cautious of this process with girls, they tend to undervalue their achievements and set extremely high standards for themselves.

An Example of Assessment from a "You and Your Machine" Unit (GEMS Vol 1, No.1,36.)

The form of assessment can vary but should reflect the variety of activities engaged in during the unit. These can be drawn from:

- a written report
- an oral report
- model building
- an interview with the student
- a report of a student interview with a person outside school
- an oral/visual presentation to the class.

Evaluation of Visits by 'Achieving Women Scientists and Technicians' and Women in Non Traditional Trades

Whyte (1986:70-78) provided a useful template for evaluation of such intervention for boys and girls. Both science teachers and visitors kept 'anecdotal' records, for example:

> "it brought science alive for girls"
>
> "The visitors did not represent as wide a spread as we would have liked" (p70)
>
> "it led to heart-searching and deep reflection on their careers in science and technology" (p71)
>
> "The domination of boys had to be monitored in question time, girls in single sex groups were more communicative" (p78).

N.B. Currently in WA, "Trades women on the Move' are visiting all high schools (Troy, G. (1990:16) - and could be monitored for success by the schools.

Evaluation of Single Sex Grouping or girls' only clubs for compensatory, three dimensional activities and physical science

Catton cited in Whyte (1986) evaluated the progress of girls in 'Industrial Arts' girls' only clubs and observed the raising of confidence, competence in skills, enjoyment and freedom of harassment from boys. Spatial abilities were improved and transferred to mathematics and science.

Evaluation of Excursions, Visits, Special Events in Science by Students (Lewis and Davies 1989) is important:

COUNTERING GENDER BIAS IN ASSESSMENT AND EVALUATION IN SCIENCE

(1) Developing Teacher Awareness to Differential Teacher Expectations of boys and girls in Assessment of Written Reports on Science Practicals

Spear (1984) used an adaptation of the classic Rosenthal and Jacobson (1968) experiment by getting moderators to mark reports on science practicals. Results indicated that identical science reports were given a statistically higher mark when they were purportedly written by boys. Teachers need to be aware of such sex stereotypic bias. (Lewis & Davies 1989 Inclusive Check-lists).

Teacher Sensitivity to Sex Differences in Responding to Various Types of Questions under Examination Conditions

(a) Harding (1981) showed that boys tend to achieve higher marks in multiple choice papers and girls in essays, while structured questions appeared to show the least bias. There is a need to carefully balance the types of questions, the context and setting. (See Preferred Learning Styles).

(b) There may also be a need for an intervention strategy to improve pupils' attitudes towards examinations and assistance in improving their performance.

(c) Castenell (1987) noted the mismeasurement of low income black students in America, which has implications for Aboriginal groups and girls of low income groups, their academic placement and future adult roles in the family and workplace. It was proposed that:

- teachers be in-serviced in 'raising expectations' and 'developing awareness of the face validity of items'
- parents be in-serviced in motivating and encouraging 'test readiness'
- students attend workshops for 'test wiseness' information
- all participants be encouraged to evaluate the workshops.

A Current Issue is Girls' Age and Aspirational Readiness for Major Examinations

GIST action research in UK (1979-84) hinted that girls may be ready a year earlier than boys for public examinations. This is further supported by Kfir's (1988) Israeli research where girls "slow back" for boys at 17 years of age.

Love and Wild (1989) with a case study in UK, concluded that "Girls would probably do better if their course and final examination in lower school Chemistry were brought forward possibly by one year".

PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS

> "The history of science teaching is littered with lost opportunities to help the construction of a better world" (Bernal 1939, 1946 cited in Cross 1989)

Introduction

The high point of the past twenty-two years of Gender Inclusive Curriculum Development especially for Women Science teachers has been in classrooms or laboratories where sincere practice, reflections, evaluation and feedback to "women's networks" has led them back to the classroom again - refreshed, uplifted, more confident, building up observation skills, a new philosophy of science, knowledge of self, increased scientific knowledge, a variety of teaching strategies and improved evaluation techniques.

It is essential in the 1990's that both men and women in Science Education be committed to professional development in achieving gender equity and a new conception of science (Keiler 1988; Cross 1989).

Urgency to tap the "reservoir of scientific talent of Girls in Australia in 1990

Proposals to achieve this goal with the focus on the science teachers

1. Pay increases for science and mathematics teachers to attract talented people to the profession. (Victorian Government proposal Button 1987:3)

2. Multifarious strategies to increase the number of girls in maths, science and technology (Hildebrand 1989:7-16; de Laeter et al 1989:31)

3. A "shake-up" in teacher training with regard to gender inclusive curriculum (Button 1987:3) and action research by Science Educators. (Kent Street Senior High School 1990).

4. Inservicing teachers as effective science educators in primary and early childhood science and technology. (Kirkwood 1989:79; Rennie Parker and Hutchinson 1985).

5. Practising science teachers to be effectively inserviced in Equity issues (Klein 1985), and promoting gender inclusive curriculum as part of a whole school approach to equity (GAMAST 1988; PEP 1987); and to evaluate equity in terms of access, participation and outcomes (Secada 1989).

6. Active involvement of science educators and teachers in curriculum development, particularly in the physical sciences for gender inclusiveness at state-wide and Australia wide levels (Beruldson 1989:57; Dangerfield 1989:55).

7. Action research as a whole school approach is a powerful means of professional development. The GIST project in UK "clarified and illuminated both the research and action needs for gender equity in schools, such that future work on both fronts may be better informed and ultimately enriched" (Whyte 1986:266; Kelly 1985b). An intended outcome of the original action research design was achieved where changes in science teachers' consciousness to the gender issue led to subsequent modifications of actual classroom practices ... and "they began operating as classroom researchers in the field of gender in their own right" (Hustler 1985) cited in Whyte (1986:261).

8. Role modelling by science teachers committed to Gender Equity by developing a project with these committed volunteer teachers "even if they were scattered thinly across schools". The aim would be "to test out strategies and examine how these have worked in favourable conditions. Dissemination would concentrate on showing what could be done, and creating an educational climate where other, less committed teachers felt they could and should do the same". (Kelly 1985a&b) in Whyte 1986:269). This has very much been the approach taken during the 1980's in Australia where networking is a vital component. (The McClintock Collective 1989:128-138).

9. Needs-based practical workshops on ways to make science more relevant and appealing to girls (The McClintock Collective 1989:133-134).

10. Development of curriculum resource materials by science teachers, for alleviating bias and increasing visibility of women and girls, is a positive form of professional development.

<u>Evidence of Two Successful Inservice Programmes - in the early eighties</u>

<u>Biddulph and Osborne</u> (1984) outlined an interactive approach developed at the Science Education Research unit at the University of Warkato (Learning in Science Project). Aims were clearly set out, workshops organized with continuing 'networking' support. An approach now adopted by Canberra. (Kirkwood 1989).

<u>Rennie, Parker and Hutchinson</u> (1985) developed, implemented and evaluated an inservice program to facilitate a non-sexist approach to the teaching of science in primary schools in Western Australia. The project found that teachers reported increased confidence, knowledge and skills in teaching electricity and changes in their awareness of the problems of girls in science.

The experimental group were also inserviced to assist them in creating and maintaining a non sexist environment in their science classes. Their children's attitudes became less sex stereotyped and interactions in mixed sex groups enabled girls to participate more equitably in science activities.

<u>Professional Development Initiatives for Science Teachers at the Systems Level</u>

"Plan to lift Science and Maths teaching"
<u>The Age</u> October 24:3 1987.

1. There have been three major catalyst groups, in Victoria, namely:

The McClintock Collective 1983
The GAMAST Project 1988
PEP Schools Resource Program 1986-87
(Peck and Dick 1989:65)

GAMAST and PEP have enabled the schools and participant teachers to explore change over a significant period of time. Time to raise awareness, develop and trial new approaches, reviewing and trying again and time to document their findings. Teaming with other

schools and project coordinators has created the supportive climate essential when teachers are encouraged to take "professional risks". Peck & Dick (1989).

The GAMAST Professional Development Book, that resulted, is an ideal starting point for schools in their action research (Lewis and Davies 1988).

The McClintock Collective produced Getting in Gear in 1989 to facilitate girls' learning in the Physical Sciences.

2. In New South Wales, GES Inservices 1990 has been established including workshops related to:

   - The Neuter Computer and Equity of Access by girls
   - Teaching strategies for Maths, Science and Industrial Arts teachers to promote group work and inclusive classroom methods.
   - Inservicing Career advisors to plan strategies to broaden girls' work experiernce and career options
   - Head teachers and promoting student welfare for girls (Bates 1989:81).

3. In Western Australia, 1989, a "Girls in Maths, Science and Technology Reference "Group has been established by the Ministry of Education to collate information regarding initiatives in the area, to review the gaps and to decide on practical directions. The group includes policy consultants, curriculum project team members, teachers, district office personal and representatives from tertiary institutions. (Lymon 1989:82)

4. Kirkwood (1989) outlines a year long inservice project in Canberra whose goal is:

   "to improve teaching and learning in science and technology of girls and boys by increasing the number of primary and early childhood teachers who are effective science educators" and is based on the Biddulph and Osborne (1984) interactive approach.

Teacher Education and Professional Development for Science Teachers at the School Level

Workshops and action research related to teacher attitudes and Girls in Science

The adoption of a 'caring' morality, almost actively demands that science teachers closely examine their attitudes, feelings and expectations towards girls. Professional Development of teachers, then, has over the years become an essential component in developing a curriculum for girls. It would seem to me that it is absolutely essential for teachers to examine stereotypic or inequitable attitudes that they hold with regard to gender, race and ethnicity particularly in the masculine areas of science, maths, computing and industrial arts.

"When non-conscious attitudes are expressed, they immediately touch the conscious awareness of others, and reaction against the stereotype emerges rapidly" Block (1984) ... this has consequences for our own personality development as science teachers and people.

What can be done?

(a) Teacher Education requires the inclusion of modules related to gender equity, where student teachers have the opportunity to examine their own attitudes and to create awareness of sex stereotypic influences on personality development (reference EDU 2400 WA College Nedlands 1990).

(b) Workshop for teachers as part of initial orientation to action research in school for achieving gender equity.

Workshop and Action Research Related to Teacher Beliefs and Expectations and the effect on girls' confidence, competence, self esteem in science and aspirations for the future.

"If teachers beliefs are important influences on how they interact with and teach their students, then these teachers' beliefs could be seen as an influence on the development of gender differences in Mathematics" and Physical Sciences. (Fennema et al 1990).

As David Hargreaves wrote in 1972:

"A teacher's behaviour is like a stone dropped in a pond. It sends out ripples which affect areas that were not part of the original target" (Hargreaves D. 1972:134).

Teacher beliefs and expectations of girls in Science, Mathematics and other "masculine" disciples must initially be identified, aired and matched with the myths related to girls' potential and achievements. (Shegog 1989:21-26).

This may be achieved in initial teacher education modules and/or as part of initial workshops before implementing a gender inclusive curriculum.

The need for Action

"Action is urgently required to redress the neglect of girls in classroom practices, to remove the limitations placed on girls' aspirations, competence and opportunities". (Girls & Tomorrow 1984 :vii).

Klainin (1988) and Parker and Offer (1989) found that when Teacher Expectations of girls are high, girls achieve at least equally with boys in Physics, Chemistry and General Science.

Workshops and Action Research that focuses on Teacher-Pupil Relationships in the Laboratory

"the ability to engender a positive and warm relationship with students again proves to be the most important factor in promoting changed attitudes" (Foster 1989:37).

Teachers need research evidence on gender biased classroom interaction through workshops or in their initial teacher education (Stanworth 1981; Spender 1980, 81, 82) to develop skills in recording, monitoring and changing gender biased behaviour which has been found to be deleterious to all aspects of development in girls. Finally to put small changes into effect in their laboratory setting. (Doenau 1989).

Workshops and Action Research related to eliminating gender bias in Science Resources and increasing the visibility of women by including 'herstory' and contributions of women to science (Rennie and Mottier 1989, Lewis and Davies 1988)

Workshops and Action Research to Incorporate Teaching Strategies that:

(a) match preferred learning styles of boys and girls (Galton 1981; Sjoberg 1989)

(b) encourage cooperative, collaborative group work (Hildebrand 1989; Lewis and Davies 1988)

(c) incorporate strategies to enhance creativity, through writing, poetry, art, drama and constructive tinkering. (Hildebrand 1989; Groves 1984; Lewis and Davies 1988).

(d) facilitate negotiation, goal setting and progressive assessment (Lewis & Davies 1988).

Workshop to Alert Teachers and/or Intending Teachers to the "Masculine" Nature of Science, the reductionist philosophy of traditional science and the need for a holistic approach to science with its concern for human dignity and the care of the world environment (Cross 1989).

Workshops to develop effective assessment and evaluation skills, free from gender bias

Action research to help students and groups of students in realistic self evaluation particularly in the context of negotiated curriculum. (Lewis and Davies 1988).

Workshop that introduce teachers to the latest curriculum developments; projects; evaluation instruments, reports in Gender Inclusive Curriculum and linking teachers to state networks. (The McClintock Collective 1989).

Accessing to the School Library

Journals such as GEMS; joining the mailing list of newsletters, such as GEN; reading the current Australian Science Teachers' Journal (ASTJ Vol 35, NO.3, Special Gender Inclusive Edition) and WA Education News (Ministry of Education Perth).

Newsletters and "Staffroom talk" that include all teachers in the school to share information, to exchange news of successful innovations in promoting equity in the school. Promoting the notion of integrated curriculum and thematic organization of content. (Lewis and Davies 1988).

Workshops to link Science Education with Career Education, especially for girls

(a) formal interviews and (b) incorporating into the science units. (See ASTJ, Vol.35, No.3, GES Inservices 1990).

Workshops that help teachers, administrators to collate annual reports related to improvements to Gender Equity in schools, to be disseminated to the community and interested gender equity networks. (Lymon 1989).

RECOMMENDATIONS - SCIENCE EDUCATION FOR GIRLS - Towards a Gender Inclusive Science Curriculum

It is recommended that Tertiary Educators in their education of Science Teachers provide:

- preservice education courses for teachers of all levels of science for promoting gender equity, attitudes, expectations, skills, knowledge and competencies for the laboratory.

- provide professional development courses for teachers of science, including those particularly related to gender issues, transformative teaching capabilities and expertise in evaluation for equity.

- provide support for science teachers in promoting gender equity in schools, by establishing networks between the Ministry, Tertiary Institutions, Industry and the Schools.

It is recommended that Science Educators and Teachers:

- be committed to transforming a science curriculum that for generations has devalued women, their scientific talent and moral concerns (Whyte 1986; Kelly 1985)

- become aware of the problem of creating equality within a flawed system, that is one which requires the re-evaluation of the 'culture of science' (Cross 1989).

- familiarize themselves with a feminist conception of science, which is in harmony with the existence of life, is hopeful, creative and acknowledges human dignity in all people. (Bleier 1986).

- offer students alternative conceptions of what science can be like, by considering the possible outcomes of holistic and cooperative science and the revised roles for science in the post modern world that acts in the interests of humankind. (Cross 1989).

- have a vision of the scientist and technologist for the 21st century so that as curriculum developers they may meet the long term goals of science education. (Newhouse C.K. 1989).

- bring values and aesthetic valuing into science and technology. (Newhouse C.K. 1989).

- bring the creativity so evident in the arts (literature; multifaceted), music, art, homecraft) into the sciences and technology. (Ellyard 1988; Hildebrand 1989; Stocklmayer 1989).

- perceive science education as a life long process with special consideration of pre-primary, compulsory years 1-10 (with a bridge between primary (1-7) and secondary (8-10), the non-compulsory schooling (years 11 & 12) and post-school education at TAFE and tertiary levels. (ASTJ 1989, Vol.35, No.3).

- provide encouragement and maximum opportunity to early school leavers to develop their mathematical and scientific potential for personal competence and broadening employment options.

- encourage girls in upper school to develop positive attitudes towards the higher study of mathematics and the physical sciences, as essential pre-requisites for further study and careers in a technological world.

- actively encourage gifted girls to choose options, especially in non-traditional occupations, that are commensurate with their capabilities, taking care not "stereotype" giftedness in girls to a too narrow field of creative endeavour.

- examine hindrances to girls' achievements particularly in the physical sciences, in the interaction in the laboratory, practical work, problem solving and examinations with due regard to the research related to sex differences; cognitive/learning styles; spatial ability; science interests; sex stereotyped beliefs, aspirations, expectations in relation to science held by teachers, parents and girls, girls' anxiety, fear of success, fear of failure, adolescence and femininity conflict with scientist role.

- consider the preferred cognitive and learning styles of girls which tends to be "person oriented" and perceives science as a constructive human enterprise. (Sjoberg 1989; Foster 1989).

- cater for individual differences in intellectual and creative ability; and interests of boys and girls particularly in upper school physics (Beruldson 1989).

- consider gender differences in relation to spatial ability and early childhood constructive play for future capability in science, maths and technology.

- plan to provide "tinkering" experiences for girls in science and practical experience in Industrial Arts throughout their schooling.

- plan a gender inclusive science curriculum as an integral part of a whole school policy and programme for equity.

- use an action research model, involving all science staff in planning, implementing and evaluating a gender inclusive science curriculum (Whyte 1986).

- are aware of the roles of other departments in the school in implementing equity programmes (eg. English Department).

- develop a healthy dialogue with other departments such as Home Economics, Industrial Arts and Health Education where science is taught.

- organize workshops and inservice programmes to meet the needs of science staff with regard to gender equity.

- closely integrate career education with science education, which may require professional development of science teachers, counsellors in the school, and administrators. (Mullins-Gunst et al 1989).

- encourage parents to be actively involved in gender equity science programmes; to raise their expectations of and aspirational levels of their daughters to become literate and competent in the physical and biological sciences. (Lewis and Davies 1989).

- are aware of current research and action research in establishing gender inclusive curricula in science and technology (Whyte 1986; ASTJ 1989, Vol.32, No.3.)

- develop plans to monitor progress towards equity in science with due regard to the roles modelled by male and female teachers in the department; timetabling physical sciences to facilitate girls' access to units of study; participation and retention rates; and outcomes related to post compulsory education, apprenticeships, occupations and careers in non traditional areas. (Harvey and Klein 1988).

- develop a consciousness towards bias in all resources by making a concerted effort to counter bias, whether of gender, racial or ethnic origin.

- develop a critical attitude towards gender bias in science textbooks, and materials they construct

- create an awareness in pupils of such bias

- scrutinize language in science text books and learned scientific treatises for gender bias and marginality of women scientists. (Sadkar and Sadkar 1988)

- create visual images that reflect active male and females in teaching materials.

- consciously include the past and present contributions of women in science.

- consider using a thematic approach to organizing content in science, to encompass social issues, creativity, real life context. (ASTJ, Vol.35, No.3.)

- select a variety of teaching strategies to match the content and objectives; and meet the needs of <u>all</u> students. (Lewis and Davies 1989).

- encourage a negotiated curriculum in the learning of science, which is in accord with girls' preferred learning styles. (Hildebrand 1989).

- develop skills to monitor all aspects of classroom interaction that may marginalize girls, with resulting lowered expectations, aspirations, lowered self esteem and reinforcement of a passive, 'learned helplessness' approach to science education.

- encourage and develop group and individual problem solving skills and strategies, where such processes are carefully monitored and assessed by teacher, pupil, group and peers where appropriate. (Lewis and Davies 1989).

- o create "girls only" groups at times to enable them to share experiences particularly in physical science, in a comfortable setting, without real or perceived harassment from boys. (Villiers 1989).

- o deal with boys' stereotyped views of science and sex roles (Whyte 1986).

- o think carefully about 'analysis of freedom' and making science compulsory in schools to broaden girls' life chances and options. (Issacson 1986; Parker 1989; Sjoberg 1989).

- o use assessment and evaluation techniques, that pay due regard to "contexts" that do not marginalize, exclude or hinder girls' achievement in science.

- o consider the timing of major examinations especially for adolescent girls at the zenith of their aspirational levels.

- o disseminate a report on progress in gender equity in science to the Principal annually.

REFERENCES - SCIENCE EDUCATION FOR GIRLS

Access to Science, (1989), South Australian Education Department, Adelaide.

Alic, M. (1986), Hypatia's Inheritance : A History of Women in Science from Antiquity to the late Nineteenth Century, Women's Press, Boston.

Allen, J.L., et.al., (1987), The Effects of Communication Avoidance, Learning Styles & Gender Upon Classroom Achievement. Paper Presented at the Annual Meeting of the Speech Communication Association, Boston MA.

Anderson, D. and Vervoorn, A. (1983), Access to Privilege Patterns of Participation in Australian Post Secondary Education, Canberra ANUP.

Annas, P., et.al., (1986), (eds), Women in Science special issue of Radical Teacher, 1986-30).

Apelt, L. (1989), Gender Inclusive activities in Queensland in Australian Science Teachers Journal. Vol.35, No.3:98.

Are Girls Calculating? (1986), Video, Ministry of Education, Perth WA.

Armstrong, K. et.al. (1987), Policy - Girls and Women in Science and Technology, Australian Science Teachers' Association.

Ashenden, D. and l'Ausou, H. (1983), The Democratic Curriculum, Focus Film Productions, Sea Cliff, SA.

Assessing & Reporting No.6, (1986), In Implementation of Ministerial Paper No.6, Victorian Ministry of Education.

Australian Committee on Technical and Further Education (1974), TAFE in Australia: Report on Needs in Technical and Further Education. AGPS Canberra.

ASTA (1987), Policy on Girls and Women in Science Education.

Barnes, M., Plaister, R., & Thomas A. (1984), (eds), Girls Count in Maths and Science: A Handbook for Teachers, Mathematical Association of NSW, Sydney.

Becker, J.R., (1981), "Differential Treatment of Females and Males in Mathematics Classes" Journal for Research in Mathematics Education, Vol.12, No.1, pp.40-53.

Beckham, J.C., Carbonell, J.L., & Gustafson, D.J., (1988), Are there Sex Differences in Problem Solving? An Investigation of Problem Context and Sex Role type. Journal of Psychology, Vol.122, 21-32.

Berryman, S.E. (1983), Who will do Science? Rockefeller Foundation, New York.

Berryman, S.E. (1985), Minorities and Women in Mathematics and Science: Who chooses these fields and why? Paper presented at the Annual eeting of the American Association for the Advancement of Science. Los Angeles.

Beruldsen, A. (1989), 'PHRED: Physics for Real Education in ASTJ, Vol.35, No.3.

Biddulph & Osborne, (1984), Making Sense of Our World, Hamilton NZ. University of Waikato, New Zealand.

Bindon, P.R., (1988), 'Science in Aboriginal Australia' in The Australian Science Teachers Journal, Vol.34,No.2.

Bleier, R. (ed), Feminist Approaches to Science, Pergamon Press.

Block, J. H., (1984), Sex Role Identity and Ego Development, Jossey Bass Publications, San Francisco.

Bone, A., (1983), Equal Opportunities Commission, Girls and Girls' only Schools: A Review of Evidence pamphlet, EOC, London.

Boudreau, F.A., Sennot, R., Wilson, M., (1986), Sex Role and Social Patterns, Praeger, New York.

Brenner, M. (1981), (ed), Social Method & Social Life, Academic Press cited in Lewis and Davies, (1988).

Brown, S. & Fitzpatrick, J. (1981), Girls, Boys and Subject Choice, Discussion Paper II, Education Department of WA.

Burfitt, H. (1988), The Contributions of Women to the Development of Australian Science and Technology. Australian Science Teachers Journal, Vol 34, No.3:31-37.

Burt, M.A. (1981), 'Workshops are never easy or are they? Counselling and Human Development, Vol 14, (1), 1-15.

Butler-Kahle, J. (1983), Girls in School: Women in Science Memeo, National Association of Biology Teachers, USA.

Butler-Kahle, J. (1985), Women in Science, Barcombe, Falmer Press.

Button, J. (1987), 'Plan to lift science and maths teaching' The Age, October 24:p3.

Byrne, E. (1979), Equality of Education and Training for Girls (10-18 years) Commission of the European Communities.

Byrne, E. (1982), The Economic & Social Case for Affirmative Action in Vocational Training, International Perspectives. Paper to Third Women and Labour Conference, Adelaide University.

Calabrese, A., et.al. (1984), Rainbow Shave Ice., Crackseed, & Other Ono Stuff, Sex Equity Goodies for the Classroom, EGO Project, Equal Goals in Occupations. Hawaii State Dept. of Education, Office of the Director for Vocational Education. Honolulu.

Calvert, A. (1978), Girls in Apprenticeships, Education Department of Victoria, Melbourne.

Castenell, (1987), The Mismeasurement of Low In-come Blacks : A Quadmire for Counsellors Conference Paper. Georgia (RIE Oct 1987).

Catton, J. (1985), Ways and Means: Girls in Craft, Design and Technology, Longman Harlow for the Schools Council.

Catton, J. (1985), cited in Whyte (1986), Girls in Science and Technology: the Story of a Project, Routledge & Kegan Paul, London.

Chandran, S. (1990), Australian Science in Schools Week, Theme Environment. October 15-19.

Charles, C.M. (1989), (3rd ed), Building Classroom Discipline, Longmans, New York.

Chisholm, L.A. & Holland, J. (1986), Girls and Occupational Choice - Anti sexism in Action in a Curriculum Development Project. British Journal of Sociology of Education, Vol.7, No.4.

Clarity Collective (1983), Taught Not Caught, Spiral Books, Melbourne.

Clarricoates, K. (1980), The Importance of being Ernest, Emma, Tom, Jane: the Perception and Categorization of Gender, Conformity and Gender Deviation in Primary Schools, in R.Deem, Schooling for Women's Work, RKP, London.

Commonwealth of Australia (1988), National Data Base on the Education of Girls in Australian Schools, NSW Ministry of Education & Youth Affairs, July Dr Helen Waite Compiler.

Commonwealth of Australia (1988), Girls in Schools, Report on the National Policy for the Education of Girls in Australian Schools. Australia Government Publishing Service, October. Coordinated by Officers of NSW Dept of Education.

Cooper, P. (1987), In or out of the Pumpkin Shell? Sex Role Differentiation in Classroom Interaction. Paper Presented at the Annual Meeting of the Speech Communication Association, 73rd Boston MA. Nov. 5-8.

Connell, W.F., Stroobant, R.E. Sinclair, K.E., Connell, R.W., & Rogers, K.W., (1975), 12 to 20 : Studies of City Youth. Hicks Smith, Sydney.

Cooper, N. (1969), 'The Education of Women in McLean D.' Its People that Matter, Angus & Robertson, Sydney, pp68-80.

Connor, G. (1990), Science Book 1, Science Press, Marrickville, NSW.

Cosgrove, S. (1981), Do you discriminate against girls in your classroom? SASTA Journal, No.813, p11-12.

Cross, R. (1989), 'Teaching Science for Humankind in a Sustainable Biosphere' in ASTJ, Vol.35, No.3.

Curtin University Prospectus (1989:2).

D'Alpuget, B. (1979), Jobs for the girls? How careers education can help. Australian Journal of Social Issues. 14(2) 103-11.

Dainton Lord (Chair) (1968), The Dainton Report: The Flow of Candidates in Science & Technology in Higher Education HMSO.

Dangerfield, E. (1989), Engaging Science: A CDC Science Technology and Society Project, produced in Association with ASTA.

Dart, B.C. and Clarke, J.A. (1988), Sexism in Schools: A New Look, Education Review, Vol.40, No.1, pp41-49.

Dale, R.R. (1969, 1971, 1974), Mixed or Single Sex School? Vols 1,2 and 3. Routledge and Kegan Paul, London.

Davidson, L. (1981), Learning Style: The Myth, the Panacea, The Wisdom. Phi Delta Kappan, May. pp 641-645.

Day, N.A. (1987), "Factors associated with student choice of Mathematics, Science and Technology" in Report of the Working Party on Education for Science and Technology. Improving the Science, Mathematics and Technology Education base in Victoria. Ministry fo Education, Melbourne, Victoria Part 4:1-29.

Deekers, J., de Laeter, J. and Malone, J. (1986), Upper-Secondary Science and Mathematics Enrolment Patterns in Australia, 1970-1985. Science and Mathematics Education Centre, Curtin University, Perth.

de Laeter, J.R. & Malone, J. (1989), 'Female Science Enrolment trends in Australian Secondary Schools' The Australian Science Teachers Journal, Vol.35, No.3, August. Special Issue: Gender Inclusive Science and Technology Education. pp.23-33.

Delamont, S. (1980), Sex Roles and the School. Methuen, London.

Dick, B. (1987), Tinkering, Lab Talk, 31 (5) 14.

Dick, D. (1987), Jobs for the Girls, Times Education Supplement Scotland, No.1087, Sept 4, A Comparative Treatment.

Discipline Review of Teacher Education in Mathematics & Science (1989), Vol. 1, Vol.2, Vol.3. Australian Government Publishing Service.

Dobry A.M. (1986), "Creating a Classroom of Equity: A Look at Teacher Behaviours", Illinois Teacher of Home Economics. Vol.30, No.2, pp.42-45, November-December.

Doenau, S. (1987), Are Teachers Fair to Girls? School of Education, MacQuarie University. pp.191-192. Edvance Publications Pennant Hills NSW.

Dufty, W.F. (1972), Entrance to Tertiary Education in Western Australia. Australian Journal of Higher Education, (4:235).

Dweck, C.S. & Bush, E. (1976), "Sex Differences in Learned helplessness: I Differential Deliberation with peer and adult evaluators" Developmental Psychology, Vol.12, No.2, pp.147-56.

Education Department of Western Australia (1980), Equality in Education with particular reference to women and girls (No.23) Policy from Director General's Office, Perth WA.

Edwards, E. (1985), Teenagers, Alcohol and Road-Safety Values Clarification Activities, Road Traffic Authority, Melbourne.

Eggleston, J., Galton, M. and Jones, M. (1976), Processes and Products of Science Teaching, Schools Council Research Studies, MacMillan Education.

Ethington, C.A. & Wolfle, L.M. (1988), Women's Selection of Quantitative Undergraduate Fields of Study: Direct and Indirect Influences. American Educational Research Journal. Summer. Vol.25, No.2, pp.157-175.

Ellyard, P. (1988), "Art, Science and Technology in Australia's Future". The Australian Science Teachers Journal. Vol.34, No.2.

Evans, T.D. (1988), A Gender Agenda: A Sociological study of Teachers, Parents and Pupils in their Primary Schools. Allen & Unwin, Australia.

Evans, T.D. (1989), 'Living Curricula' in G.C. Leder and S.N. Sampson (eds) Educating Girls: Practice and Research. pp.73-83.

Fennema, E., Peterson, P., Carpenter, T.P., & Lubinski, C.A. (1990), 'Teachers' attributions and beliefs about girls, boys and mathematics', Educational Studies in Mathematics, 21,1, 55-67.

Fitzgibbon, S. (1989), 'Tasmanian Schools Cooperate' in Leder & Sampson (1989) Educating Girls.

Foster, L.E. (1989), (2nd ed), Australian Education: A Sociological Perspective, Prentice Hall, Sydney.

Foster, V. (1989), Is Gender Inclusiveness Curriculum the Answer for Girls? in Leder, G., and Sampson, S.N., (eds), Educating Girls: Practice & Research, Allen & Unwin Australia. (pp32-34).

Fowler, R. (1987), Principles of Inclusive Curriculum in Towards Inclusive Curriculum in Maths and Science, p3, Melbourne Victoria Ministry of Education, Participation and Equity Program.

Frazer, B.J. & Giddings, G.J. (1987), (eds), Gender Issues in Science Education, Curtin University, Perth.

Frazer, S. (1982), SPACES - Solving Problems of Access to Careers in Engineering and the Sciences. Lawrence Hall of Science, Berkeley.

Galton, M. (1981), 'Differential Treatment of boy and girl pupils during science lessons' in A Kelly (ed), The Missing Half: Girls and Science Education, Manchester University Press. pp.180-192.

Garnett, P., Tyson, L., McGowan, M., Rennie, L., (1989), "A New Approach to Teaching Mechanics, or how to be a little cog in a big wheel". Paper presented at The Western Australian Science Education Conference, 22 September.

GEMS (1989), Gender Equity in Maths and Science Vol 1, (also 2-5) - a professional development magazine for maths and science teachers, career counsellors and equal opportunity advisors.

GES (Girls Education Strategy), (1990), Inservices, in Bates, M. (1989), 'Girls in Education in NSW', ASTJ, Vol.35, No.3.

Gianello, L. (1988), (eds), Getting into Gear: Gender Inclusive Teaching Strategies in Science Developed by the McClintock Collective, Canberra CDC.

Gold, K. (1990), Get thee to a laboratory, New Scientist, 14 April, pp.42-46.

Good, T., Brophy, J., (1987), (4th ed), Looking into Classrooms, Harper & Row Publishers, New York.

Goodings, A. (1987), "Role Play : Electro Chemistry" Lab Talk 31 (5), 15.

Goodwin, A.J., Hardiman, B. and Rees, V. (1981), "An Investigation of the Attitudes to School, Science and Science Lessons of 10-13 year old Children" Mimeo, Manchester Polytechnic.

Graf, R.C. & Riddell, J.C., (1972), Sex Differences in Problem Solving as a function of problem context. Journal of Educational Research, Vol.65, pp.451-2.

Gray, A. (1984), "Human Values in An Age of Technological Change". Paper Silver Jubilee Conference of the Australian College of Education.

Griffiths, D. and Saraga, S. (1979), Sex Differences and Cognitive Abilities: a Sterile Field of Enquiry? in O Hartnett, G. Boden and M. Fuller, Sex Role Stereotyping, Tavistock, London.

Groves, V. (1984), McClintock Memos, 4:18-21, Assessing Creative Writing.

Groves, V. (1987a) Tinkering in PEP (1987), Recreating Mathematics and Science for Girls, Melbourne PEP.

Groves, V. (1987b), Values Clarification, Lab Talk, 31(5)16-17.

Groves, V. (1989), 'Technical Skills for Girls', ASTA, Vol. 35, No.3.

Gunstone, R., & Mitchell, I, & Monash Children's Science Group (1989), Two Teaching Strategies for Considering Children's Science in What Research Says to the Science Teacher, pp1-12. International Council of

Associations for Science Education. Year Book No.2 cited in Lewis and Davies (1989).

Hacker, S.L., (1983), Mathematization of Engineering: Limits on women and the Field in Rothschild, J. (ed), Machina Ex Dea, Pergamon, London.

Hansot, E. & Tyack, D. (1988), Gender in American Public Schools:Thinking Institutionally in Signs, 113 (4).

Haralambos, M. (1985), Sociology and Themes, Bell and Hyman Ltd, London.

Harding, J. (1980), 'Sex Differences in performance in Science Examination' in R. Deem (ed), Schooling for Women's Work, Routledge & Kegan Paul.

Harding, J. (1981), 'Report on Science examinations and type of school' in Contributions: GASAT Conference: Eindhoven University of Technology.

Harding, J. (1981), Sex Differences in Science examinations in A Kelly, The Missing Half: Girls and Science Education, Manchester University Press.

Harding, J. (1983), Switched Off: the Science Education for Girls. Longmans for School Council.

Harding, J. (1986), Chemistry from Issues, in McClintock Memos, 5, 1-9.

Harding, J. (1987), Educational Links, 32, 12-14.

Harding, J., Hildebrand, G., Klainin, S. (1988), Recent International Concerns in Gender and Science Technology. Ed! Review, Vol.40, No.2.

Hargreaves, D. (1972), Interpersonal Relations and Education, Routledge & Kegan Paul, London.

Harpole, S.H. (1987), The Relationship of Gender and Learning Styles to Achievement and Laboratory Skills in Secondary School Chemistry Students. Paper Presented at the Annual Meeting of the Mid-South Educational Research Association, Mobile, Al, November.

Hart, C., (1987), 'A teaching sequence for introducing forces to Year 11 Physics Students" in Australian Science Teachers' Journal, Vol. 33, No.1. May.

Harvey, T. J. & Stables, A. (1986), Gender Differences in Attitudes to Science for third year pupils in Research in Science and Technological Education 4(2) 163-70.

Head, J. and Carre. C. (1974), (eds), "Through the Eyes of the Pupil: A Collection of Pupils' Writings." Science Teachers Education Project.

Henry, M., Knight, J., Lingard, R., & Taylor, S. (1989), Understanding Schooling: An Introductory Sociology of Australian Education. Routledge, NSW. Ch 5 & 6.

HMI (1979), Aspects of Secondary Schooling, HMSO, London.

HMI (1980), Girls and Science, HMI Series Matters for Discussion 13, HMSO London.

Hilbert, A. (1990), 'She's in her Element' The Times, September 18, p7.
Hildebrand, G.M. (1985), Girls in Science, Lab Talk, 29(3),9.

Hildebrand, G.M. (1989), Creating a Gender Inclusive Science Curriculum, The Australian Science Teachers' Journal, August Vol.35, No.3, pp 7-16.

Hutchinson, P. (1980), Western Australian State Schools, Women in Promotional Positions in the Primary Division' Social Sciences Forum, December.

Hyman, R.T., (1977), Paper, Pencil and Pennies : Games for Learning and having fun, Prentice Hall, Englewood Cliffs, New Jersey.

Isaacson, Z. (1986), Freedom and Girls' Education: A Philosophical Discussion with Particular Reference to Mathematics in Burton (1986) (ed), Girls into Maths Can Go. pp.223-240.

James, L., (1989), 'The Atoms Party' in ASTJ, Vol.35, No.3.

Johnson, L. & Hall, R.M. (1984), Selected Activities Using "The Classroom Climate: A Chilly One for Women"? Association of American Colleges, Washington DC. Project on the Status and Education of Women.

Johnstone, B. (1984), Technology: must the girls keep losing out. The Times, 6 November.

Jones, A.K., & Newhouse, L.P., (1981), A School-based Programme for Gifted and Talented Students. An account of an innovation, its implementation and evaluation, printed by Rossmoyne Senior High School.

Jones, A.K., & Newhouse, L.P., (1982), (eds), A School-based Programme for Gifted and Talented Students. Progress Report printed by Rossmoyne Senior High School.

A School level evaluation of the Gifted Student Extension Programme at Rossmoyne Senior High School.

A report submitted to the Commonwealth Schools Commission as part of their Projects of National Significance Programme, video tapes of organization, student/staff evaluation and processes together with products of excellence were also submitted.
Directors: A.K. Jones and L.P. Newhouse (March 1984).

Jones, A.K. and Newhouse, L.P., (1984), The Rossmoyne Model: A School Based Approach to Gifted Education, Printed by WA Education Dept, Perth.

Joyce, B. & Weil, M. (1980), (2nd ed), Models of Teaching, Prentice-Hall, New Jersey.

Kalia, N.N. (1986), From Sexism to Equality, New India Publications, New Delhi.

Keeves, J.P., & Reade, A.D., (1974), Sex Differences in Preparing for Scientific Occupations. IEA (Australia) Report, 6 : 1-35 ACER Hawthorne, Victoria.

Kelly, A. (1978), Girls and Science, Stockholm Almqvist and Wicksell.

Kelly, A. (1981), (ed), The Missing Half: Girls and Science Education, Manchester University Press.

Kelly, A., et.al., (1982), 'Gender Roles at home and School' British Journal of Sociology of Education, Vol.3, pp.281-295.

Kelly, A. (1985a), 'Changing Schools and Changing Society' in Arnot M (ed) Policy Making in Education, OUP Milton Keynes.

Kelly, A. (1985b), 'Action Research: What is it and What can it do?' in Burgess R. (ed) Issues in Educational Research: Qualitative Methods, Falmer Press, Brighton.

Kelly, A. (1985c), 'The Construction of Masculine Science', British Journal of Sociology of Education. Vol.6, No.2.

Kelly, A., & Smail, B. (1986), 'Sex Stereotypes and Attitudes to Science among 11 Year old children. British Journal of Educational Psychology, Vol.56:158-68.

Kelly, A. (1987), (ed), Science for Girls? Open University Press, Milton Keynes.

Kent Street Senior High School, (1990), Upper School Physics for Girls.

Kfir, D. (1988), Achievements and Aspirations among Boys and Girls in High School: A Comparison of Two Israeli Ethnic Groups. American Educational Research Journal. Summer Vol.25, No.2, pp213-236.

Kieler, K. (1988), Women Teaching for Change: Gender, Class and Power, Critical Studies in Education Series.

Kingsland, R. (1989), CSIRO Women in Science Project in ASTA, Vol.35, No.3.

Kirkwood, V. (1989), 'Primary and early Childhood Science and Technology Education Project'. The Australian Science Teachers Journal. Vol.35, No.3, August.

Klainin, S., Fensham, P.J. and West, L.H.T. (1989), Successful achievement by girls in physics learning. International Journal Science Education. Vol.11, No.1, pp.101-112.

Klein, S., Russo, L.N., Campbell, P.C. & Harvey, G. (1985), Handbook for Achieving Sex Equity Through Education, John Hopkins University Press, Baltimore.

Leder, G.C. (1989:84), Do Girls count in Maths? in Leder G.L. and Sampson S.N. (eds) (1989). Educating Girls: Practice and Research. Allen & Unwin, Australia.

Leder, G.C. & Sampson, S.N. (1989), (eds), Educating Girls: Practice & Research. Allen & Unwin, Australia.

Leggett, M., Lawson, G., & Miller, E. 'Fun with Physics' in ASTJ, Vol.35, No.3, p76.

Lewis, S. and Davies, A. (1988), GAMAST Professional Development Manual - Gender Equity in Mathematics and Science, Canberra CDC.

Lockheed, M.E., & Harris, A.M. (1982), Classroom Interaction and Opportunities for Cross Sex Peer Learning in Science. Paper presented at American Educational Research Association. New York. Mar 18-23.

Love, R.M., & Wild, B., (1989), A Case Study on the Relative Performance of Girls and Boys in Chemistry. Science Education Notes. SSR March 1989:pp 112-116.

Lymon, K. (1989), 'Girls in Education in WA'. ASTJ, Vol.35, No.3.

Lyne-Brown, R. (1973), A Chapter for Girls on You're Going to be What? Sydney Management Development Publishers, Sydney. p29-31.

Mahoney, P. (1985), Schools for the Boys? - Co-education Reassessed. Hutchinson in Association with The Explorations in Feminism Collective. London.

Mann, M. (1983), (ed), The MacMillan Student Encyclopaedia of Sociology, MacMillan Press, London.

Mares, P. (1989), 'Science' Gender and Curriculum in the University. Bibliography. The Gender and Curriculum Project Research Centre for Women's Studies. The University of Adelaide pp 103-109.

Marsh, H.W., Smith, I.D., March, M., & Owens, L., (1988), "The Transition from Single Sex to Co-educational High Schools : Effects on Multiple Dimensions of Self Concept and on Academic Achievements" (University of Sydney). American Educational Research Journal. Summer, Vol.25, No.2, pp237-269.

Martin, J. (1972), Sex Differences in Educational Qualifications in Selleck R. (ed). Melbourne Studies in Education, Melbourne University Press.

Martinez, L., Diamond, A., & Daws, L. (1989:58). A Rural Girls' Self esteem Project in Leder and Sampson Educating Girls'.

McDermott, M. (1983), The Impact of Classroom Interaction patterns on students' Achievements; Related Beliefs and Behaviours. Paper presented at the Biennial Meeting of the Society for Research in Child Development. Detroit, M1 April 21-24.

McPherson, M. (1989), An Engineer's Perspective, in Australian Science Teachers Journal, 35:3:117-118.

Meade, P.H. (1974), 'Adolescent Attainment of Educational and/or Occupational Status' PhD Thesis, University of New South Wales.

Ministry of Education, (1989), Inclusive Curriculum, Equity News, Ministry of Education, Perth. (extracted from: Inclusive Curriculum: Making the Change: An Initial paper to Support Schools. Ministry of Education, August 1988).

Mitchell, J., & Oakley, A. (1976), The Rights and Wrongs of Women, Penguin Books, Great Britain.

Morse, L.W., Handley, H.C., (1982), Relationship of Significant others, Parental and Teacher Influences to the Development of Self Concept; Science Attitudes and Achievement among Adolescent Girls. Final Report Mississippi State University, Bureau of Education Research.

Moss, J. (1982), Towards Equality Progress by Girls in Mathematics in Australian Secondary Schools ACER, Melbourne.

Moss, J. (1982), Sex Differences in Achievement in Mathematics at Year 12 in Australian Schools 'A Changing Picture' Research in Mathematics Education in Australia, ACER.

Mozans, H.J. PhD (1974), Women in Science. The MIT Press, London.

Mullins-Gunst, K. (1987), Female images in Australian Chemistry Textbooks, Contributions to the Third GASAT Conference (pp 212-221). Chelsea College, University of London.

Nappi, C.R. (1990), on Mathematics and Science: Education in the US and Europe. Physics Today, May. pp.77-79.

Newhouse, C.K. (1989), Engineering as a Career Option for Science Students' The Australian Science Teachers Association. August, Vol.35, No.3, pp.90-92.

Newhouse, L.P. (1990), Gender Equity: Retrospect and Prospect with Recommendation for the School of Education. Part 1 and 2 A Curriculum for Girls: Classroom Interaction and Gender Equity Bias in Materials and Use of Resources. Learning Styles - Implication for Teaching Strategies and Evaluation. Career Education. Part 3 See also Mathematics Education for Girls, Computer Education for Girls, Industrial Arts for Girls.

O'Barr (1988), Evaluating Course for Inclusion of New Scholarship on Women Association of American Colleges. Washington DC. Project on the Status and Education of Women.

Office of the Status of Women, (1983)(a), Meeting Young Women's Needs, Canberra.

Office of the Status of Women, (1983)(b), Women's Contribution to Economic Recovery, Government Information. Paper prepared for the National Economic Summit Conference, Canberra.

Ormerod, M.B. (1975), Subject preferences and choice in co-educational and single sex secondary school. British Journal of Educational Psychology, 45, pp.257-67.

Ormerod, M.B. (1981), Factors Affecting the Science Subject Preferences, Choices and Attitudes of Girls and Boys in Kelly, A. The Missing Half: Girls and Science Education. Manchester University Press.

Osborne, R. & Freybreg., (1985), Learning in Science. Heinemann cited in Lewis & Davies (1989).

Outram (1987), The Most Difficult Career: Women's History in Science in International Journal of Science Education 9(3).

Parker, L. (1984), Science for all? the role of science teachers in eliminating gender differences in access to scientific knowledge in Australian Science Teachers' Journal. 30(1).
Parker, L. (1986), Expert: Girls equal Boys in Maths. The West Australian, 26.5.86.

Parker, L. & Offer, J. (1987)(a), School Science achievement: Conditions for Equality. International Journal of Science Education. Vol.9, No.3, pp.263-69.

Parker, L. & Offer, J. (1987)(b), Girls, Boys and Lower Secondary School Achievement. The Shifting Scene 1972-86. Unicorn, 13,3:148-54.

Parker, L.H. and Offer J.A. (1989), In favour of Compulsory Science in G.C. Leder and S.N. Sampson (eds), Educating Girls' Practice and Research, pp.118-127. Allen & Unwin Australia.

Patterson, J. & Wallace, M. (1984), Girls and Education: A Second Class Experience in Pivot, 11,5,18-23.

Payne, G., Hustler, D., and Cuff, T. (1984), GIST or PIST: Teachers' Perceptions of the Project Girls in Science and Technology. Manchester Polytechnic.

Peacock, S. & Shinskin, (1983), Review of the "Insight Programme" designed to encourage girls to be engineers. Engineering Industry Board.

Peek, D. and Dick, B. (1989), What's been happening in Victoria for Girls Science Education? Australian Science Teachers' Journal. August Vol.35, No.3.

PEP, (1987a), The Bee Dance and Other Stories, Participation and Equity Programme, Melbourne.

PEP, (1987b), Recreating Maths and Science for Girls, Participation and Equity Programme, Melbourne.

PEP, (1987c), Up, Up and Away, Participation and Equity Programme. Melbourne.

PEP, (1987), Into Practice: Goal Based Assessment and Negotiated Curriculum. Participation and Equity Programme, Victoria.

Phillips, S. (1979), 'Prejudice in Middle Childhood: An Exploratory Study in Nesdale, A. (ed), Advances in Child Development: Theory & Research. University of WA 1981.

Polding, N. (1989), Equity News, Ministry of Education 1 (pp.21-26).

Porter, P., (1986), Gender and Education, Deakin University.

Poole, M.E. and Beswick, D.G., (1989), 'Girls Expectations' in Leder and Sampson (eds), Educating Girls Practice and Research. Allen & Unwin, Australia. pp.12-25

Powles, M. (1987), Women's Participation in Tertiary Education. Commonwealth Tertiary Education Commission, University of Melbourne.

Powney and Watts, (1987), Interviewing in Educational Research, cited in Lewis and Davies (1988).

Pratt, J., Seale, C., & Bloomfield, J. (1984), Option Choice: A Question of Equal Opportunity, NFER Slough/Nelson, Walton on Thames.

Radford, W. (1959-60), School Leavers in Australia, ACER, Hawthorn, Victoria.

Ramsay, E. (1983), "Language, Politics and Sexism in the Classroom". Education News, March.

Rennie, L.J., Parker, L.H., Hutchinson, P.E. (1985), The Effect of Inservice Training on Teacher Attitudes and Primary School Science Classroom Climates.

Rennie, L.J., Parker, L.H., & Hutchinson, P.E. (1985), Teacher Inservice as an Avenue to Equality in Science and Technology. New Directions in Education: Women's Role and Influence Women in Education Conference 10-11 April. pp. 61-71. Perth WA.

Rennie, L.J. and Mottier, I, (1989), Gender Inclusive Resources in Science and Technology. The Australian Science Teachers Journal. Vol.35, No.3, 17-22.

Rennie, R. (1989), "Microstat Satellite Receiver for the Apple IIe". The Australian Science Teachers Journal. Vol.35, No.3, August.

The Report of the Senate Select Committee on the Education of Gifted and Talented Children. Australian Government Publishing Service, March 88, Canberra.

Roe, R. (1988), Negotiation in Science Classes and Student Learning. Lab Talk, 32(4), 14-16.

Rosser, S.V., (1988), Teaching Science and Health from a Feminist Perspective: A Practical Guide. Pergamon, Oxford.

Rothschild, J. (1988), Teaching Technology from a Feminist Perspective: A Practical Guide. Pergamon.

Russel, S. (1983), Factors Influencing the Choice of Advanced Level Maths By Girls and Boys, Centre for Students in Science Education, Leeds University.

Senator Susan Ryan, (1987), Girls in Science, Position Paper.

Sadkar, D., et.al. (1984), Teacher Reactions to Classroom Responses of Male and Female Students. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans. LA.

Sadkar, D., & S, Sadkar, M., (1985), Is the OK Classroom OK?, Phi Delta Kappan, Vol.66, No.5, pp.358-61.

Sadkar, M. Sadkar, D., (1988), Equity and Excellence in Education Reform: An Unfinished Agenda. Position Paper.

Salner, M. (1985), Women, Graduate Education and Feminist Knowledge. Journal of Education. Vol.167, No.3, pp.46-58.

Sampson, S.N. (1974), 'A Problem in the Education of Women' Paper presented at a Forum on Changing Attitudes in Australian Education.

Sampson, S.N. (1982), The Role of Women in Leadership in Australian Schools' in Browne R, and Foster, L. (eds) (1983), Sociology of Education. MacMillan, Melbourne.

Sampson, S.N. (1986), 'Teachers Careers and Promotion in Australia' in Schmuck, P. (ed), Women Educators, University of New York Press, New York. pp.43-55.

Sampson, S.N. (1987), Equal Opportunity alone is not enough or why there are more male principals in schools these days: in Australian Journal of Education.

Sampson, S.N. (1989), Are Boys a Barrier for Girls in Science? in Leder and Sampson (1989), Educating Girls: Practice and Research. Allen & Unwin, Sydney. pp139.

Samuel, J. (1981), The Teachers Viewpoint - Feminism and Science Teaching: Some Classroom Observations in A Kelly (ed), The Missing Half: Girls and Science Education. Manchester University Press.

Schofield, Murphy, P., Johnson, S., & Black, P., (1982), APU Science in Schools Age 13, Report No.1, HMSO, London.

Schools Commission (1975), Girls School and Society, Report by a study group to the Schools Commission, November.

Schools Commission (1985), Girls and Tomorrow: The Challenge for Schools. The Report of the Commonwealth Schools Commission Working Party on the Education of Girls. January.

Science for Everybody? Towards a National Science Statement, (1988), CDC, Canberra. Dawkins challenging a narrow view of science teaching in an age when all must be literate in science and technology.

Scott, K.P.. (1980), Sexist and non-sexist materials: what impact do they have? The Elementary School Journal, 81, 47-52.

Secada, W. (1989), (ed), Equity in Education, The Falmer Press, UK.

Shannon, S.G., Sleet, R.J., & Stern, W. (1982), School students attitudes and choice of science subjects cited in de Laeter's article (1989:31).

Sharma, S., Meighan, R. (1980), Schooling and Sex Roles: The Case of GCE 'O' level Mathematics. British Journal of Sociology of Education, Vol.1, No.2.

Shegog, V. (1989), Equity News, Ministry of Education, pp 21-26.

Simon, S. Howe, L., & Kirschenbaum, H. (1978), Values Clarification - A Handbook of Practical Strategies for Teachers and Students, Hart Publishing , New York.

Sjoberg, S. (1989), Gender and Science Education: Interests and Career Choices in ASTA, Vol.35, No.3.

Skog, B. (1983), Circular Options - a Barrier against women's participation in scientific and technological work? in GASAT II (1983).

Sleet, R.J. & Stern, W. (1980), Student Selection of Science Subjects and Careers. Australian Science Teachers Journal, 26, 25-30.

Smail, B. (1983), 'Spatial Visualization Skills and Technical Crafts Education' Educational Research. November.

Smail, B. and Kelly, A. (1984), "Sex Differences in Science and Technology among 11 year old school children: I Cognitive". Research in Science and Technological Education. Vol.2, pp.61-76.

Smail, B. (1984), Girl Friendly Science: Avoiding Sex Bias in the Curriculum, Longman Harlow for the Schools Council.

Smail, B. (1985), An Attempt to move mountains: the Girls into Science and Technology Project in Journal of Curriculum Studies. 17(3).

Spear, M.G. Science Teachers' Perceptions of the Appeal of Science Subjects to boys and girls in International Journal of Science Education. 9 (3).

Spear, M.G. (1984), The Biasing Influence of Pupil Sex in a Science Marking Exercise. Research in Science and Technological Education 2(1) 55-60.

Speedy, R., (1989), 'Energiser: A Role Play' in ASTJ, Vol.35, No.3.

Spender, D. (1980), Man Made Language, Routledge & Kegan Paul, London.

Spender, D. & Sarah, E. (1980), Learning to Lose: Sexism and Education, The Women's Press, London.

Spender, D. (1981), Men's Studies Modified, Pergamon Press, Oxford.

Spender, D. (1982a), Invisible Women: The Schooling Scandal, Writers and Readers Publishing Cooperative, UK.

Spender, D. (1982b), Women's Ideas and What Men have done to them. Ark Paperbacks.

Standish, L. (1982), Women, Work and Scientific Enterprise, Science for the People 14(5) 12-18.

Stanworth, M. (1981), Gender and Schooling : A Study of Sexual Divisions in the Classroom. Reprinted 1987.

Stern, W. (1989), Chemistry Majors in Tertiary Studies: An update Chemistry in Australia 56, 136.

Stewart, H., Brown, S., Parker, L., Sherwood, L. (1981), Women in Education. A Report of the Women in Education conference. Perth.

Stocklmayer, S. (1989), Creativity and Girls in Science ASTJ, August, Vol.35, No.3.

Taylor, J. (1987), Sexist Bias in Physics Textbooks, Physics Education, 15,277-280.

Temple, D.M. and Parker, L. (1989), Scientist's Viewpoint in Australian Science Teachers Journal, Vol.35, No.3, 113-16.

The McClintock Collective (1989:128) 'A Science Teachers' Collective' in Leder and Sampson (1989).

Thompson, P.J., (1987a) Emancipatory Education: is Home Economics the Missing Link? Journal of Home Economics Education, Vol.XXVI, No.3. September.

Thompson, P.J., (1987b), "Beyond Gender: Equity Issues for Home Economics Education" Theory into Practice, Vol XXV No.4.

Tobin, K. (1987), "The Role of Wait Time in Higher Cognitive Level Learning", Review of Educational Research, Vol.57, pp.69-85.

Tobin, K. (1987), Gender Differences in Science? They Don't Happen Here! Paper. Science & Mathematics Education Centre, WAIT.

Towns, D. (1985), The Responsibility to Educate Girls for a Technologically Oriented Society. Equal Opportunity Unit. Education Department, Deakin University Press, Victoria.

Trotter, R.J. (1986), 'Profile Robert J. Sternberg: Three Heads are Better than One' Psychology Today, August, pp.56-62.

Troy, G. (1990), 'A Friend in the Trade', The Times, September 18, p.16.

Universities Commission Australia, (1974), Open Tertiary Education in Australia: Final Report of the Committee on Open Universities, AGPS, Canberra.

Vasey, J. (1989:98), 'The Family Maths Project' in Leder and Sampson, (1989).

Walford, G. (1980), Sex Bias in Physics Textbooks, School Science Review, 62:pp.220-7.

Walford, G. (1983), Science Education and Sexism in the Soviet Union. School Science Review, Vol.65, No.231, pp.231-24. December.

Wallsgrove, R. (1980), The Masculine Face of Science in Brighton Women and Science Group Alice Through the Microscope Virago, London.

Ward, R. (1983), Wasted Potential TES 4th November.

Ward, R. (1986), 'Girls and Technology' in Burton (eds) (1986b) Girls into Maths Can Go, Holt, Rinehart & Winston, London.

Ware, N.C. & Lee, V.E. (1988), "Sex Differences in Choice of College Subject Majors" American Educational Research Journals. Winter, Vol.25, No.4, pp.593-614.

Weiler, K. (1988), Women Teaching For Change: Gender, Class and Power, Bergin and Garvey, Critical Studies in Education.
Weiner, G. (1985), Just a bunch of Girls. Open University Press.

Welch, W.W. (1985), Sugar and Spice and All Things Nice? Australian Educational Researcher. 12(2), 5-23.

Whyld, J. (1983), (ed), Sexism in the Secondary Curriculum, Harper Row, London.

Willis, S. (1989), Real Girls Don't Do Maths: Gender and the Construction of Privilege, Deakin University Press, Geelong, Victoria.

Willis, S. (1989), The Education of Girls in Mathematics and Science, Curriculum Perspectives, 9, 1, 21-26.

Wilson, H.T. (1989), Sex and Gender, E.J. Brill Leiden, The Netherlands.

Wilson, K., Boldizar, J. (1990), Gender Segregation in Higher Education: Effects of Aspirations, Mathematics Achievement and Income. Sociology of Education, 63, 1, pp.62-74.

Women in Science, (1988), Pic-a-print of 12 large coloured photographs to be used with existing photographs of men in labs, for displays, for career education lessons. Education Production Services, South Australia.

Whyte, J. (1984), Encouraging Girls in Science & Technology, Some European Initiatives. (UNESCO Science & Technology in Education, Vol.7).

Whyte, J. (1985), 'Girl Friendly Science and the Girl Friendly School' in Whyte, J., Deem, R., Kant, L., and Cruickshank, M. (1985), Girl Friendly Schooling Methuen, London.

Whyte, J. (1986), Girls into Science and Technology: the Story of a Project. Routledge & Kegan Paul, London.

Yates, L. (1985), "Is Girl-friendly schooling what girls need?" Whyte et.al (1985), Girl Friendly Schooling, Methuen, London.

COMPUTER EDUCATION FOR GIRLS:

> "Institutions, books, education, society all go on training human beings for the old, long after the new has come". (John Stuart Mill 1869)

> "Equity is what we do to achieve equality of outcomes concerned with training for non-traditional occupations and, an important precursor is to increase girls' computer participation". (Sanders in Secada 1989:158).

SITUATIONAL ANALYSIS: (using Print's (1989) Curriculum Model, Wlodkowski's (1981) Affective Model and Harvey and Klein's (1989) Measuring Equity in Education Model)

Systems Level:

Concern that senior level girls are much less likely than boys to study subjects such as mathematics, science, computing and technical subjects which would qualify them for many of the jobs being created through technological change (Sanders 1989:158).

In 1982, less than 2% of 140,000 Apprentices (excluding hairdressing) and only 3.6% of Engineering and Technology tertiary students in Australia were women (MacPhee 1982:7). Newhouse (1989:91) has demonstrated that numbers of women engineering students have increased to 10%, with up to 35% in Chemical Engineering and adds that the quality skills of women engineers are much sought after by employers. However, Towns (1985:40) has noted a backlash against sex equity in apprenticeships. Sanders (1989:158) provides statistics from USA Department of Labour 1987, that affirm Australia is falling behind the United States in the percentage of women in Technology occupations. Men in the USA still out-earn women in every occupation listed by Sanders.

1. Technology is having an adverse effect on the kind of work in which a large number of women are traditionally employed.

2. School leavers who are confident in computers will be better prepared to venture into jobs which involve computers and other sophisticated machinery. Therefore it is important that all pupils become involved with computers at school. (Johnstone 1984).

3. Need for equal access to computer facilities. Major concern of Victorian Education Department (1982) because computers play a fundamental role in this age of technology and if girls are not involved they will be left behind, will lose jobs and not be qualified for new jobs. (Johnstone 1984; Sanders & Stone 1986; Towns 1985).

4. Timetabling, language used, software purchased, classroom dynamics must all take into account counter-sexist strategies to enable equal access to learning in computer education. (Towns 1985:16).

5. All curriculum areas are gradually requiring computer skills. Therefore girls must not be disadvantaged in "traditional" feminine areas, like history and geography, because they lack the skills and positive attitudes towards computers and computing. The need for affirmative action must be practised in Computer Education in its broadest sense. (Evans & Hall 1988).

6. Issues that require attention include lack of confidence amongst girls, classroom dynamics, lack of female role models, factors related to girls' experience, interests and perceived futures, stereotyped views about girls' skills and abilities, inappropriate content or methods and location of the course both physically within the school and on the time table. (Burton et.al. 1986:123.139; Lawrence 1981).

7. Student anecdotes suggest female are already beginning to develop negative attitudes towards computers and computing in spite of the relatively recent introduction of the new technology into many schools (Burton et.al. 1986). Lockheed & Frakt, (1984) provide evidence of the emerging stereotype of computers as male machines.

8. Sarah Goodwin (1984) points out that girls may find the "social environment" infinitely more fascinating to study in, than the "computer environment". She cautions that boys should also discover the social environment as girls discover the computer world to develop 'both sides of intelligence". Girls are not as intrinsically.motivated in computers as boys; for boys it is a real interest area. (Oliver R. 1989).

9. School computing needs a better image and more female involvement could have a beneficial effect for both women teachers, girls and the subject matter taught.

10. Lyotard's (1985) disturbing statement needs serious consideration, "to the extent that learning is translatable into computer language and the traditional teacher is replaceable by memory banks; didactics can be entrusted to machines linking traditional memory banks (libraries) and computer data banks to intelligent terminals placed at the students' disposal". (cited in Nicholson (1989:199).

    As educators we need to be vigilant with regard to this "anarchistic utopian vision of solitary students playing perfect information games" ... without human discourse with the teacher. (Hattie 1988:7).

11. Whilst taking very seriously the need to educate girls in computer and computer studies, we must continue to develop students abilities to read and interpret texts, think critically and communicate effectively in natural as well as computer language, and to be critical of content on the computer. We should encourage creative expression and appreciation of the area and attempt to train citizens capable of responsible decision making and action. (Johnston 1987; Nicholson 1989:199-200).

12. There is a need to enable girls to have a realistic awareness of technological careers and to provide greater access to computer education that is gender inclusive.

13. At the same time, there is a need to ensure that there is a balance of technical and vocational needs within the curriculum so as to present both the humane direction of education and the possibility of flexibility in meeting future social and economic changes. (Randall 1984).

14. New Technologies have the potential to allow people to work in their homes, to assist men and women to choose to work and bring up young children or study or pursue new leisure patterns.

15. A need for caution in "computerizing" education and society totally. Lyotard (1985) recognizes that "computerization of society may lead to totalitarian control", but holds out the hope that "it will lead to free public access to all available information, so that everyone can play whatever language game he or she wants to, which would mean the power of paralogy over terror". (Nicholson 1989:199).

16. There is a growing consensus that all students should participate equally in all types of computer related activities but there is a long way to go. (Burton et al 1986:125).

SITUATIONAL ANALYSIS - LESSONS FROM THE UK EXPERIENCE:

The Participation by Girls in Computing and Computer Studies, in schools, the home and extra curricula activities:

1. It would appear that it is the quality of participation in compulsory computer lessons in Mathematics that is the focus of current research (Kinnear 1989).

2. There is a higher proportion of boys than girls in all categories where participation is not compulsory. Differences are likely to increase with age (Burton et al 1986:126).

3. Girls are "opting out" when they have the opportunity and the situation is worst in mixed secondary schools, though there are similar trends in single sex schools and junior schools. Males are encouraged to continue the course despite negative feelings. (Burton et al 1986:126).

4. D.E.S. (1983) found fewer girls than boys are entering public examinations in U.K. in computing, partly due to option schemes (timetabling computing alongside languages, for instance) and partly because Computer Studies - like Physics and Chemistry - is considered as a mathematics related subject and a "masculine area of pursuit".

   In Computer Studies, 54,412 boys, 28,766 girls entered 'O' level and CSE exams of whom 39.29% and 28.49% respectively were awarded O level A-C grades and CSE grade 1 respectively. (See Figure 1.4 in Burton et al 1986:18).

5. Fewer girls than boys are participating in extra curricula activities in computing. A survey of 23 schools in Croydon, showed only 6.6% of participants in the Computer Club were girls. This percentage decreased with age. (E.O.C. 1984) Interpretation of this data could show the intrinsic interest of boys in computing (Oliver 1989).

6. Access to home computers. Girls are less likely to have computers in the home (Grady 1983; Robin Ward 1986) and most acute for girls from 'girls-only' families (Straker 1986). Further research by Gribbon (1984) confirms exacerbation of the dilemma for girls from different cultural and economic backgrounds.

   In the EOC (1984) survey, one school in a very mixed cachement area with 1200 pupils, 109 pupils had access to a home computer, only 30 were girls. This demonstrates how parental influence can contribute to girls' failure to participate equally or with the same quality of skill competence, achieved by out-of-school practice.

7. Consumer pressure contributes to girls' failure to participate. A survey in UK found that the majority of readers of a Computer Comic, Road Runner, claiming equal status for boys and girls, were boys aged 11-13. Many computer comics are designed along the lines of traditional boys' comics and displayed in newsagents with boys' magazines. (Girls into Mathematics 1986:127).

8. Economic and cultural backgrounds may be significant in girls failure to participate (Gribbon 1984). A further dilemma in the bid for equality of opportunity for all children.

9. The picture that the pupils have of what the computer can offer, affects their attitudes and willing participation. Girls are increasingly reluctant to be involved with computers and to participate primarily because of the poor image of computer studies (hard, boring, irrelevant, lack of access to computers).

   Secondly, the parallels and links with mathematics: (male domain; emphases on maths skills and the siting of school computers) and finally, how the computer is used (the domination of boys on the machines, girls' fear of the machines, male oriented games and soft ware and time needed out of school to practice).

10. A salutary set of statistics are the numbers achieving final school qualifications in computing and computer studies in the UK.

   Figure A3 in Burton et al (1986:126) indicates that in 1983 not only were fewer girls than boys entering public examinations in computer studies and computer science, but boys tended to perform better at all levels - both in over-all pass rates and especially in percentages gaining the higher grades. Ward (1986) noted that the problem is even more acute since far too many girls who do opt for computer studies at 14 or 15 "drop out" before taking examinations at 16+.

On the "home front", a recent research by Williams (1988) investigated the trends at Rossmoyne Senior High School with regard to disturbingly low participation rates in computing and computer studies in upper school. The differential between girls and boys sitting TEE Computing in WA is increasing (1988 187 boys: 108 girls; 1989 314 boys:143 girls). The 1990 figures for Computer Science 100 at UWA show that 254 (70%) males and 110 (30%) females have enrolled, indicating that more women may be involved in the computer sector of the work force at this level.

TOWARDS A GENDER-INCLUSIVE CURRICULUM IN COMPUTING AND COMPUTER STUDIES:

"With an increased dependence on computers, there is a need for tomorrow's citizens to be technologically literate as citizens and technologically skilled as workers" (Sanders 1989:183).

Student anecdotes in Girls into Mathematics (1988) suggest girls are already developing negative attitudes towards computers, computer studies and their own competency in the area, similar to mathematics.

Improving the Poor Image of Computing and Computer Studies:

The Nature of Computer Studies:

Reporting on the Croydon Survey, Ward (1986) drew attention to the interesting fact that large proportions of both sexes 47% of girls and 56% of boys were dissatisfied with their courses in computer studies, but fewer boys opt out. This suggests that girls' attitudes to and success in computer studies lies partly in the nature of the courses offered. (Burton et al 1986:129). It also suggests that boys were encouraged by teachers and parents to "stick it out" and gain a valuable qualification.

Material Resources - textbooks, units of study and software.

There is a need for teachers to examine the content of their computer studies textbooks and units of study in order to analysis the appropriateness of the topic for fourteen to fifteen year olds and the aspects that might be problematic to girls.

French (1982) in Burton et al 1986:129) provides an instructional manual to help in this regard and found that text books tend to be very theoretical and aimed at high ability children. This is disadvantageous to lower ability girls and future employment.

Similarly, software characters tend to be male, which alienates girls who have already developed attitudes from the media that consistently portray computer as a "male oriented". (Forsyth and Lancy 1989).

An activity suggested in 'Bridging the Computer Gender Gap' (The Gen 1990:4) is for younger students to analyse the ratio of males and females portrayed in computer magazines, and whether they are active or passive roles. This not only empowers students, but makes them critically aware of the lack of visibility of women and girls in computer related material.

The processes in Computer Studies Courses:

Reasons for boys' and girls' dissatisfaction recorded by the Croyden Survey (Burton et al 1986:130, Figure A.6) indicate that girls more than boys find the subject difficult and boring, boys want more programming and more games. Neither sex liked the amount of writing and theory involved nor the lack of access to the machines. Girls are more negative to computer studies which leads to an aversion of computers themselves. This is often exacerbated by such attitudes shared by teachers. The attitudes and competencies of teachers will be considered later.

Necessary Attention to Computer Software - resources:

"Girls are frequently put off by what it does" (Burton et.al 1986:136)

There is a need to survey what children use the computer for at various levels and according to gender. Charlotte Beyer (1983) reporting on an American survey, suggests girls preferred stereotyped software, titles like "Typing Tutor", Typing Fractions", "Consumer Buying" and "Counting Calories". While Sherry Turkle (1984) maintains that girls like "creative packages which allow them to express their artistic ability".

Brian Hudson (1985) examined the educational software available for use in Mathematics, he found many exercises were based on "war games" which emphasised the macho male image of destruction. "This, I am sure, must have a detrimental effect upon the motivations of most girls" (Burton et al (1986:137). Hattie (1988) found the most popular software for girls was that which allowed the girls to produce or achieve something. Teachers are advised to think carefully about what they use the computer for, to ensure that any educational software in class appeals to both sexes. (Johnston 1987; Smith & Keep 1986. The Girls in Mathematics team provide further information on software (in Burton et al 1986:138-140). See also The Gen (October 1990:4) published in Australia.

Teaching-Learning Situation - Process emphasis:

Activities in mathematics classes, which concentrate on problem solving and investigational aspects of mathematics involving Logo which is structured and accessible are popular with all students. Feedback from students was very positive. (Burton et al 1986).

Activities to encourage Girls' Participation in non-threatening Voluntary Extra Curricula Activities in Computer Studies.

Useful ideas presented in Burton, et.al (1986) and The Gen (October 1990) suggest organizing a computer club. Either by running separate clubs for boys and girls; or offer different times for different ability levels, "expert" "beginner" and "complete beginner". They suggest Computer Clubs may be better organized for girls at lunch-time (safety reasons and peace of mind of parents, especially minority groups).

Variety of Outcomes - Process and Product Emphasis:

Computer clubs, should include activities that appeal to boys and girls. Word Processing activities, Logo activities, games and encouraging the use of the computer as a tool, to say write and edit the School Magazine, thus encouraging the communication skills of girls.

Leadership Style in Out-of-School Setting:

Computer Clubs should be well-supervised to monitor and correct boys' dominating behaviour and possible harassment of girls. (Ward 1983). Working collaboratively with girls could help girls to acquire some of the "fervour" of boys for computing and could help boys to appreciate the other functions of the computer, especially the more aesthetic creative problem solving.

Career Education and the Computer:

Is a vital aspect in the curriculum. It is necessary to continually re-evaluate the current career expectations of girls. One would expect change as a result of positive intervention and student empowerment.

Present Career Expectations of Girls based on (1985) - Situational Analysis and Needs Assessment in UK and Suggestions for Curricula:

- There is a need to counter parental and media views that computers are not relevant to girls' future careers, by challenging images and assumptions in advertisements and other media. (Burton et.al 1986).

- Encourage female teachers to make use of the computers in school time to act as visible role models and school visits by women who work with computers (The Gen October 1990).

- Use the Equal Opportunities booklet "Working with Computers (UK), which outlines careers available to girls.

- Arrange visits to local industries. Encourage opening of bank accounts, opening awareness of the competence of predominantly female "bank tellers".

- Parent nights encouraging home computer use for both girls and boys. A recommendation in line with the "Better Schools Report" in WA and increased participation of parents.

- Develop P.A.V.E. programmes in the schools in Western Australia, to discuss issues in girls' education and their future employment needs, especially here in the area of computer competency.

TEACHERS AS LEADERS AND ROLE MODELS AND ATTITUDES TO COMPUTER USE:

Gribbon (1984) stated:

> "At the age of nine, children in our society are conditioned to accept that boys and men are the proper users of a computer, that girls might be allowed an occasional touch at the key-board and that a women's job is to feed and care for the man". Sanders (1989:160) suggests that sex equity efforts in schools are critical especially in technology education and careers.

Teachers are partly responsible for conveying the impression that computers are for men. In a UK research, Straker (1986) found those teaching computing were predominantly male and often dominated other uses of the computer as well, both in class and in the staff-room. More males in primary schools attend computer inservicing, despite 75% of the primary teaching force being women. Finally the almost non-existent representation of women advisory teachers in computing in the L.E.A.S. in UK. This reflects significant ingrained attitudes and lack of motivation in attending inservice computing courses by women. Perhaps too the inservice courses and physical settings were inappropriate for women's needs and preferred learning styles. Changing attitudes of all teachers to computing is vital. (Clarke 1990).

PROFESSIONAL DEVELOPMENT CURRICULUM, PRECEDING OR PARALLELING CURRICULUM INNOVATIONS IN COMPUTING AND COMPUTER STUDIES:

Initial inservice programme

Clarke (1990) provides a professional development model that would be invaluable to all teachers, counsellors, administrators and parents. Initially it is recommended that 5 (five) major myths be dispelled and the following action taken to correct or counter such misconceptions and entrenched value systems, prior to concern for the curriculum for girls in computer studies and computing.

1. "Girls are no good at Computing":

   The reported differences are from assessment techniques which focus in on the "mathematical and technological aspects" of computing and leave out the "communications" aspect (Anderson 1987 cited in Clarke 1990:53-59).

2. "The Computing Culture is Male Oriented":

   This perception has arisen from a focus on specific aspects of the "computing culture". For example Arcade games, computer clubs and university terminal rooms perceived as male preserves. The culture equally should be defined by people who work on their own PC's, using menu-drive, user-friendly software, to achieve specific goals, while enjoying peaceful surroundings of private offices or homes, this would include a large proportion of females. (Clarke 1990).

3. "'Experience' Differences have long term Implications:"

   Studies on tertiary students entering a compulsory introductory course in computing indicate that the benefits of prior computer experience are short lived. Males entering the course with considerable computer experience out-performed females in the early stages but by the end of the course gender differences in achievement disappeared.

4. "To use a Computer one must understand the Technicalities of Computers":

Today's computer users require no knowledge of how a computer works to be able to use one efficiently. Most software is user-friendly and has menus to achieve the desired goals.

5. "Girls are not interested in Computers":

This depends on how the term "Computer" is defined when asked directly about interest in computers most girls and women would respond in the negative, but when asked about word processing or drawing programs very positive replies emerge.

Action for Countering Invidious Stereotypes:

Redefine "Computing" - a need for a broadened concept

Computing is not all "bits, bytes, chips and programming" - "it's word processing, data bases, spread sheets and desk top publishing packages".

and in parallel:

(a) Change attitudes of the computing teacher concerning their values and judgements about the "computing culture" that it may be expanded to all areas of human endeavour and be performed in many different settings.

(b) Balance "Male Oriented" Values with "Female Oriented" Values:

The use of computers where females interest lies, should be given equal status to "technology and programming", the traditional interest of males.

(c) Changing Attitudes of all Teachers to computing and the possible uses in their subject areas for themselves and their pupils. (Davis and Davis 1983)

(d) Career Education and Girls in Computing:

(i) Redirect the Self-fulfilling Prophesies of parents, teachers and counsellors who may perceive computing as mathematical, technical and essentially masculine, with "little appeal to girls".

(ii) Counteract stereotypes, especially in the media that computers are not relevant to girls' future careers by challenging images and assumptions in advertisements. (Burton 1986:139).

(iii) encourage and support girls as they start to accept computing as a suitable subject choice and career - since they too must overcome socially determined roles and alter their self concept. (Schulz-Zander 1990:195).

The Special case of Women Teachers and a Possible Programme for Computer Competency.

"It has been suggested that women teachers should be actively encouraged to make use of the computer in school time to act as visible role models".

This requires, as with girls, a progressive programme to convince women teachers of the importance of their perceived competency in the use of computers; their need to use computers in all subject areas in the future; and finally active encouragement to gain computing skills as required for themselves and other women teachers.

(a) The package, I believe, would be a necessary first step in this process of re-education of women teachers is presented as a book, Girls into Mathematics, 1986:123-140. The strategies developed in the book are presented in an interactive mode where either an individual teacher or a group of teachers may participate. The strategies actively encourage teachers to reflect on the need for computer competency in all pupils, the dilemma of girls and women in the labour force, and their attitudes to girls and boys in Computing and Computer Studies. The package provides useful pointers of what might be done to transform computing and computer studies to make it gender inclusive. The package is not too prescriptive and enables participants to develop beyond the suggestions to meet future needs to ensure a gender-inclusive curriculum in computer studies and computing.

(b) The school administration, mainly male, needs to actively encourage the participation of women teachers in "in-service programs for competence in computing and their consequently effective role modelling in the school. This could be "effected" on their school site by competent colleagues in an atmosphere of mutual support and encouragement. It would help the men to appreciate the challenge of inclusiveness at all levels and the needs of women teachers in this transitional period.

(c) There is a need for a network encouraging other women to become computer literate, since good role models are so vitally important to girls in the school. This could be initiated by already competent women.

THE NEED FOR COLLABORATION BETWEEN HIGHER INSTITUTIONS AND SCHOOLS TO BROADEN THE HORIZONS IN COMPUTER TECHNOLOGY AND EDUCATION: "No school is an island entire to itself" (apologies to John Donne).

Girls into Mathematics, 1986, is an example of a collaborative effort of a Higher Education Institution with an Education Authority in the UK.

Their book is an innovative package developed through the collaboration of the Open University and the Inner London Education Authority. This is an important break through in the partnership between a higher education institution with its 'Centre for Mathematics' education and an Education Authority. An important spin off are the concerns that computer competence for girls may be inhibited by too close links with Mathematics; and the disastrous consequences for girls should all knowledge be computerized in the future, because as a group they are illiterate, unskilled and negative towards computers and their use (Concern expressed by Spender (WACAE 1989).

The main thread of the package is the gender issue with a possibility to interweave ethnic, cultural and economic viewpoints as teachers define their own particular school situations. The writing team encourage individuals and whole departments to carry out small scale research on the effects of gender (as well as race and social class) in their schools.

Comment by the Writer (1990) - With regard to Computer use in other areas of knowledge.

If computing is to be opened up to include other areas of study that are not traditionally "male" subjects, schools should open the "computer" and "gender" debate to all teachers not just Mathematics departments - and this package would be an ideal starting point. The package does pick up the need for a balance in studies and the development of the needs and interests of girls and women. Implicit is the need to value other areas of the curriculum and other modes of thought. (Goodwin S. (1984) Figure A1.p.124).

ASSESSMENT & EVALUATION OF TRANSFORMATIVE CURRICULUM:

Girls into Mathematics (1986), provides a series of ideas which could be used to monitor progress in "the active participation of girls" in Mathematics and Computing, so vital in a technologically oriented society.

Iowa State Department of Public Instruction (1986) have produced a self-evaluation check-list as a general guide for reviewing Computer Programmes to see how consistent they are with regard to equity as reflected in curriculum structure, curriculum content, instructional materials and teaching strategies.

Indicators of Successful Change or need for Modification:

- For example, teachers collecting data about changing pupil participation rates in computer related activities and examination success of girls. (eg. TEE results in WA 1986-1989 published by SEA)
- Inventories of competent computer users on the academic staff, both male and female and 'areas of computer competence'. (Self and Peer Assessment Valuable).
- Assessment of attitude change in girls (Journaling, anecdotal records, joining computer clubs).
- Classroom interaction, including girls in computer classes (Teacher-Pupil, Pupil-pupil).
- Participation rates of girls in Computer Clubs
- Time on computer tasks in 'formal' classroom (quantity and quality).
- Innovations, such as computer appreciation courses, may indicate volitional staff and student involvement.
- monitoring the effect of new software on competency, interest and attitudes of girls.

o A valuable new development is the evaluation of software by teachers and pupils. Pupils' evaluation is increasingly being perceived as an essential active requirement of participants in the computer learning . The major aims being: to enhance the pupils' discriminatory powers in the soft ware's suitability for "inclusive" education; to encourage and value evaluation of the learners; a move towards pupil empowerment and control over their own destinies. (Johnston 1987; Smith & Keep 1986)

o Monitoring equality of outcomes (Sanders 1989:158 USA Department of Labour 1987).

BREAKING THE TRADITIONAL LINKS BETWEEN COMPUTER STUDIES AND MATHEMATICS AND FUTURE DEVELOPMENTS FOR THE 1990'S

"Computing is regarded as a male domain in common with other scientific and technical subjects" (Burton et.al. 1986:132).

1. Many teachers of mathematics have responsibility for computing, computers are frequently sited in the maths department and hence used in Mathematics classes rather than in other discipline areas. (Burton et.al. 1986:132-135).

2. Ward (1986) noted that 48% of Computer Studies teachers in Croydon UK held mathematics posts too. Some were coerced, but many chose to do so. Added to this many more mathematics teachers were male.

3. Computer syllabuses as a result are highly mathematical. Many people believe that communication skills are more relevant to computer studies than mathematics. The Cockcroft Report (UK) 1982 recommended that computer studies should be totally divorced from mathematics. This could have a beneficial effect on the image of computer studies and release Mathematicians to teach Maths.

4. DES (1985) the influence of microcomputers as an approach to teaching and learning mathematics should not be denied. (Burton et.al. 1989:134).

5. A need to emphasise the computer's use as a tool and learning resource in all subject areas. For example, languages, Home Economics, English, Science need programming skills taught within the context of the subject area.

6. "Elitism" and "Aloofness" of some mathematics teachers prevent the widespread use of computers in schools, which is especially noticeable in 'office practice' where many girls are involved. (Burton et.al. 1986:134).

7. Computers as a general resource, like a video recorder, would encourage all members of staff to acquire machines if and when resources allow.

8. Observations have discovered that younger children who have met the computer as a learning resource in mathematics and other classes, or as a tool in a computer appreciation course, do not have such negative attitudes and suggests a way forward. (Burton et.al. 1986:131).

9. Ward (1986) describes an innovatory Computer Appreciation course in Croyden (cited in Burton et.al 1986:131). She believes the information - technology approach, where computing is perceived as being very much concerned with ways of communication will improve girls' attitudes to computers and computing, as they are more interested and better at communication skills than boys. Assessment and evaluation are eased in Appreciation courses since the emphasis is on changing attitudes, developing awareness of the value of computing skills to be acquired for a technological world - and less threatening to "beginners".

10. The need for more "hands-on" experience from primary schools through to upper school. Computer Clubs may help those who do not have access to home computers to consolidate skills.

11. The need for a resource officer to hold responsibility for computer use - to eliminate allegations of the elitism and aloofness of some mathematics teachers in preventing the widespread use of computers. This would also help women teachers to develop confidence with a back up for repair or adjustment to hard ware.

12. Teachers should consider the contention that girls work better with computers, when no boys are present (Lawrence 1984 cited in Towns 1985:15). This would counter societal pressures that computers are simply "not for girls". It would also help in the need for equal access to computer facilities and "free" girls from boys' harassment and domination. This may alleviate girls opting out when they have the opportunity. (This situation is worst in mixed secondary schools, although there are similar trends in junior schools and single sex schools). (Fletcher TES 83).

13. Laurence (1984) and Schulz-Zander (1990) provide a rationale for the importance of computer education for girls and provides resources and strategies for use of schools which parallels the UK suggestions.

14. Subtle forms of teacher pressures promote difficulties for girls. There is need to monitor classroom verbal and non-verbal interaction - especially encouraging perseverance with enjoyment.

15. "Catch them young" by beginning computer education at primary school. In a recent research paper, Kinnear (1989) suggested primary teachers need to develop rosters for equity of access for boys and girls, to foster equity of use, especially encouraging girls, to carefully monitor and evaluate extra curricula (free choice) situations; to create a non-threatening computer environment; to be critical of software that may be gender specific and counter children's views that "men and boys are the proper users of computers". (Gribbon 1984).

16. Involvement of outside agencies, Sanders & Stone (1986) developed a computer equity training project - at the Women's Action Alliance, which led to a 144% increase in girls' computer use. This project included 56 activities for computer excellence and 96 activities for ensuring computer equity.

17. Hattie (1988) believes that the key to girls competency is "learning to control adversive events in computing". He perceives computers primarily as a learning tool, an innovation, to enhance learning - which needs to be conveyed especially to girls and women.

18. Current research into selected software purported to raise attainments in scholastic aptitude tests when utilized with short term computer assisted instruction, needs careful monitoring especially if it affects girls' attainment in the future. (Davis 1985).

19. Current action research in Western Australia, where computers are used in the construction of knowledge and epistemological development of children:

Hattie (1988) has developed a package of software relating to numeracy, literacy and self concept to be used in the community in Western Australia with links to the University of WA. The software is written to give the students a sense of product and how they achieve immediate control over the process. Incorporated in the package are opportunities for different learning strategies (simultaneous and successive processing) to encourage students to optimize both strategies. The teacher's perception of control of learning is still present and critical to this learning situation.

Hattie, (1988), is most interested in the research into children's thinking processes when using computers:

"The literacies involved in computing can throw light on children's thinking processes. Knowledge structures develop differently after interacting with computers". Olson (1988) has argued computers play three important roles in children's learning, they can provide rich data bases that children can use as information sources in their own construction of reality, they permit students to organize knowledge in a new way and via talking about what they are doing, trying to do and why they succeed and failed, computers permit a greater understanding of one's own and others' minds". (Hattie 1988:9).

20. Girls Preferred Learning Styles in Computer Studies and Computing:

A growing issue in the current research (1986-89) is cognisance of learning styles and learning environments. To promote 'inclusiveness' it is essential that girls' preferred learning styles be considered in the context of computer studies and computing. Changing the environment at school and classroom levels includes:

- divorcing computer studies from the physical and emotional environment of mathematics (male knowledge).
- using highly visual programmes related to the real world.
- perceiving computers as an aid to learning, learning difficult concepts at their own pace and in mathematics, science and technology.

- comfortable setting - colour, people posters, role models portrayed, information charts on computer jobs and pre-requisite courses - and a variety of examples of where a computer is used. (Hildebrand 1989:7).

- working collaboratively in pairs or groups creating a cooperative environment. (Shaw 1990:4)

- creative-problem solving in other areas, especially in feminine knowledge areas such as Home Economics, where they could learn Mathematics and statistics in a non-threatening <u>integrative subject environment.</u>

- developing an inner locus of control and control over the adverse effects of computer use, to eliminate the concept of fear. (Hattie 1988; Hines & Seidman 1988; Hattie & Fitzgerald 1987).

- creating computer environments that are "challenging, exciting and fun".

- using the computer to develop word processing and communication skills.

- expanding horizons of computer use as a basis for gaining knowledge and as a medium for investigative work in all areas of human endeavour. (Hattie 1988).

- consciously overcoming barriers to equitable instruction (Shubert J.G. 1984).

- teachers carefully considering which courses in computer programming and computer literacy would best suit girls' and women's learning styles. (Kagan 1988).

- the October 1990 edition of <u>The Gen</u> focusses on Girls and Computers providing general findings (Shaw & Fielden), a case study (Helier) and a resource for professional development of teachers from Victoria.

21. <u>Classroom Management</u>:

<u>Concern for Boys' Behaviour in the Context of Computer Classes</u>:

Robin Ward (1983) observed boys' dominating behaviour in Computer Clubs, particularly when unsupervised, completely intimidating girls who were clearly interested initially in this extra curricula activity. This requires careful monitoring to distinguish between the deep intrinsic motivation to use computers or the more generalized need for domination and power. Their intrinsic interest could be used to enhance girls' interest through collaborative learning, at times.

22. <u>Evaluation of Innovations in the Computer Curriculum</u>:

A need to monitor and evaluate innovations in Computer Studies and Computing, in terms of affective, conative, cognitive, psychomotor skills and quality of involvement of girls.

There is also a corollary for boys, their behaviour towards girls needs careful monitoring and correction, so too the balance of their interests in the arts and, science and technology.

23. The Computer and Gendered or Gender Free Language:

An essay by Rothschild (1986) compared two books on computer technology in terms of their usage of gendered or gender-free language. The two books examined were "Turing's Man: Western Culture in the Computer Age" by J. David Bolter and "The Second Self: Computers and the Human Spirit", by Sherry Turkle. It is argued that the two authors' gender differences in language usage and style (with Bolter using gendered language, and Turkle using gender-free language) reveal gendered differences in approach to subject matter, questions asked, content, and cultural and philosophical assumptions. The impact of this critique for teaching was examined by Rothschild with specific consideration of use of the critique for raising gender issues in the classroom.

24. Looking to the Future: Moral Integrity and the Computer:

The computer is undoubtedly a supreme facilitator of research, but it requires of its programmers and users the highest moral integrity. I believe it will increasingly be so as we move towards a realization of true inclusiveness and the "curriculum for life". A particularly vulnerable group of individuals are highly integrative thinkers (Peel 1967: 30-34) Adshead 1990:3).

An integrative thinker can feed in two or three variables on a topic, and within a few hours synthesis from a myriad of research focuses and perspectives the prime emphases; groups under special investigation or vulnerability; and intuitively consider the changing social attitudes implicit in the researches. Without high moral integrity, there could be damaging or too 'precipitous social engineering'.

The greater incidence of corporate crime is also a natural consequence of lack of integrity and heartfelt concern for the well being of human beings in society. (Neal 1990)

25. Mathematics for the 21st century indicates the growing expectation that it would increasingly be integrated with computer and graphic calculator technology to facilitate problem solving, graphic representations and problem posing. This could have serious consequences for girls and effectively raise another barrier to their access; participation and productive outcomes in mathematics. (Malone et al 1990:237-42; Zaslavsky 1990:315-318).

26. Include "herstory" in the field of computer studies and development. For example, Rear Admiral Grace Murray Hopper revolutionized computer software in 1952, she invented the first computer "compiler" which allowed for the first automatic programming. (Vare and Ptacek (undated))

27. The Dangers of Sole Reliance on Computers for "Inclusiveness" Research in the Social Context:

It would be naive to assume that computer information is the only form of communication, in researching 'inclusiveness' in a social context. No matter how effective the graphics are, there is a certain "black and white" blandness about its output.

This may be countered by the "living colour", which the 'searcher' brings to the computer screen to generate a balanced perspective. In particular, it is the knowledge, feelings, values and skills gathered, over time, from literature, films, newspapers (local and national), magazines, journals, communing with nature, physical recreation, meditative silence, art in all its myriad of forms and communicating with special people from all walks of life. It is this aspect that presents the searcher after "Truth, Beauty, Time, Space, Causality, Goodness and Life itself" (Peel 1967:30) with the living perspectives of her/his culture, with its colour, joy, enjoyment and hope.

Maybe there is a salutary lesson to be learned from the Science Fiction television "Max Headroom", whose theme was the "Totalitarian control of computers and television with the balance of highly moral experts countering "deviancy in the society".

Conclusion:

Sutherland's vision for "inclusiveness" in 1981, where she stated that "Computer education more than any other field has the facility to strengthen weak points and build to all round excellence in both boys and girls". Sutherland (1981:69), is taken up again by Hattie (1988:9) as he looks ahead with vision and enthusiasm to the 1990's "Let us move from what was and what is, to what could be, then we can tap the golden opportunities of computers".

RECOMMENDATIONS FOR COMPUTER STUDIES AND COMPUTING:

It is recommended that:

o Every effort be made to increase the competence and positive user attitudes of girls in computing to the furtherance of their education in any field of endeavour, and for future employment in a technological world.

o Educators encourage girls and women, away from 'learned helplessness' and towards an internal locus of control so vital in computer use and the acquisition of skills and computer knowledge.

o We carefully consider the possibility of "stereotyping" giftedness in girls into a too narrow area of creative endeavour, say by socially engineering their entry too forcibly into the fields of pure mathematics, science, technology and computer studies.

o In computer education and computing, there is active concern for the preferred learning and cognitive styles of women and girls and an investigation into the best learning environment for females in schools and college.

- All students learn to regard the computer as an innovative technological aid to enhance learning, research and the pursuit of knowledge, with the highest moral integrity.

- Each department analyse their staff and students' participation in computer related activities, with a view to increasing competence and positive user attitudes particularly in women.

- The computer studies department provide a college wide breakdown of computer study participation percentages according to the students' gender and major subject area over the past 5 years.

- All departments provide statistics and/or qualitative evidence on computer use in their courses and staff/student research.

- The mathematics department provide statistics on the number of major area mathematics female students, who are also engaged in computer studies.

- The computer be promoted as a valuable technological tool to facilitate learning and advance knowledge.

- We investigate the possibility of students and qualified teachers particularly women, engaging in non-award computer competency programmes at the college.

- A survey be made of what male and female students and staff use the computer for and to analyse how far computers are being used in their own area of specialization.

- Consideration of the computer as an interactive machine, capable of transforming knowledge in the future, be given careful and scholarly consideration.

- A valuable innovatory role of the college may be in creating software with a creative, problem solving function in any area of human endeavour, where evaluation of such software is essential. (Forsyth et al 1989)

- The department of Computer Studies work collaboratively with schools and other departments to develop computer studies and computing in schools that are gender inclusive, intrinsically interesting to all students, and are modified to meet the needs of all ability levels.

- All faculty members avail themselves of access to trends (competency) in computer participation and use during the schooling years; involvement in compulsory and non-compulsory units, and retention rates in TEE computer studies and competency trends in earlier school leavers. (ref SEA statistics TEE 1988, 1989)

- Books on computer technology and textbooks be closely examined for their usage of gendered or gender free language.

- Consider all the deliberations of this report in promoting gender equity in the Computer classroom particularly for girls and in tempering boys' sexist behaviour.

o As we move towards the concept of "inclusiveness" at both the societal and education levels, there will be a growing need to monitor the users and programmers of computers particularly in the research field and their moral integrity.

REFERENCES:

Adshead, G. (1990), "Family mourns tragic waste of life" The Western Australian, February, 20:3.

Beyer, C. (1983), 'Growing Sex Gap shows up in Computer Tastes' TES, 18 Nov.

Bolter, J.D. "Turing's Man: Western Culture in the Computer Age" examined by Rothschild (1986).

Burton, L., et.al. (1986), Girls into Mathematics, The Open University Centre for Mathematics Education and the ILEA educating Inner London. Appendix: The Computer and Mathematics, pp 123-131.

Burton, L. (ed) (1986), Girls into Maths Can Go, Holt Rinehart & Winston, UK.

Chambers, S., & Clarke V. 'Sex Related Differences in Attitudes and Achievements of a Fourth Grade Class', Learning Computing. Cognitive Psychology Research Group, Deakin University.

Clarke, V. (1990), Girls and Computing: Dispelling Myths and Finding Directions. Computers in Education. Publishers 3V, North Holland.

Cockcroft, W.H. (Chair), The Cockcroft Report Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools, HMSO.

Davis, J.E. and Davis, H.K. (1983), (eds), Focus: Teaching English Language Arts - Computers in Teaching English, Ohio University. Spring. Vol.IX, No.3.

Davis W.D. (1985), An empirical assessment of selected software purported to raise SAT scores significantly when utilized with short term CAI on the micro-computer (in Print) Research Report, Nov 1987, Florida.

D.E.S (1985), Mathematics from 5 to 16 Curriculum Matters 3:, An HMI: Series, HMSO.

E.O.C., (1984) Subject Options at School: A Positive Choice at 13 has a positive effect for life, E.O.C.

Evans, A. & Hall W. (1988), 'Computer Education & Gender Inequality NUT Education Review. Vol.2.No.1, Spring.

Forsyth, A.S.(Jnr) Lancy, D.F. (1989), 'Girls and Microcomputers: A Hopeful Finding Regarding Software', Computers in The Schools, Vol.6, No.3/4, 51-59.

Foster, V. (1989) "Is Gender Inclusive Curriculum the answer for Girls" in Educating Girls: Practice & Research, Allen & Unwin, Sydney.

French, C.S., (1982), Computer Studies: An Instruction Manual, D.P. Publications.

Grady, C. (1983), 'New Survey confirms the needs for girls' micro schemes' TES, 16.

Goodwin, S. (1984), "Women's' Intuition" TES, 22nd June.

Gribbon, M. (1984), 'Boys muscle in on the keyboard' in Burton (1986).

Hattie, J., & Fitzgerald, D., (1987), Sex Differences in Attitudes, Achievements and Use of the Computer in Australian Journal of Education, 31:1.

Harvey, G. & Klein, S.S. (1989), 'Understanding and Measuring Equity in Education in Secada (1989), (ed) Equity in Education. The Falmer Press UK.

Hattie, J. (1988), Golden Opportunities for Learning, Control and Literacies, Key Note Address, Australian Computers in Education Conference, University of Western Australia.

Helier, Y. (1990), 'Footscray City Secondary College - turning girls on to computing - a case study' in The Gen. Department of Employment, Education and Training. October.

Hines S.J., & Seidman S.A., (1988), The Effects of Selected CAI Design Strategies on Achievement: and an Exploration of Other Related Factors. Paper presented at the Annual Meeting of the Association for Educational Communication & Technology. New Orleans. January.

Hudson, B. (1985), "Please don't shoot the rabbits", Micromath, Spring page 64.

Iowa State Department of Public Instruction, (1986), Computer Education in Iowa Schools: Multicultural Non-Sexist Education, Teaching Guide.

Johnstone, B. (1984), 'Technology: Must the Girls Keep Losing out' The Times, 6 November.

Johnston, V.M. (1987), Attitudes towards Micro-computers in Learning: 1 Pupils and Software for Language Development :2 Teachers and Software for Language Development, Educational Research, Vol.29.No.1.Feb, Vol.29.No.2, June.

Kagan, D. (1988), Learning How to Program or Use Computers : A Review of Six Applied Studies, Educational Technology, Vol.28, No.3, March.

Kinnear, A. (1989), Computers in the Primary Classroom: Science Revisited", A Paper presented at the Western Australian Science Education Association 10th Annual Conference, 22 September.

Klein, S.S. (1985), (ed), Handbook for Achieving Sex Equity through Education. John Hopkins University Press, Baltimore.

Laurence, J. (1984), Girls and Computer Education. A Discussion Paper, Equal Opportunity Unit, Ed Dept. of Victoria.

Lockheed, M.E. and Frakt, S.B., (1984), Sex Equity: Increasing Girls' Use of Computers, Computing Teacher, Vol.11, No.8, p16-18 April.

Lockheed, M. (1985) Women, Girls and Computers: A First Look at the Evidence in Sex Roles, 13(314).

Lloyd, A. & Newell, L. (1985), Women and Computers in Faulkner, W. & Arnold, E. (eds), Smothered by Invention, Pluto.

Malone, J., Burkhardt, H. & Keitel, C., (1990), The Mathematics Curriculum: Towards the Year 2000. Published by Curtin University of Technology, Perth. WA.

Mill, J.S. (1869), Essay 'The Subjection of Women'.

Moont, S. (1984), Computer Literacy: An Anthropological Viewpoint - in Hughes, J. (ed) Computers and Education: Dreams and Reality, 2nd Australian Computer Education Conference.

Newhouse, L.P., (1990), Gender Equity: Retrospect and Prospect With Recommendations for the School of Education: Part I, WACAE, Perth, WA.

Oliver, R. (1989), Discussion at WA College on the Intrinsic Interest of boys in Computing.

Olsen, D.R. (1988), Mind and the Technologies of Communication in Hattie, J.A. Kefford, R. Porter (eds) (pp.72-81) Technology, Skills and Education: The Dynamics of Learning, Australian College of Education, Melbourne.

Max Headroom, Television Science Fiction, Perth Television, February 1990.

Neal, M. (1990), Corporate Crime Growing, The Canning Times, February 13:13.

Nicholson, C. (1989), 'Postmodernism, Feminism and Education: The Need for Solidarity' Educational Theory, Vol.39, No.3, pp 197-205.

Peel, E.A. (1967), (2nd ed), The Pupil's Thinking, Oldbourne, London, p30-34.

Print, M. (1989), (2nd Impression) Curriculum Development and Design, Allen & Unwin, Australia.

Resource: 'Bridging the Computer Gender Gap' State Equal Opportunity Resource Centre, (Victoria) October 1990.

Rothschild, J. (1986) "Turing's Man, Turing's Woman or Turing's Person? : Gender Language and Computers", Working Paper, No.166, Mass. Centre for Research on Women, Wellesley College.

Sanders, J.S. (1984), The Computer: Male, Female or Androgenous in The Computing Teacher, 11(4).

Sanders, J.S., & Stone, A. (1986), The Neuter Computer: Computers for Girls and Boys, Published by Neal-Schuman.

Sanders, J.S. "Equity and Technology in Education An Applied Researcher Talks to the Theoreticians" in Secada, W.G. (ed) (1989), Equity in Education. The Falmer Press, UK.

Schulz-Zander, R. (1990), Concepts and Strategies Concerning Information Technology Education for Girls and Young Women. Computer in Education, Science Publishers, 3V. North Holland.

Schubert, J.G., et.al. (1984), Ideas for Equitable Computer Learning, American Institute for Research in the Behavioural Sciences. Palo Alto.

Secondary Education Authority (1988, 1989) Tertiary Entrance Examination - Analysis of Candidates by Sex.

Shaw, E. and Fielden, K., (1990), 'Equal time: girls and computers', The Gen, Department of Employment, Education and Training, October.

Shegog, V. (1989), Equity News, Ministry of Education, Perth WA. pp 21-26.

Smith, D. & Keep, R. (1986), Children's Opinions of Educational Software, Educational Research, Vol 28, No.2, June.

Software: John Copley's Crimes of 1st Fleet Convicts'.

Straker, A. (1986), "Should Mary have a little Computer" in Burton (ed) 1986.

Sutherland, M. (1981), Sex Bias in Education, (page 69).

The GEN, (1990), Newsletter of the Gender Equity Network Special Edition: Computers and Girls, Department of Employment, Education and Training.

Towns, D. (1985), The Responsibility to Educate Girls for a Technologically Oriented Society, Equal Opportunity Unit, Education Dept. Deakin University Press, Victoria.

Turkle, S. (1984), The Second Self: Computers and the Human Spirit, Granada.

Vare, E.A. and Ptacek, G., (undated), A History of Forgotten Women and their Unforgettable Ideas, William Morrow & Co. Inc. USA.

Ward, R. (1983), "Wasted Potential", TES, November.

Ward, R. (1986), Girls and Technology, in Burton (ed) 1986.

Wilder, G., Mackie, D., Cooper, J. (1985), Gender and Computers: Two Surveys of Computer related attitudes in Sex Roles, 13(3/4)

Williams, J. (1988), Rossmoyne Senior High School. Survey of Law and Computer Studies participation in Upper School.

Wlodkowski, R.J. (1981), 'Making Sense out of Motivation: A Systematic Model to Consolidate Motivational Constructs across Theories. Educational Psychologist, 16, 101-110.

Zaslavsky, C. (1990), 'Will Technology come First in Mathematics' in Malone, et al, (1990:p315-318).

INDUSTRIAL ARTS FOR GIRLS:

Situational Analysis:

In the UK, much has been done to make "Craft, Design and Technology" available to girls. Four articles by Catton 1982; Harding 1982; Rogers 1988; and Morgan 1988, convincingly show that accessibility for girls is not yet a reality. Though Eggleston (1985) believes that girls are participating in increasing numbers in the courses, helped by GIST and GATE (1982) projects. Most LEA'S have CDT teachers but, in London, for example only 8% are women. Very few girls in UK (between 1979-84) were taking 'O' level technical drawing and few boys taking 'O' level cookery.

In the USA, work in the early and mid 1980's focussed particularly on the professional development of vocational educators in secondary and post secondary sectors in promoting access, desirable learning environments and equitable outcomes for "non-traditional students". (Jolly 1981; Whyte 1984; Texas Education Agency 1984; Lydiard 1986).

It is possible to extrapolate from their papers, ways in which we can facilitate girls' productivity in the area of Industrial Arts in Western Australia. It would also seem very important to encourage women to teach in these areas to vibrantly interact with young girls and boys in a predominantly masculine domain, thus acting as valuable role models and dispelling invidious sex stereotypes. Whyte (1986) provides valuable insight into implementing change for gender equity in Science and technology in eight co-educational schools in UK, using an action research model (GIST 1979-1984)

NEEDS OF GIRLS:

Technology in its broadest sense is the educational basis for entry to occupations in applied science and technology. Girls' exclusion from this wider sphere of technology is reflected in dramatic differences in choices in the crafts subjects which are the most visible and symbolic focus of "masculine" and "feminine" areas of the curriculum. (Whyte 1986).

1. Girls need the opportunity to gain technical expertise as a real preparation for technological work (Whyte 1986).

2. The craft issue is one of central concern for girls, where Home Economics and Technical Studies "enshrine the separate values of masculinity and femininity as subjects at the extreme ends of the gender spectrum" (Whyte 1986:23).

   The aim of the GIST (1979-84) project was to break down these barriers so that girls, particularly, could comfortably and profitably engage in non-traditional crafts and technical drawing.

3. The need for girls to improve their spatial ability through Craft, as a prerequisite for future success in Maths and Science.

   "It seems likely that girls poorer performance in visio-spatial tests during adolescent years could be modified by more experience of three-dimensional activities where these were offered in craft education" (Whyte 1986:22).

4. The need for compulsory technical crafts for girls. Whyte (1980) found decided "Negativity towards any educational advantage of Home Economics and Technical Crafts" amongst the teaching profession. Nevertheless, she believed that some sort of design based technical crafts should be an integral part of education up to 16 years, because of the intellectual development the subjects could potentially foster "... " particularly for supporting skills and understanding in Physics and Maths".

5. The need to develop confidence in girls to be able to participate in non-traditional craft areas.

   Whyte (1986:146), from her GIST project findings, believed that the chief barrier to girls' opting for traditional boys' craft seemed to be fear of being uncomfortably visible in a male dominated group.

A FOCUS ON THE TEACHER:

Professional Development for Teachers in Vocational Education:

> "In many of the GIST schools, the content and organization of the curriculum, no less than the stereotyped assumptions of many craft teachers, prevented girls from obtaining the authentic experience of competence and delight which craft, design and technology can potentially offer" Whyte (1986:142).

Preparation for Teaching for Equitable Outcomes:

In the USA, Jolly (1981) produced a manual designed to teach teachers how to incorporate sex fair practices into their vocational education classroom. The manual contained three sections:

The first section, A Look at Where We Are, contained seven activities for teacher self-assessment of attitudes toward sex roles and sex fairness and a paradigm for assessing influencing factors relating to entry of students in areas non-traditional to their sex.

Section 2, A Look at Where We are Going, provided general suggestions for creating a sex-fair climate in any vocational classroom. It contained nine learning experiences on such subjects as the media, attitudes, career choice, self-concept, and languages; attention getters, such as quotations and sentence completions that may be reproduced for student use; suggestions for audio-visual; listening tips; and information on assertive behaviour and consciousness raising.

The final section, A Pathway for You, contained lessons and activities designed to provide specific learning experiences for students in the various service areas of vocational education (agriculture, distributive education, health occupations, home economics, handicapped, industrial arts, trade and industrial, and office occupations). Language and audio visual aids were suggested for establishment of classroom climate. These were followed by attention-getters and learning experiences, and some bulletin board ideas were included. For each subject, a sample plan of action was provided for the teacher.

In UK, Catton (1982) believed that time and effort was required in teaching strategies to confront many of the broader social barriers. In 1984, the Texas Education Agency in Austin produced materials for training secondary and post secondary educators to promote equal access to vocational education. Topics addressed inequalities in the workplace, the role of articulation in promoting equal access, outreach, career exploration and role models, recruitment and enrolment, teaching methods student retention and supportive services, student placement and follow up.

The Role of the Industrial Arts Teacher in promoting Gender Equity in the workshop or laboratory. Catton (1982) stressed that the teacher can influence pupils' attitudes and the degree of interest and enjoyment in 'Craft, Design and Technology' workshop/studies teaching - learning situations by:

(i) directing Teacher-Pupil interactions, which in turn influences pupil-pupil interaction not only the verbal nature, but silent gestures and the written pictorial information received.

(ii) promoting an atmosphere and environment where all pupils are fully involved. He found girls noticeably quiet and reserved and produced a useful overview of traditional boy/girl behaviours in the CDT situation, with ways of counteracting the dilemmas for girls.

The Need for observation techniques for Teacher Self Evaluation:

Whyte (1984) developed techniques of classroom observation to increase teachers' awareness of the variable participation of boys and girls in craft and science lessons. She concluded that considerable effort is needed to achieve the balanced participation of girls.

FOCUS ON THE STUDENT:

The Problem of Retaining the Non-Traditional Student and promoting Gender Equity:

Harding (1982), in the UK, focussed on the major need for counselling and guidance in the area of vocational education.

Lydiard (1986) provided the following suggestions for educators in "non-traditional" girls' studies:

1. have more than one non-traditional student in a class;

2. give extra help to non-traditional students in areas in which they have not had much background;

3. don't tell dirty jokes and watch out for sexual harassment;

4. encourage open discussion of tensions;

5. don't be patronizing or chivalrous;

6. treat all students alike;

7. establish support groups for non-traditional students;

8. use gender-free terms and occupational titles;

9. help students to identify sex stereotypes; and

10. invite role models into the classroom.

Catton (1985) describes his work at "Green Park", one of the GIST schools in UK, and the ideas on which it was based appeared in his source book for Craft teachers. He organized a Work Experience Course; a trip to a Design Workshop, and single sex classes. He established a girls' technology club because the GIST cohort of girls was timetabled only for Domestic Crafts. On evaluating the outcome of the girls' club he stated:

> "I attribute much of this confidence (of girls) to the fact that boys were not present; if a girl did not understand something she did not hesitate to ask for clarification or assistance". Catton (1985).

Rhydderch (1982) cautions that "Staff Attitudes may over-ride in determining whether schemes (like Girls' only clubs) continue, even if it can be shown objectively that girls are benefitting from it" (cited in Whyte 1986).

Morgan (1988) went further to suggest that there was a need to change attitudes from the traditional teaching strategies to more problem solving orientation. She compared "good practices in an all girls department" with "typical practices in mixed departments" and found in CDT classes that design briefs were boy oriented; that girls were isolated and invisible; that in new technology and Robotics boys were overwhelmingly represented. She believes that the dearth of girls taking up CDT opportunities may be countered by: teaching style, teacher expectations, cognisance of differential interaction with and between boys and girls in the practical environment and close examination of curriculum content.

Rogers (1988) wrote about her experiences in setting up a new CDT department in UK and the processes involved. She initially established a close liaison with the Science and Art Departments and produced an integrated studies course. A computer and Graphics Technology room was set up for a "Graphical Communications Course" with its clear set of aims.

There was an emphasis on community oriented projects which included "Computerized Manual Design" (2nd year Art Group); a "Vehicle project" and a "Playground project". Girls were a special concern, so too the varied cultural and social backgrounds of all pupils and pacing in mixed ability groups, all of which were carefully monitored, evaluated and findings disseminated.

Rogers' (1988) findings have stressed that for 'inclusiveness' and reducing sex role stereotyping, the teacher must focus on the:

(1) Importance of the physical environment for CDT activities (see above)

(2) Nature of projects set

(3) Content of available resources

(4) Language being used both during demonstration lessons and general teacher/pupil interactions

(5) Interaction between pupils, also influencing perceptions of subject area.

(6) Effect of the media where many pupils (mostly girls) are receiving the message that CDT is not for them. She instanced a Poster "Wood work is for you" with a large male hand.

(7) Examination syllabuses and being alert to phrasing like "may discuss work with him" thus excluding girls.

(8) Further reinforcement of stereotypes by unthinking comments or sexist language that engender feelings of being unwelcome.

(9) Need for teachers addressing issues and ask questions about the physical experiences offered through CDT (eg encouraging girls to 'tinker' and community projects).

Placing Technological Activity in its Social Content - An Advantage for Girls:

It would seem important to reflect more deeply on Rogers (1988: point 9) with regard to teachers addressing issues and asking questions about the nature of physical experiences offered in Industrial Arts. Secondly at a deeper, more philosophical level, to consider how far these experiences in technology are in accord with the feminine "caring" morality espoused by Gilligan (1982); Noddings (1984) and French (1986).

> "Existing approaches to technology education, by removing technological activity from its social context, appear to be placing yet another barrier, in addition to institutional and attitudinal factors, in the way of many girls commitment to Craft, Design and Technology". (Grant (1985) in Eggleston 1988:7)

Eggleston 1988 has edited a superb collection of "Craft, Design and Technology" papers, one in particular by Grant (1983), where he commented on the findings of the GATE project in UK. In a limited study of pupils' entries in a national design competition, they found that girls gave greater emphasis to social aspects of technology in school "design and make" activities. Grant (1985) considered that approaching "Design and Technology from Issues and Situations" would change the emphasis from objects to people and from the impersonal to the personal and hence make it more welcoming to girls.

In such an approach the "values" component would be highlighted and used to guide the "designing and making" activities, rather than from the "knowledge" or "problems" approaches. This "values" approach, Grant believed, would "ensure pupils had an opportunity of becoming fully involved in the design process; that they acquired knowledge related to materials and scientific principles; and above all, it encouraged young people, particularly girls, to define their own and to pursue it in their own interests". (Grant (1983) in Eggleston 1988:6-7).

RECOMMENDATIONS FOR INDUSTRIAL ARTS EDUCATION FOR GIRLS:

It is recommended that Industrial Arts lecturers and educators:

- critically investigate the period 1978-1989 in UK, from the perspective of Industrial Arts encompassing progressively the arts with a central focus on creative production, design and technology.

- monitor the "state of the art" of Industrial Arts in Western Australian schools to establish whether opportunities are not only restricted for girls but also for boys.

- make every effort to facilitate the competence of girls in Industrial Arts, both in knowledge and skills, to the furtherance of their education and for future employment in a technological world.

- ensure that girls are well counselled in continuing to pursue studies in Industrial Arts for future job prospects in a technological society.

- be actively concerned about the preferred learning and cognitive styles of girls and women and investigate the best learning environment for girls.

- analyse their female students participation and retention rates in Industrial Arts.

- analyse their female students participation in activities and their subject preferences, with a view to increasing their competence and self esteem in the workshop situation.

- closely examine books, handouts, visual aids and evaluative instruments for usage of gendered or gender free language.

- encourage girls to "tinker" (skilfully and safely).

- seriously consider the pursuit of projects with a social emphasis (people oriented) for girls.

- promote the use of the computer as a valuable technological tool, especially for design purposes.

- create a classroom climate that is welcoming and supportive of girls in terms of quality verbal and non-verbal interaction between teacher and pupils and pupil and pupil.

REFERENCES:

Catton, J. (1982), "Girls in CDT - Some Teaching Strategies for Mixed Groups", Craft Design & Technology, Vol 15, No. Winter.

Catton, J. (1985), Ways and Means: Girls in Craft, Design & Technology, Harlow for the Schools Council.

Eggleston, J. (1988), The Best of Craft Design and Technology, Trentham Books.

French, M. (1986), Beyond Power: On Women, Men and Morals, Abacus Sphere Books Ltd. London.

GATE, (1982), 'The Involvement of Girls in National Design Competitions', GATE Project Report, 1982:1.

Grant, M. (1983), 'Starting Points', Craft Design & Technology, Vol.15, No.2, Spring.

Gilligan, C. (1982), In a Different Voice, Harvard University Press, Cambridge, Mass.

Harding, J. (1982), CDT What's Missing?. Craft Design & Technology, Vol.15, No.1, Winter.

Jolly, S. (1981), Sex Equity in the Classroom - Teaching Strategies, Mississippi Research and Curriculum Unit for Vocational and Technical Education, Mississippi State Department of Education.

Lydiard, B.W. (1986), Strategies for Retaining Non-Traditional Students, Paper Presented at Annual Convention of the American Vocational Association, Dallas.

Morgan, S. (1988), Girls in a Male Environment: Mixed CDT Craft Design and Technology, Vol.18. No.3. Summer.

Newhouse, L.P.(1990), Gender Equity: Retrospect and Prospect: With Recommendations for the School of Education, WACAE, Perth, WA (p71).

Noddings, N. (1984), Caring: A Feminine Approach to Ethics and Moral Education, University of California Press, California.

Rogers, M. (1988), Accessible or Merely Available? - CDT for Girls, Craft Design and Technology, Vol 18. No.3, Summer.

Texas Education Agency (1984), Forum for change: An Articulation Workshop for Secondary and Post Secondary Educators to Promote Equal Access in Vocational Education. Education Service Centre Region 2, Corpus Christi, Texas.

Whyte, J. (1984), Observing Sex Stereotypes and Interactions in the School Lab and Workshop. Educational Review, Vol.36, No.1, pp 75-86.

Whyte, J. (1986), Girls into Science and Technology: the Story of a Project. Routledge & Kegan Paul, London.