ENCOURAGING GIRLS IN SCIENCE: FACTS, THEORIES AND PRACTICAL SUGGESTIONS

by

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THE UNIVERSITY OF LETHBRIDGE
FACULTY OF EDUCATION

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AND

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Approved:

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Advisor

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DEDICATED

TO

MY NIECE AND NEPHEW

SHANDRA ANNE

AND

COLE KENDRICK ROSS

"MAY YOU ALWAYS BE WHO YOU WANT TO BE"

> "...schools are important agents of socialization,...those who wish to change society frequently suggest that education will be their vehicle." (Delamont, S., 1980, p. 3)

It is the objective of this paper to present the facts concerning the current status of Canadian women in science, to review the theories which have been put forth to explain gender disparities in science participation, to outline the findings of research in the area of gender and science, and to suggest ways in which science teachers could respond to these research findings.

A. THE FACTS

According to the 1981 Canadian census, the percentage of women employed as scientists, engineers and technologists within the "Natural Sciences and Engineering" occupational group is 47.9% (calculated from the Canadian Census of 1981, Table 1, p. 180). At first glance, this is an encouraging representation - it shouldn't be unreasonable to expect half the participation rate from half the population. However, if we examine this occupational group more closely a disproportionately large number of women occupy the "Medicine and Health" section (75.0%), as shown in Table 1.

Table 1

SCIENTISTS, ENGINEERS AND TECHNOLOGISTS BY OCCUPATIONAL GROUP AND SEX

OCCUPATIONAL GROUP	1971			1981		
	M	F	Total	M	F	Total
	(in thousands)					
NATURAL SCIENCES AND ENGINEERING . . .	290 (54.2%)	245 (45.8%)	535 (100%)	454 (52.0%)	419 (48.0%)	873 (100%)
Medicine and Health . . .				122 (25.0%)	366 (75.0%)	488 (100%)
Mathematicians and Statisticians . . .				46 (69.7%)	20 (30.3%)	66 (100%)
Life Sciences . . .				20 (76.9%)	6 (23.1%)	26 (100%)
Physical Sciences . . .				31 (81.6%)	7 (18.4%)	38 (100%)
Architects and Engineers related . . .				104 (89.7%)	12 (10.3%)	116 (100%)
Architects and Engineers . . .				131 (94.2%)	8 (5.8%)	139 (100%)
*Eliminate "Medicine and Health"	208 (93.3%)	15 (6.7%)	223 (100%)	332 (86.2%)	53 (13.8%)	385 (100%)

NOTE: Data calculated from Statistics Canada publication, Science and Technology Indicators' 1985, Table 1, p. 180

This high figure should not be surprising; the overwhelming majority of medical personnel include nurses and lab technicians, most of whom are female. What the figure tends to do, however, is offset the impact of the other five occupational subgroups in which women **are** underrepresented. Of these five subgroups, the highest female representation is in the occupational grouping of "Mathematicians, Statisticians and Systems Analysts" (30.3%) and the lowest percentage are "Architects and Engineers" (5.7%). By excluding the "Health Sciences" from the occupational groups, the mean percentage of females employed within the "Natural Sciences and engineering" group drops dramatically to 13.8%! (On a positive note, over the past 10 years this figure has doubled; in 1971 this same means calculation translated into 6.7%).

What is the situation in the school system? In Alberta the breakdown of males and females who wrote the 1986 Grade Twelve Diploma exams in science and math is recorded in Table 2.

Table 2

NUMBER OF ALBERTA STUDENTS BY SEX
WRITING SCIENCE DIPLOMA EXAMS IN 1986

	Males		Females	
Subject	**No.**	**%**	**No.**	**%**
Physics 30	5509	69.4	2428	30.6
Chemistry 30	7445	50.6	7275	49.4
Biology 30	6770	40.6	9855	59.3
Math 30	8924	51.2	8510	48.8
Math 31	3083	65.7	1611	34.3
TOTAL SCIENCES	19724	50.2	19558	49.8

Note: Data obtained from Student Evaluation Branch, Alberta Education

In total, the proportion of females to males who wrote the exams is a close 50/50 split - 49.8% to 50.2% respectively. Such a figure is most promising but before high school educators can breathe a sigh of relief it is necessary to scrutinize the breakdown by sex of each subject. The highest involvement by females is in Biology 30 (59.3%) and the lowest in Physics 30 (30.6%) and Math 31 (34.3%). Many teachers would respond, "it's not surprising" - an interesting commentary on the ease in which we accept the inevitability of such a situation. If we examine the University of Alberta's 1986/87 prospectus, the folly in passively accepting these skewed statistics becomes clear. From this prospectus, one table has been drawn in which the required and recommended courses for entrance to the B.Sc. Honors and Specialization programs are cited (see Table 3).

TABLE 3: **Subject Requirements for B.Sc. Honors and Specialization Programs**
(In addition to English 30 and Mathematics 30)

Programs of Study	Hon	Spec	Courses: Biol 30	Chem 30	Phys 30	Math 31	Advising Department
Applied Mathematics	H				X	X	*Mathematics*
Biochemistry	H	S	X	X	X		*Biochemistry*
Botany	H	S	X	X	R		*Botany*
Business Applications		•			X	X	*Computing Science*
Cell Biotechnology	H	S	X	X	R		*Microbiology*
Chemistry	H	S		X	X	R	*Chemistry*
Computer Design		•			X	X	*Computing Science*
Computing Science	•	•			X	X	*Computing Science*
Economics and Mathematics	H	S			X	X	*Mathematics*
Entomology	H	S	X	X	X		*Entomology*
Food Science		S	X	X	X		*Food Science*
Genetics	H	S	X	X	R		*Genetics*
Geography	H	S					*Geography*
Geology	H	S		X	X		*Geology*
Geo-Information Processing		S				X	*Geography*
Geophysics	H	S		X	X	R	*Physics*
Linguistics	•	S	X		R	R	*Linguistics*
Mathematical Physics	H				X	X	*Physics*
Mathematics	H	S			X	X	*Mathematics*
Meteorology		S			X	R	*Geography*
Microbiology	H	S	X	X	X		*Microbiology*
Northern Frontier Studies		S					*Geography*
Paleontology	H		X	X	X		*Zoology*
Pharmacology	•	S	X	X	X		*Pharmacology*
Physical Geography	H	S					*Geography*
Physics	H	S			X	R	*Physics*
Physiology	•		X	X	X		*Physiology*
Psychology	•	S					*Psychology*
Resource Studies	H	S					*Geography*
Scientific Applications		•			X	X	*Computing Science*
Software Design		•			X	X	*Computing Science*
Statistics	H	S			X		*Statistics*
Survey Science		S			X		*Geography*
Zoology	H	S	X	X	X		*Zoology*

X Required
R Recommended
• No Direct Entry to First Year

NOTE: From the University of Alberta, <u>1986/87 - A prospective student guide</u> (p. 17).

The chart suggests that if either the Physics 30 or Math 31 requirement is not met, the choices of programs available to students at the U. of A. could essentially be limited to five out of thirty-four programs of study! (Competition is fierce for University entrance these days therefore we can assume that those students who completed the recommended as well as the required subjects for entrance to a specific program would more be successful in their bid to enter the program). Clearly, we must encourage science oriented high school students to complete all three sciences - biology, chemistry and physics - and to tackle Math 31, if they are to be assured of unrestricted career options.

In higher education, the picture is much the same. Enrollment of first year undergraduates attending Alberta universities by sex, degree sought and degrees granted at these same institutions shows an intriguing differentiation by sex (see Table 4a and 4b). The lowest participation of females in science is found in the programs of Engineering, Dentistry, Computing Science and Medicine with the highest participation in Rehabilitation Medicine, Dental Hygiene, Nursing, and Medical Lab Science. Females appear to be opting out of the science professions to which a higher status is assigned. For example they are selecting Dental Hygiene (100% female) rather than Dentistry (28.6% female) and Nursing (95% female) rather than Medicine (35.1% female) (see Table 4a).

Table 4A

ENROLLMENT OF FIRST YEAR UNDERGRADUATES ATTENDING ALBERTA UNIVERSITIES BY SEX AND DEGREE SOUGHT

	U. of C.		U. of A.		U. of L.		Total n	Totals	
	M	F	M	F	M	F		M%	F%
Pre-Dent	23	12	62	18	5	0	120	75%	25%
Pre-Med	N/A	N/A	194	158	36	9	397	57.9%	42.1%
B.Ed.	39	187	233	391	41	114	1005	36.1%	68.9%
Pre-Vet	12	17	13	21	4	8	75	38.7%	61.3%
B.Sc. (Chem)	13	4	13	2	6	3	41	78.0%	22.0%
B.Sc. (Comp Sci)	56	17	48	11	20	2	154	80.5%	19.5%
B.Sc. (Eng)	384	33	428	43	30	4	922	91.3%	8.7%
B.Sc. (Pharm)	N/A	N/A	29	68	N/A	N/A	97	29.9%	70.1%
B.Sc. (Zool)	25	28	10	12	26	18	103	48.5%	51.5%
Total B.Sc. (Hon)	22	7	25	17	N/A	N/A	71	66.2%	33.8%
Total B.Sc. (Gen)	289	176	265	253	*	*	983	56.4%	43.6%
B.N. (Nursing)	4	64	2	37	1	32	140	5.0%	95.0%
Medicine (M.D.)	47	27	77	40	N/A	N/A	191	64.9%	35.1%
Med Lab Science	N/A	N/A	2	33	N/A	N/A	35	5.7%	94.3%
Dentistry	N/A	N/A	35	14	N/A	N/A	49	71.4%	28.6%
Dental Hygiene	N/A	N/A	0	42	N/A	N/A	42	0%	100%
B.A. (Psych)	56	110	41	92	14	32	345	32.2%	67.8%

* Combined B.A./B.Sc. at the University of Lethbridge

Source: U of A Summary of Statistics 1985-86, U of L Facts Book 1985-86, U of C Fact Book 1985-86

Table 4B

1985/86 DEGREES GRANTED AT ALBERTA UNIVERSITIES BY SEX AND MAJOR

	U of C		U of A		U of L		n	TOTAL	
	M	F	M	F	M	F		%M	%F
Dentistry	N/A	N/A	37	6	N/A	N/A	43	86.%	13.9%
B.Ed.	88	379	251	740	57	125	1287	24.1%	75.9%
B.Sc.	19	12	4	4	2	2	35	60.0%	40.0%
B.Sc. (Comp Sci)	112	43	72	24	9	0	260	74.2%	25.8%
B.Sc. (Eng)	251	22	323	33	N/A	N/A	629	91.2%	8.7%
B.Sc. (Pharm)	N/A	N/A	23	38	N/A	N/A	61	37.7%	62.3%
B.Sc. (Zool)	20	16	17	18	10	8	89	52.8%	47.2%
Total B.Sc.	555	179	468	280	36	24	1542	68.7%	31.3%
B.N. (Nursing)	1	97	8	140	1	22	269	3.7%	96.3%
M.D. (Medicine)	52	17	77	37	N/A	N/A	183	70.5%	29.5%
Rehab Medicine	N/A	N/A	4	106	N/A	N/A	110	3.6%	96.4%
(a) Occ Therapy	N/A	N/A	2	41	N/A	N/A	43	4.7%	95.3%
(b) Phys Therapy	N/A	N/A	2	40	N/A	N/A	42	4.8%	95.2%
(c) Speech Path	N/A	N/A	0	25	N/A	N/A	25	0.0%	100%
Med Lab Science	N/A	N/A	5	10	N/A	N/A	15	33.3%	66.7%
B.A., B.Sc. (Psyc)	45	111	40	51	13	27	287	34.1%	65.9%

Source: U of A Summary of Statistics 1985-86, U of L Facts Book 1985-86, U of C Fact Book 1985-86

As we progress through the ranks of higher education the number of females choosing the doctorate route drops dramatically. In 1983 only 16.2% of the doctorates awarded federally in the "Natural sciences and engineering" field of study were awarded to females (Statistics Canada, Science and Technology Indicators' 1985, Table 27, p. 202). It is interesting to note the minimal impact of excluding the "Health Sciences" this time - the percentage of females decreases by only 3.3% (see Table 5).

Table 5

EARNED DOCTORATES, BY FIELD OF STUDY AND SEX

FIELD OF STUDY	1983		
	M	F	Total
		(number)	
NATURAL SCIENCES AND ENGINEERING . . .	822 (83.4%)	159 (16.2%)	981 (100%)
Health Sciences . . .	119 (68.4%)	55 (31.6%)	174 (100%)
Agriculture and Biological Sciences . . .	197 (79.8%)	50 (20.2%)	247 (100%)
Mathematics and Physical Sciences . . .	296 (87.0%)	44 (13.0%)	340 (100%)
Engineering and Applied Sciences . . .	210 (95.5%)	10 (4.5%)	220 (100%)
*Eliminate "Health Sciences"	703 (87.1%)	104 (12.9%)	807 (100%)

NOTE: Data obtained from Statistics Canada publication, Science and Technology Indicators' 1985, Table 27, p. 202.

The majority of women who study in the health sciences, appear to favor working within their profession, to furthering their formal education. A contributing factor to this could be the underlying pressure of economic survival which drives women to participate in the workforce; the economic survival of many two-parent families and most one-parent depends on the woman's income and the luxury of continuing in their education is simply out of reach. Also, if one considers that the highest proportion of women in the health sciences work in the nursing profession and that a Ph.D. program in nursing is currently **not** available in Canada, the low percentage of women with Ph.D.'s in the Health Sciences is not surprising (L. Hardy, personal communication, February 26, 1987). The reality for those women in science that do go on to complete their doctorates, is that they are less likely to find employment, and they are usually paid less than their male equivalent (Harvey & Noble, 1985; Stage, Kreinberg, Eccles (Parsons) & Rossi Becker, 1985; Symons & Page, 1984).

B. THE IMPACT

Since we are in the midst of a technological revolution, it is essential to develop a scientifically literate populous (Science Council of Canada, 1984). Decisions must be made to determine the direction new technological advances should take; it is imperative for women to have an equal say in this decision-making process. The current 13.8% participation rate of Canadian women in technical fields is inadequate, not only because it is an underrepresentation of half of the population, but because it effectively muzzles a different approach to the world (Gilligan, 1982; Greene, 1985; Kremer, 1984). Gilligan (1982) states that "...in the different voice of women lies the truth of an ethic of care, the tie between relationship and responsibility ..." (p. 173). It could be argued that in our volatile atomic age, it is more critical than ever to be able to hear such a voice.

Aside from taking a philosophical stance, it is critical to examine the economic impact of an underrepresentation of women in science and technology. Menzies (1981) states that "women's increasing presence and permanence in the labour market is one of the most significant developments in Canadian society over the last thirty years" (p. 5). Canadian statistics show that "eight out of ten women will work for wages for at least thirty years" (Glaze, 1980, p. 21). Furthermore, the 1981 Statistics Canada report, Charting Canadian Incomes 1951-1981, states that 60 per cent of Canadian families have two or more earners (p. 11). Of the two income families only 12.5 per cent were earning less than $20,000 per annum, versus 36.9 per cent in the one-income family (Statistics Canada, Income Distributions by Size in Canada, 1984, Table 9, p. 34). Taking into account that an income of $20,000 per annum is required to maintain a family of four slightly above the poverty line (calculated from the National Council of Welfare figure in 1986 Poverty Lines of $367/week, p. 6), the financial contribution of the female partner in a marriage is clearly a necessity to most families of the 1980's.

The tragedy is, however, that most families do not retain their two-income status. The reality of the 1980's is that 11.3% of marriages result in divorce, which translates into one in eight females and one in 10 males nationally (Statistics Canada, Family History Survey, 1984, p. 31). This does not include statistics on separation. In most separation or divorce cases, the female wins custody of the children and is financially responsible for their upbringing (Harvey & Noble, 1985). The Family History Survey publication by Statistics Canada further states that of the 16% lone parent families identified in 1984, 78% are headed by a female (p. 31). When one considers that in 1981, men earned an average of $18,000, almost double the $9,700 earned by women it isn't difficult to understand why many of these female-headed households plummet below the poverty line (Statistics Canada, Charting Canadian Incomes 1951-1981, p. 7). According to the National Council of Welfare publication, 1986 Poverty Lines, the Canadian reality is that "six in every ten women under age 65 who are single parents raise their children on an income below the poverty line" (p. 6).

The problem now is to relate this information to the concern for the number of girls opting out of the sciences. The relationship is surprisingly direct. The impact of technological advances on the employment will hit occupations dominated by women first. Approximately two-thirds of the occupations occupied by women are in the clerical, sales or service occupations (Menzies, 1981). Although more women are moving into non-traditional areas - that is, areas which were previously considered male domains eg. business, management, agriculture, architecture, engineering - a high percentage are still selecting occupations within the clerical sector (Harvey & Noble, 1985). Menzies (1981) paints a bleak picture for individuals employed in the clerical sector as a result of what she terms "informatics". An overwhelming majority of women are employed as bank tellers, telephone operators, clerks, secretaries, etc. - occupations which are at high risk of displacement by computerization. Menzies (1981) states that, "... women represent over 90 per cent of telephone operators and a similarly high proportion of other clerical workers...."(p. 19) In examining the telephone operator positions for example, Menzies cites specific cases in which the number of operators was reduced in Toronto by 40 per cent in one year with the introduction of a semi-automated long distance system, and a further reduction by 20 to 25 per cent was being projected within another year or two with the introduction of a mechanized directory assistance service. The push for productivity is strong - one which doesn't wait to consider who is supporting a family and who isn't. The technological age is an exciting one to those holding the reins but can trample, cripple and destroy those left underfoot. To extend the metaphor, it is essential that young women use the sciences as a ticket to climb aboard the technology coach and take hold of the reins - only by so doing will they avoid being one of its victims. The choice is a matter of economic survival - there is no doubt that if women don't become more involved in the emerging technology they will be destroyed by it.

C. THEORIES FOR THE DISPARITY IN PARTICIPATION OF WOMEN IN THE SCIENCES

Greenberg (1985) states that as early as two years of age children are aware of their gender identity. She further states that "...at about age 3 children will be vigilant in avoiding actions, activities and events they believe "inappropriate" for their own sex ..." (p. 457). How this translates into problems associated with the participation of women in science is something we will explore in the following section.

Reported Gender Differences In Science

Since the 1930's, batteries of standardized achievement tests have been used to evaluate the performance of students worldwide at every level of the school system. The temptation to take the results of such widespread testing and compare the performance of homogenous groups of students identifiable by socio-economic level, racial origin, or country of citizenship, etc. is great. Within the area of science achievement testing, no comparisons have been more widespread or more controversial than those comparing the results of males to females.

The results of the science component of international tests such as the International Association for the Evaluation of Educational Achievement (IEA) which was administered through twelve countries in 1964 and U.S. surveys ranging from Project TALENT in 1963 and the National Assessment of Educational Progress (NAEP) which was administered initially in 1971, widely publicized the fact that boys were outperforming girls in the sciences (Erickson & Erickson, 1984). Since these findings came to light, the literature has been deluged with studies investigating the relationship between science achievement and gender (Baker, 1985; Cannon & Simpson, 1985; DeBoer, 1984, 1986; Deptuck, Whelan & Leuthy, 1986; Erickson & Erickson, 1984; Fennema, 1983; Fennema & Peterson, 1986; Humphreys, 1984; Kahle, 1985a, 1985b; Kremer, 1984; Larowitz, Baird, Allman, 1985; Lowry & Woodhull, 1983; Maehr, 1983; Matyas, 1985; Orpwood & Souque, 1984; Persson Benbow & Stanley, 1984; Reyes, & Psadilla, 1985; Ridley & Novak, 1983; Science Council of Canada, 1984; Simpson & Oliver, 1985; Smith & Stroup, 1978; Stage, Kreinberg, Eccles (Parsons) & Rossi Becker, 1985; Steinkamp, 1983; Steinkamp & Maehr, 1983; Talton & Simpson, 1985; Walleat, Pedro, Becker & Fennema, 1980; Weiner & Robinson, 1986; Zerega & Walber, 1984).

What characteristic of the sciences has created this performance differential between males and females? Zerega & Walberg (1984) state that, "Science,... often requires proficiency in arithmetic reasoning and analytic ability, and in the ability to manipulate objects...." (p. 40) If this task analysis of science is accepted and is related to the cognitive strengths of the sexes as identified in the landmark work by Maccoby and Jacklin (1974) in their comprehensive review of gender research, a male advantage to achieving in science appears to emerge. These male strengths that have been identified by Maccoby and Jacklin (1974) are in the areas of "quantitative ability" (p. 85), "spatial ability and disembedding" (p. 91) and "field independence" (visual-spatial tasks) (p. 98) - all of which would contribute to success in the sciences. Findings by

Kolb & Whishaw (1985) support this assessment, stating that, "on tests of recall and detection of shapes, mental rotation of two- or three-dimension figures, geometry, maze learning, map reading, aiming at and tracking objects, and geographical knowledge, males perform better on average than do females" (p. 363). The time frame in which this male advantage has been identified generally begins in pre-adolescence, at approximately age 11 (Kolb & Whishaw, 1985). Those cognitive strengths favoring girls such as - "verbal abilities" (p. 75) and "set-breaking" (within the "analytic abilities" category) (p. 98) which involves the ability to complete restructuring exercises such as anagrams - are not generally associated with skills required to achieve in the sciences. Tests which can be used to demonstrate male and female advantage tasks are illustrated in Figure 1.

There is some controversy, however, as to how clearcut these sex differences are. Research since Maccoby and Jacklin (1974) indicate that the findings are anything but definitive. Hyde (1981) applied meta-analysis techniques to the studies reviewed by Maccoby and Jacklin in order to assess the magnitude of the gender differences in the identified cognitive areas. Although she acknowledged that the cognitive gender differences were great enough to be statistically significant she argues that the differences are too small to use the sex of a child as an ability predictor in subjects requiring these cognitions.

Figure 1: Examples of Male Advantage and Female Advantage Tasks

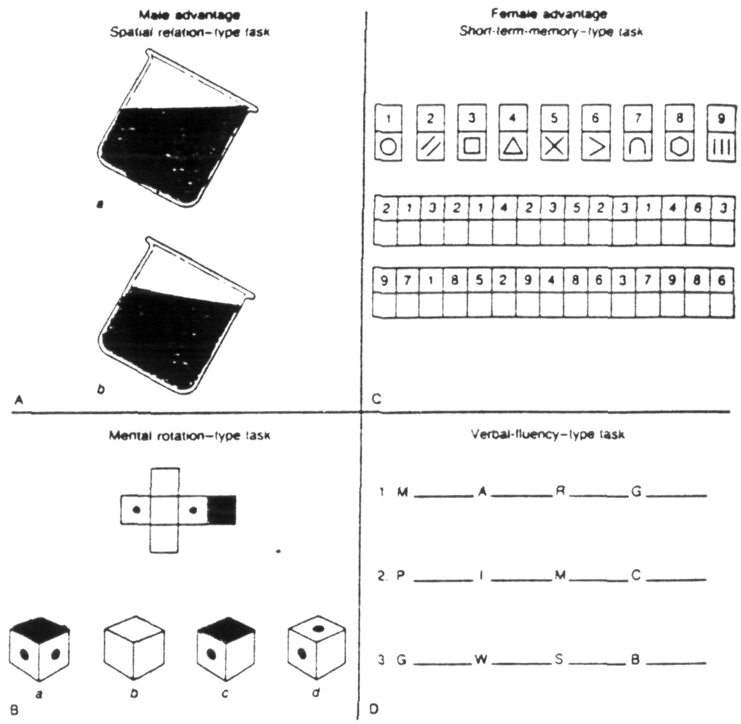

FIGURE 15–1. Examples of four types of tasks that reliably show sex-related differences. A. The top drawing shows a line drawn to indicate waterline in which the response indicates comprehension of the concept of horizontality of fluid level. The bottom illustration shows the line drawn incorrectly, indicating no comprehension of the concept. This response is typical of about two-thirds of females. B. This task, which is similar to those in the spatial relations test of the Differential Aptitude test, requires the subject to choose the one box from the bottom four that could be made from the plan above. Males typically find this task much easier than females. C. In this test the subject must fill in the empty boxes in the bottom rows with the appropriate symbols from the examples at the top. This is similar to the digit symbol test on the Wechsler Intelligence tests. When given a larger number of boxes to fill and a time limit of 90 seconds, females complete 10 to 20 percent more items than males. D. This test of verbal fluency requires the subject to fill in each blank in order to form words that make a sentence. Females are faster at this type of test than males.

(reprinted with permission from Kolb & Whishaw (1985), p. 364).

She warns of the danger in the widespread acceptance of research which identifies cognitive abilities by gender; the misuse of such information by vocational counsellors and teachers could be devastating. Steinkamp & Maehr (1983), consolidated the results of sixty-six leading studies in the area of gender and science. Their meta-analysis did uncover performance differences which favored the boys in both cognitive ability and achievement, but they also emphasize that the differences are only slight. Although Kolb & Whishaw (1985) consider the results of neuropsychological tests to be different enough to warrant the establishment of separate norms for males and females they too warn that the male versus female dichotomy is not absolute, indicating that the standard deviation for the spatial advantage of males is only about .4 and the verbal advantage of females is .25. A study by Rakow (1984) reported that of 2000 nine year olds selected randomly across the U.S. and tested by the Minnesota Science Assessment and Research Project in 1982, the boys scored higher than girls on all achievement items except classification but the overall difference was only 0.7%. Benbow and Stanley (1984) report that of the students involved in their study that were identified as mathematically precocious in seventh and eighth grade, the girls have a lower mathematical reasoning ability than boys of the same age. Several researchers have shown, however, that differences within the sexes is often as great as between the sexes (Hyde in Ferguson, 1982; McNeill Kavrell & Petersen, 1984).

The controversy is far from over. The persistent re-occurrence of differential findings in science achievement by gender has stimulated much research in the area, resulting in the development of numerous explanation-seeking theories in the late 1960's and early 70's. The theories can be divided into two major categories - Biological, Socio-cultural and Psychological - the degree to which their interplay influences differential achievement by gender is still keenly debated today.

1. BIOLOGICAL THEORIES

HYPOTHESES:

1. Spatial ability might be inherited by a recessive major gene carried on the X chromosome. This pattern of inheritance would produce sex differences since boys, XY, only possess the one X chromosome, inherited from their mother, and would express the gene if it is present on that chromosome. On the other hand, the opportunity for girls (XX) to express the gene is sharply reduced as they would require the recessive gene on each of their chromosomes (cites Bock & Kolakowski, 1973). Earlier results have not been replicated by more recent studies - cites Bouchard & McGee, 1977; Defries, et al, 1976; Sherman & Fennema, 1978). Due

to lack of evidence the hypothesis has been disconfirmed (McNeill Kavrell & Petersen, 1984).

2. The influence of hormones as having an effect on cognitive functioning was suggested by Broverman and colleagues in the 1960's (Ferguson, 1982; McNeill Kavrell & Petersen, 1984). According to this hypothesis the sex hormones at puberty could have an effect on brain development as well as somatic development resulting in the strengthening of cognitive styles which is responsive to the specific hormone. The female hormone, estrogen, purportedly enhances the development of the automatized style (walking, talking, reading), whereas the cognitive restructuring style is influenced by the male hormone, testosterone. As most of the sex differences tend to appear in pre-adolescence this theory fits the timing of the emergence of the identified cognitive advantage. Ferguson (1982), however, in citing Kimball (1982), found contradictory studies that demonstrated that the more testosterone the male has, the better <u>he</u> performs in automatized tasks and furthermore these studies have not found the monthly fluctuations of estrogen experienced by females to affect <u>their</u> ability to perform automatized tasks. However,

there is evidence that these hormone fluctuations effect the spatial and verbal ability in females. During ovulation, spatial ability is depressed and verbal skills peak. After ovulation the reverse has been found to be the case (B. Kolb, personal communication, March 26, 1987).

3. The theory of brain organization or "Brain Lateralization" is one of the most recently developed theories. It was developed in 1972 by Buffery and Gray, as cited by Kimball in Ferguson (1982). The two hemispheres are undifferentiated at birth and later become lateralized. The right hemisphere is associated with spatial strengths and the left hemisphere with verbal skills. McNeill Kavrell & Petersen (1984) cite the literature review completed by McGlone (1980) suggesting that the cognitive functioning of females is more equally lateralized. This difference in lateralization between males and females has been linked to sex differences in spatial skill. In citing Levy (1972), McNeill Kavrell & Petersen (1984), indicate that the lateralization in females creates competition between the hemispheres, which serves to reduce spatial ability.

Supportive Research

Benbow & Stanley (1984) followed the science choices of mathematically precocious students and found that the girls shied away from physics and engineering, fields which the researchers identified as requiring good mathematical reasoning ability. These students were originally identified in seventh and eighth grade by an SMPY (Study of Mathematically Precocious Youth) talent search as being superior in mathematics. Previous studies are cited (Benbow & Stanley, 1980, 1981) in which Benbow and Stanley argued that "sex differences in mathematical reasoning ability (were apparent) and ruled out certain socialization explanations for these differences" (p. 170). They continue by citing Maier & Casselman (1971) who found sex differences in approaches used in problem-solving and hypothesized that, "women do not enter scientific careers...(as) their cognitive preferences are incompatible with studying science" (Benbow and Stanley, 1984, p. 187).

Kolb & Whishaw (1985) suggest that the spatial advantage in males could be applied to the dominance of males within chess and musical composition - "in the Soviet Union, where chess is a national pastime, no women have achieved grand-master status" (p. 365).

2. SOCIO-CULTURAL AND PSYCHOLOGICAL THEORIES

THE EVIDENCE

It is most tempting to use the knowledge of an inherent male advantage in spatial cognitions to explain the poor showing of females in the sciences. The temptation must be avoided, however, as overwhelmingly the literature states that when other factors such as differential training and experience are taken into account sex differences tend to disappear (Erickson & Erickson, 1984; ; Fennema, 1983; Fennema & Sherman, 1977; Hyde, 1981; McNeill Kavrell & Peterson, 1984; Science Council of Canada, 1984; Steinkamp & Maehr, 1983). If girls were biologically inferior in the sciences then it would also be impossible for them to achieve top marks and yet the contrary has been found to be the case. In analyzing the results cited by Benbow and Stanley (1980) in their study of mathematically precocious youth, Kimball (1981) notes that, "...perhaps the most important figure to consider in the context of this study is that 43 per cent of the top 3.0 per cent of students were girls" (p. 51).

Kremer (1984) points out the flaws of many studies which in their investigation of the relationship of gender to math and science achievement conclude there exists a male advantage. Her criticism includes:

a. not taking into account the different course-taking and play background of males and females in mathematics

b. ignoring the more aggressive nature of males which causes low-ability males to drop out of school resulting in a homogeneous motivated sample group versus a heterogeneous group of females, and

c. the small sample size of many studies.

A study by Erickson and Erickson (1984) is based on results from the British Columbia Science Assessment tests which were provincially administered in 1978 to students in Grade 4, 8 and 12. Although boys outscored girls at all three grade levels, the researchers found that in ranking the test items in order of those with the greatest male advantage to the greatest female advantage, the content of those items favoring each sex was found to relate more closely to their life experiences. Overwhelmingly the content of the items were biased to the male experience. Viewing the tests in this light tends to reduce the impact of a purely biological explanation for such sex differences.

Sociological influences are unique within each culture, affecting the degree to which sex-typing of subjects occurs. In a paper on the impact of environment on the science achievement of girls, Fischer (1981) as cited in Ferguson (1981) states, "In the Soviet Union 70 per cent of doctors and 30 per cent of engineers are women indicating many women in that country are encouraged to develop their scientific potential" (p. 63). This is supported by the results of internationally administered Science Achievement Tests in which girls from Japan had higher physics scores than boys in any of the ten countries involved in the testing. Hungarian girls had better chemistry scores than boys in every country but Japan. It's important to note that the boys in both Japan and Hungary had higher scores than did the girls. While such findings do not negate the biological theory, they strongly support the impact of sociological influences.

The internalization of societal pressures has been determined to have a psychological effect on individuals - the degree to which the pressures are internalized depends on the strength of the gender identity of the individual. The separation is not a simple delineation of black from white - with masculine traits on one side of the line and feminine traits on the other. A grey area of androgyny exists in which individuals, of both sexes, express both masculine and feminine characteristics. Bem (1975), the researcher who developed the Bem Sex Role Inventory (BSRI), states, "there exists a distinct class of people who can appropriately be termed androgynous, whose sex role adaptability enables them to engage in situationally effective behavior without regard for its stereotype as masculine or feminine" (p. 643).

Advantageous as it is to be androgynous, judging from the influence of gender-role stereotyping on the career choices of school children, it is not the common psychological profile of adolescents (Purvis, 1987). In early adolescence, particularly, young people are experiencing the most negative and unstable self-concept of their development; the pressure to conform within the narrow boundary of a strict gender definition is very strong. In relating this to the study of science, McNeill Kavrell and Petersen (1984) state, "For the adolescent girl, the development of mathematical and spatial skills which society stereotypes as masculine, is clearly not consonant with a feminine sex role identity" (p. 17). At a time when peer acceptance is so critical, it is not surprising that boys express a greater interest in math and science than do the girls. Maccoby and Jacklin (1974) found that prior to adolescence no sex differences in mathematics ability was evident.

The interplay between sociological and psychological factors is so closely entangled that they may more appropriately be combined under the label - psycho-social influences. It is not denied that the inherent characteristics of males and females which shape their cognitions is also tightly interwoven with these influences. This paper, however, with its pedagogical emphasis is focusing on influences that can be changed, influences which society created and is therefore capable of modifying. The biological sex of an individual is a fixed entity, a given, and as such cannot be influenced by the education system.

The research outlining the impact of psycho-social influences on the science achievement of girls can be separated under the following headings: Sex-role Stereotyping; Nature of Classes; Free-time Play; Peer Pressure; Role Models; Teacher Interactions and Expectations; Concept of Self, Confidence Level and Expectations of Success; Sex-role Identity; Motivational Style; and Family and Counselling Influences. Following this literature review, practical suggestions for teachers, related to the findings, will be discussed.

SUPPORTIVE RESEARCH

1. Sex-role Stereotyping

Deptuck, Whelan, & Leuthy (1985) provide an example of a situation presented in the First Annual Conference for Women in Science and Technology where teachers were to draw a profile of two students named Dennis and Denise, who were high achievers in science. Traditional male/female occupations were assigned respectively because of the names. Beginning with the sex-appropriate pink or blue blankets at birth even babies receive differential treatment by their sex (Skolnick, Langbort & Day, 1982). Steinkamp & Maehr (1983) state that as early as second grade, reading and art are considered feminine endeavors and mathematics, sports and spatial-mechanical pursuits are labelled masculine. Science itself is definitely perceived as a male domain (Handley & Morse, 1984; Hanson Frieze & Hartman Hanusa, 1984). Matyas (1985) cites Chambers (1983) in a study where 4,807 children ranging from kindergarten to grade five were asked to draw a picture of a scientist and only 28 drew a female. Overwhelmingly, scientists are seen as male in our culture (Hanson Frieze & Hartman Hanusa, 1984).

The greatest difference in science achievement by gender, noted through the literature, occurs in adolescence (Erickson & Erickson, 1984; Handley & Morse, 1984; Hart Reyes & Padilla, 1985; Kremer, 1984; Steinkamp & Maehr, 1983). Steinkamp & Maehr (1983) speculate that young adolescents adhere closely to sex role stereotypes with young male adolescents using science achievement as an assertion of their masculinity. If sex-typing is too strong the girls will take fewer courses and will have a lower achievement (McKeill Kavrell & Petersen, 1984). In a study by Kerr (1985), involving gifted girls in Grades 5, 8 and 12 it was noted that career goals became lower in status, salary and prestige with age.

Martin (1981) uses the term "double bind" to describe how a woman must get ahead in science by acquiring traits, which, when acquired. are appraised negatively. Skolnick et al (1982) adds a third dimension, the "triple bind", represented by the guilt complex often felt by a career woman who is working, as well as maintaining a family, and the conflict with her self perceived role as a traditional role of wife and mother.

2. Nature of Classes

Competitive vs. Cooperative

In studying 36 fourth-grade mathematics classes Fennema & Peterson (1986) observed that "there was 2-1/2 times as much competitive activity in the boy-gain classes than in the girl-gain classes" (p. 10) Overwhelmingly the girls did not achieve as well in a competitive setting as with one of cooperation. The boys on the other hand, achieved the highest in a competitive spirit.

Single Sex Classes

Within single sex schools more girls select physics, chemistry, math and physical education and more boys take literature and foreign languages than in coed schools (Hanson Frieze & Hartman Hanusa, 1984; Matyas, 1983).

However, Mayyas (1983) does not recommend single sex classes to be the rule as they give both boys and girls a restricted perception of the other sex. This is supported by Kahle (1985) who found that boys demonstrate more stereotypic views than do girls. It is only through interactions in integrated classes that these views can be changed. The case of having occasional segregated classes or groups by sex is recommended though as it enables the teacher to pick out potential leaders or girls in need of extra encouragement.

3. Free-time Play

The active nature of boys' games such as casting a fishing line and tossing a football offers them experience in the manipulation of objects and in understanding such abstract concepts as trajectory and vectors, giving them a distinct advantage in the understanding of spatial tasks in later science and math classes (Shapiro, Kramer & Hunerberg, 1981; Steinkamp & Maehr, 1983). The different nature of boys' play, also allows more meaningful experiences to occur for them in science classes than for the girls (Ridley & Novak, 1983).

4. Peer Pressure

The fact that boys in high school see math as a male domain more than do girls can have a devastating psychological impact on the girls (Fennema & Sherman, 1977; Matyas, 1985; Steinkamp & Maehr, 1983). As peer influence increases so do the girls' attitude to science decrease (Matyas, 1985). The literature suggests that the attitude of adolescent boys has such an impact on the girls, that we need to make them as aware of the career options for girls in maths and sciences, as we do the girls.

In a longitudinal study following students from Grade 6 through to Grade 10, Talton and Simpson (1985) found a definite correlation between peer attitude towards science and the attitude of the individual. The strongest relationship was found in Grade 9.

5. Role Models

The presence of female role models in the sciences is most encouraging to girls (Highman & Navarre, 1984; ; Matyas, 1985; Hanson Frieze & Hartman Hanusa, 1984; Shamonoff, 1985). Although Matyas (1985) doesn't note any improvement in the achievement of boys and girls with either the presence or absence of role models, she does mention that the encouragement of individual high school teachers is influential in determining a science career choice with the highest career commitments resulting from experiences with same sex teacher contacts.

6. Teacher Interactions and Expectations

The attitude of the teachers plays a critical role in influencing student achievement. Skolnick et al (1982) cites the study by Rosenthal and Jacobson (1968) in which teachers were told students were high achievers, when in fact they weren't, and the children performed better.

Within the classroom, teachers interact more with boys than with girls (Fennema, 1983; Houston, 1985; Matyas, 1985; Sadker & Sadker, 1985). Teacher praise has also been found to be a powerful motivator for girls (Fennema & Peterson, 1986; Skolnick et al, 1982).

7. Concept of Self, Confidence Level and Expectations of Success

The confidence level of girls in science is generally low and it has been found to decrease from 6th grade to 12th grade (Hart Reyes & Padilla , 1985). This lack of confidence expresses itself in decreased risk taking - girls are hesitant to "guess" when they are not sure of the answers. This surfaces when males and females are asked to tackle an unfamiliar task. Males will often overestimate how they will do on an unfamiliar task while females usually underestimate their ability. In a study involving 8th and 9th graders, boys reported no shift in confidence whether they were asked to perform in a traditionally male role or a traditionally female role, whereas girls reported a lack of confidence in performing nontraditional roles (Post-Kammer & Smith (1985).

Perceived competence and self-perception of ability (sense of self-efficacy) are considered to be of primary significance to success in the sciences (DeBoer, 1986; Maehr, 183; McNeill Kavrell & Petersen, 1984; Hanson Frieze & Hartman Hanusa, 1984; Post-Kammer & Smith, 1985). The attribution individuals assign to their successes or their failures has a definite influence on continued success in science (Hanson Frieze & Hartman Hanusa, 1984; McNeill Kavrell & Petersen, 1984). Females are much more likely to attribute failure to lack of ability and success to luck.

The relationship between self-concept and gender role perceptions has been correlated with science attitude more than with achievement (Handley & Morse, 1984). In the two years from Grade 7 to Grade 8 researchers found an increased acceptance of the stereotyped view of male dominance in science.

An exceptionally subversive duo which will undermine longterm science achievement has been cited as the lack of self-confidence together with underestimating ability - traits which overwhelmingly characterize the attitude of adolescent girls in science (Hanson Frieze & Hartman Hanusa, 1984).

8. Sex role identity

Sex-role identity can range from the traditional to the liberated. If a girl has a high femininity rating she will opt for a stereotypic feminine career (Glaze, 1980; Hanson Frieze & Hartman Hanusa, 1984). Hanson Frieze & Hartman Hanusa (1984) state that, "...having nontraditional sex role expectations appears to be highly diagnostic of having high career aspirations for women (p. 146) As previously mentioned, those individuals who are not strongly sex-typed as masculine or feminine but who demonstrate both masculine and feminine traits depending on the situation are termed "androgynous" (Bem, 1975). In her study, Bem (1975) found androgynous females to be more independent of social pressure than women who scored high on her femininity rating.

9. Motivational Style

Steinkamp (1984) states that "...if exploration and compliance cannot exist independently within the same individual, habits of compliance would have to be extinguished before exploratory behaviors could be taught.... (This) reduces the chances of achieving in science for females in whom compliance tends to be programmed... at an early age."(p. 296) Girls will too often choose compliance over self-actualization.

In examining attitude and achievement motivation in students from Grades 6 - 10, Simpson and Oliver (1985) found that at all five grade levels the attitude of boys was more positive towards science than was the girls. The girls, however, were more motivated to achieve than their male counterparts It is interesting to note that attitude toward science and achievement motivation declined for both sexes from Grade 6 to Grade 10.

10. Family and Counselling Influence

The usefulness of math and science in careers must be pointed out to girls (Fennema & Sherman, 1977; Hanson Frieze & Hartman Hanusa, 1984; Steinkamp, 1984). Fennema and Sherman (1977) view math as the "critical filter" to a science career. Girls should be encouraged to take a wide range of math courses in high school. Support and encouragement from parents and the school counsellor provide critical emotional support for career aspirations (Fennema & Sherman, 1977; Hanson Frieze & Hartman Hanusa, 1984; McNeill Kavrell & Petersen, 1984; Peterson, 1986). Peterson (1986) discovered that parents are more keyed into looking for ability information in sons than in daughters in order to help them plan careers. It was also found that parents often attribute the math success of their daughters to effort and of their sons to ability. This parental attitude is detected by the girls and within a year has been considered responsible for seriously undermining their confidence in the subject. Fathers are often a strong influence on girls who succeed in the sciences (Highman & Navarre, 1984; Hanson Frieze & Hartman Hanusa, 1984). If the parents' roles are traditional, daughters are less likely to see relevance of math and science (McNeill & Kavrell, 1984). Not surprisingly, a secure emotional base with warm nurturing parents is related to a high level of achievement for both boys and girls (Highman & Navarre, 1984).

* * * * * * * * *

In light of this research, the question could be posed - "With such biological and psycho-social odds stacked against them, who are these women who manage to succeed in science?"

GENERAL CHARACTERISTICS OF WOMEN SCIENTISTS

a. View of the World

A common trait of the women scientists interviewed by Gornick (1983) was the sense of wonder they had of the world - "I wanted to learn everything there is to learn in biology and chemistry. I had to learn everything."(Gornick, 1983, p. 41)

b. Commitment to Science

If the women scientists were in a position to choose between family or science they chose science - "each of them had become devoted to the experiencing self characterized by work rather than love, and had begun to construct her life around that devotion" (Gornick, 1983, p. 17).

c. Personality Traits

In his review of the literature investigating the traits typifying successful scientists, Baker (1985) personality profile includes - more interested in ideas than in people; generally introverted, creative and intuitive; logical (likes order) and analytical; possess highly developed math and spatial abilities; have an aesthetic appreciation of the world; and a positive attitude towards science.

Maehr (1983) further states that scientists enjoy social competition, are self-confident, and have an orientation to life and work in which neither social support nor extrinsic rewards guide their behavior.

d. Childhood and Adolescence

In her biographies of eminent female scientists, Kerr (1985) found commonalities in the childhood of the women.

Overwhelmingly their childhood was characterized by spending much time alone by either choice or necessity; reading voraciously; being unconcerned with conforming; having an early adult mentor; and learning a great deal by individualized instruction or tutoring. The scientists generally found adolescence to be a difficult time and had conflicting desires with achievement and social acceptance. This was usually resolved by intensifying their commitment to work.

D. IMPLICATIONS FOR EDUCATORS

Research indicates that biological differences in cognitive abilities between the sexes does exist. It is therefore essential that educators take note of the psycho-social influences that are operating within their classrooms and work to offset any damaging stereotypes that might be present. By positively applying this knowledge into our pedagogy, we can encourage girls as well as many boys to pursue the sciences. Not all children will want to choose a career in the sciences but it is our moral obligation to ensure that the doors are fully open to those who have both the ability and the desire to do so. The following section is designed to provide guidelines to teachers who are interested in directing their pedagogy towards accomplishing this task.

Prior to beginning our "search and destroy" mission of harmful stereotypes in the school system there are two common myths which must be dispelled (Greenberg, 1985). The first myth is that girls and boys enter kindergarten with a similar aptitude for science. To dispel this myth one only has to observe boys play, to see that boys' toys serve as teaching aids for early math and science education. Paper airplanes, Meccano sets, construction blocks, the playing of hockey, football and softball - all contribute to increasing boys' nonverbal understanding of movement through space (Greenberg, 1985; Shapiro, Kramer, Hunerberg, 1981). Girls' play on the other hand is more nurturing and social in nature - playing with dolls, tea sets, reading story books - strengthens verbal rather than spatial abilities This is not to say that girls and boys play exclusively with these items - parents of the '80's are making a conscious attempt to encourage a balance between the two. But, despite these efforts, society strongly influences parents to direct their pre-schooler's play moreso in one direction than the other, depending on their sex. The greatest fear of many mothers and fathers is that their son will grow up a "sissy" and their daughter will be a "tough tomboy". Our society does a good job in perpetuating this fear - especially with the concern of boys becoming "sissies". Ironically, the attempt to offset this concern can actually result in severely handicapping boys emotionally - the price paid for the "macho" image that is so openly sanctioned by society can be very high. On this subject Felgen Fasteau (1975) outlines some of the repercussions associated with upholding the macho image "after the age of six months, boys are picked up and hugged less than girls....by five or six boys know they aren't supposed to cry, ever be afraid or...be anything like girls....friendships between men are often made shallow and unrewarding by the constant undertone of competition and the need to always put up a tough, impersonal front" and perhaps most compelling he states, "the tragedy...is that men are fighting their nature as human beings in trying to conform to the male ideal" (p. 60).

What we need in society is a little more balance. There is no doubt that the aggressive energy of boys readily directs them to action-oriented games but we, as parents and educators, must not neglect to encourage the development of their equally natural but often suppressed nurturing, social side. Anyone who challenges the existence of such a nurturing side will have to work hard to find a little boy who is willing to go to bed without his favorite "Teddy" or "Dolly" to snuggle against. How dare we deprive a child of such contact just to conform to a warped unfounded whim of society! By recognizing the folly in this myopic societal view of what is male and what is female we will open channels of communication which are too often slammed shut. The opening of the emotional and social channels in boys combined with their enjoyment of all the games and toys which we now stereotype as male should create a new strong and yet warm, caring individual. One who is capable of communicating feelings openly and unabashedly, who is open-minded to positions contrary to his own, but will stand firm in his beliefs once the options are weighed - one who doesn't understand the concept of having their "manhood" threatened. Who knows - perhaps by simply encouraging boys to balance their play, we can reduce incidences of wife battering, child molesting, and rape

- all of which result from a need to build one's manhood and sense of power, by stripping someone else of theirs. Stunting the emotional side of men, as society often does is criminal - in so doing we effectively seal an outlet which is a human right.

Girls benefit from an attempt by parents to encourage their active side - they may not equal their counterparts in aggression but I challenge anyone who spends time with a two-year old girl to keep up with their energy level. Encouraging girls to climb, throw balls, build Lego cities - all contributes to their understanding of spatial concepts. Exposure to such varied activities, besides the obvious spin-off in physical health, also develops inner strength by building self-confidence and feelings of self-worth (Greenberg, 1985). Fortunately for the little "tomboys", society views them with more favor than it does "sissy" boys. Despite this, many pre-school girls have a much greater deficit in these experiences than do pre-school boys. Again, let's project through to adulthood and envisage the characteristics of the young women who emerge from such an upbringing in which their emotional and social needs were balanced with active play. It is not unreasonable to picture a compassionate, yet assertive individual - one who is capable of communicating feelings openly and unabashedly, who is open-minded to positions contrary to her own but will stand firm in her beliefs once the options are weighed. Does this all sound familiar? I don't mean to be clever, only to make a point. Perhaps if men and women are to be most happy and effective both in living together and in society as a whole, a healthy balance must be allowed to emerge within the individual, regardless of their sex - to deny either the "feminine" or the "masculine" traits which are evident in all of us is to deny our own humanity.

The second myth to dispel is that early childhood instruction, with its emphasis on language acquisition, favors girls. This myth is open to some debate if the perspective of an advantage in the sciences is not maintained. Greenberg (1985) states that, "by stressing the knowledge, skills and abilities that girls already possess and in which boys are deficient schools in general, from early childhood setting on, meet the needs of boys but fail to meet those of girls" (p. 461). There is no doubt that elementary schools emphasize reading and writing over any other discipline. Overwhelmingly, the strength of the majority of elementary teachers lies in language arts - less than half of Canadian elementary teachers have any university math and less than one-quarter have any university level science (Science Council of Canada, 1984). This is confounded by the fact that only one in five elementary teachers have access to a science room (Science Council of Canada, 1984). When considered in this light, the fact that doing elementary level science is often reduced to reading about it is no surprise.

This disproportionate emphasis on language arts is at fault on two counts - first, it fails to strengthen the weakly developed spatial skills of girls and second, by working solely on the boys' language skills, it has been blamed for undermining their self-confidence. Boys, much more frequently than girls, suffer from dyslexia and other reading problems (B. Kolb, personal communication, March 27, 1987). The language arts centered approach used in elementary school is thus a "double-edged sword". Such a lethal weapon to both sexes could be re-shaped into a useful tool by ensuring that classroom activities are balanced between spatial activities and language arts skills.

THE APPROACH

The following points outlined by Shapiro, Kramer, Hunerburg (1981) will be elaborated upon in this section.

"Help girls develop a positive attitude toward the importance of math and science in their lives.

Provide math and science experiences that children, especially girls, may not have had elsewhere.

Help other adults understand the importance of math (and science) education for both girls and boys.

Become better informed about math, science, and technology" (p. 62).

* *

1. **"Help girls develop a positive attitude toward the importance of math and science in their lives."**

This can be achieved through the adoption of several techniques:

a. Explain the reasoning behind answers to science and math problems and demand less conformity in the students' responses

Teaching formal reasoning should reduce the cognitive gap which currently exists adolescent males and females. In testing the cognitive development of

16-18 year olds, the boys demonstrated a higher level of intelligence, however the researchers hypothesized that experience was an important factor (Hernandez, Marek & Renner, 1984). Structuring learning in such a way that students see the logic behind the right answer, gives them confidence in their ability to reason problems out instead of merely guessing at the answer. This approach reduces the chances that children will merely memorize the answer thereby obstructing the connection between effort and success (Steinkamp, 1984).

Also, by having students rationalize their answers whether they be right or wrong, either in class or in small groups, the emphasis lies in the techniques of solving the problem (Baker, 1985; Grieb & Easley, 1984). This helps minimize the impression girls often have that they lack the talent for math and science and it also reduces the effect of the socialization of girls which values pleasing the teacher over understanding the concept (Ridley & Novak, 1983; Skolnick, Langbort & Day, 1982). Children are therefore encouraged to explore their ideas, to think their work through to the point where they again see the link between effort and success (Shapiro et al, 1981; Steinkamp, 1984). Teachers should accept various approaches to a problem and try not to force conformity - it destroys creativity, a trait which is essential for success in the pure maths and sciences (Stage, 1986; Steinkamp, 1984).

b. On Attributions - encourage girls to attribute success to ability and failure to lack of effort rather than poor ability.

Fennema (1983) discovered that the confidence of girls in doing math was as highly related to achievement as was verbal and spatial ability. Similar parallels have been drawn to science (DeBoer, 1984; Ridley & Novak, 1983; Post-Kammer & Smith, 1980). Overwhelmingly girls attribute their success to factors other than their own ability, such as to luck, much more often than do boys (Fennema, 1983; Hart Reyes & Padilla, 1985; Skolnick, Langbort & Day, 1982). Dweck (1978), as cited in Skolnick, Langbort & Day (1982) discovered that a contributing factor for such attributions being less prevalent in boys could be the manner in which boys are reprimanded. Teachers frequently reprimand boys for not trying - this gives males the impression that they don't succeed due to lack of effort rather than lack of ability.

The impressive impact of attributions for success is probably best described in the research with college students carried out by DeBoer (1984) in which he states, "...for successful students...the plan to continue in science was directly related to their attribution of ability" (p. 328). Success experiences should be provided which are the result of thinking things through step by step; strategies for the way students approached the problem should be discussed and praised.

Parents also play a critical role in attribution assignments. Too often the math success of their daughters is attributed to effort and of their sons to ability. This attitude is detected by the girls and within a year seriously undermines their confidence in the subject (Peterson, 1986). It is essential we apply teaching methods that empower our science students - enabling them to attribute successes to ability rather than to luck.

c. Distribute interactions evenly between boys and girls

Through research across the grades it is clearly evident that teachers spend more time interacting with their male students than with their female students

(Fennema, 1983; Fennema & Peterwen, 1986; Hart Reyes & Padilla, 1985; Houston, 1985; Matyas, 1985; Morgan, 1985; Sadker & Sadker, 1985; Science Council of Canada, 1984; Skolnick, Langbort & Day, 1982)

Teachers must make a conscious effort to become aware of the gender of students who tend to both lead, as well as interrupt, class discussions to be certain girls have an equal opportunity to participate. An intriguing study was done by Spender, 1982 (cited in Houston, 1985) in which boys protested that girls were being favored in the classes of teachers who increased their interaction with girls to a mere 34%!

The difference in the style of teacher interaction depending on gender is most evident in praise and blame context. "While boys are usually praised for intellectual work, girls are mostly praised for behaving properly and obeying rules of form" (Skolnick, Langbort & Day, 1982). Girls are more responsive to praise than are boys. Regardless of their cognitive level - the more praise girls receive, the better they achieve (Fennema & Peterson, 1986; Peterson, 1986). Therefore, not only do girls need to be praised more but the praise should be directed to the strategy of the answer and not restricted to neatly done work or good behavior.

d. Minimize sex-role stereotypes

As teachers we must watch our covert messages which might unthinkingly serve to limit our students choices. Avoid off-hand jokes and innuendos implying the inadequacy of women in science (Shapiro, Kramer, Hunerberg, 1981). Get into the habit of using his/her pronouns. Draw the class' attention to the contribution to society made by successful women in science. Display pictures of female as well as male scientists at work and be sure to discuss their real contribution to science (Kahle, 1985). Impress this information upon the boys as well as the girls. Fennema (1983) found in her research that males at the Grade 6 level (12 years of age) stereotype math much more as a masculine field than do females.

Check illustrations in texts and avoid ordering those texts that overwhelmingly picture males doing the science activity (Steinkamp & Maehr, 1983; Weiner, 1985). If the texts are currently in use point out the sex bias to the students and offset the bias by displaying magazine and newspaper clippings of women in the sciences (Shapiro, Kramer, Hunerberg, 1981).

Order reading books and media kits for the library about famous women in science (Kirschenbaum, 1980;

Matyas, 1985) (See Appendix A). Student counselling programs directed at involving students and parents could be used to minimize the depiction of science as a masculine domain (Kremer, 1984).

e. Use of Role Models

It is not necessary to replace all male science teachers with female teachers to fulfill this requirement. On the contrary, by conveying a helplessness or disinterest in science, some female teachers undermine their girls' attitudes towards the subject to a much greater degree than does the male teacher who is sensitized to avoiding sex stereotypes. An attitude change, not a sex change is the key!

However, that same male teacher can be even more effective by inviting female guest speakers into the classroom on occasion - scientists, doctors, dentists engineers - from professions which still carry the male sterotype (Glaze, 1980; Kahle, 1985; Lowry & Woodhull, 1983; Rakow, 1984; Shapiro, Kramer, Hunerberg, 1981; Wells, 1985). By providing girls with female role models and supporting their pursuit of science they will perceive themselves as scientists as readily as the boys do presently. The similarity between the role model and female students should be pointed out with a special emphasis on how she manages to balance both a family and a career (Highman & Navarre, 1984; Matyas, 1985; Schwartz, 1980). Too often girls see a career and having a family as mutually exclusive events - as many girls plan to marry and have children, a discussion on how to strike a balance between the two would be most beneficial. Relatives of the children in the class make effective role models as they are more real to the students and prevents rationalization . Speakers could also point out that a reluctance to participate in science activities is often due to lack of practice rather than lack of ability (Shapiro, Kramer, Hunerberg, 1981).

Children could also conduct interviews with women involved in math and science, emphasizing the training that was required for them to achieve their position. The results of such interviews could form the basis of classroom presentations (Shapiro, Kramer, Hunerberg, 1981).

Teachers are influential role models as they spend a great portion of each day in contact with their students. Matyas (1985) found that the encouragement of a single high school teacher was often the deciding factor in the choice of a career in science.

f. Help girls to become more active participants in math and science activities.

Science lessons should maximize the "hands-on" approach. In mixed-sex lab pairs have the students alternate between recording and manipulating the apparatus. By insisting on such job rotations, we can avoid the common pitfall where males are doing most of the manipulation of materials and the girls are left to record the data (Science Council of Canada, 1984).

An added benefit to classroom experiments is that the teaching approach is an effective strategy for maintaining girls' interests. In questionning 15 year old girls about what they liked best about their high school biology class - "the labs" was the most common response (Kahle, 1985). The improvement in the spatial perceptions of the girls is also an important spin-off from such activities (Baker, 1985; Highman & Navarre, 1984).

The science lesson should attempt to balance experimentation with discussions (Erickson & Erickson, 1984; Shapiro, Kramer & Hunerberg, 1981). Discussions, being a verbal activity, boosts the girls' self-confidence while participating in science activities, with its spatial emphasis, is an ego-booster for the boys. As important as such confidence building activities are, as educators we are equally concerned with strengthening any deficits. For this reason, the lesson should be represented by activities and discussions to benefit both sexes. Our goal of encouraging more girls in the sciences may be within reach, but only if such a balance, between confidence building activities and activities which strengthen spatial abilities, is maintained throughout their schooling.

g. Emphasize the link between science and society, include animate aspects when possible.

Girls pick up interest in a subject when it is made relevant to life (Brady and Slesnick, 1985; Harding, 1982; Hart Reyes & Padilla, 1985; Kahle, 1985; Kremer, 1984; Simpson & Oliver, 1985). This supports observations made by Gilligan (1982) which led her to the conclusion that women "(see) a world comprised of relationships rather than of people standing alone, a world that coheres through human connection rather than through systems of rules..."(p. 29).

Regardless of whether physical, chemical or biological principles are being taught, capitalize on the animate aspects of science - relate examples to nature and the human body. In working with Junior High science students, Simpson and Oliver (1985), found that the attitude of Grade 7 (Life Science) students of both sexes, was much higher than the attitude towards science when the same students were taught in Grade 8 (Earth Science) and Grade 9 (Physical Science). In working with the Bank Street Laboratory software package, Brady and Slesnick (1985), discovered that by using the temperature probe to measure the students' own body heat rather than the temperature of water in a beaker, the girls' interest picked up considerably.

It is no coincidence that the percentage of females writing the 1986 Alberta Diploma Examination in Biology 30 approaches 60%. With this in mind, it will be most interesting to follow up on the new science curriculum which is being developed in the province of Alberta. Its overwhelming emphasis is the teaching of science in terms of its connection to society and technology. This new emphasis should prove to be most beneficial to girls in the school system.

h. Balance cooperative with competitive activities.

Generally, boys respond best in competitive situations, whereas girls are more successful in classes which promote cooperative ventures. Studies ranging from elementary classes to college level support this finding (Fennema & Peterson, 1986; Lowry & Woodhull, 1983; Maehr, 1983; Skolnick, Langbort & Day, 1982). By giving equal time to competitive and cooperative activities in the classroom we can capitalize on the strengths of both sexes. Cooperative work also enables both males and females to see each other in less sterotypic terms. The process of comparing information and answers is a valuable learning experience, both in the social interactions it involves, as well as the fact that it tends to increase the understanding of the problem.

i. Encourage autonomy in students

Fennema & Peterson, 1986 studied the difference in classroom dynamics of Grade 4 math classes in which girls excelled and those in which boys excelled. They discovered that not only was competition a factor, but, "...in classes where girls learned more than boys, they were working more independently." (p. 15) Teachers are encouraged to allow students to solve problems on their own, rather than intervening too quickly.

j. Build in success experiences in science

The key here is to build confidence. With its emphasis on spatial skills, girls very early lose their confidence in doing science as a result they are less likely to take risks (Post-Kammer & Smith, 1985; Skolnick, Langbort & Day, 1982). Approaches should be used in the classroom which reduce the fear of taking risks. Allowing many approaches, many right answers; playing question asking games, where students ask questions rather than supplying answers; encouraging guessing and estimating - all help to reduce this fear.

Another ego-boosting approach is to provide girls with opportunities for leadership in science activities. In order to identify girls who are potential leaders, or those who need extra support and encouragement, it might be necessary to organize the occasional sex-segregated lab group. Allowing for girls time on computers, or having separate boys and girls tutorials in math and science can be especially effective, especially in adolescence, when the male stereotype is considered to be very strongly attached to these subjects. In integrated groups the more aggressive boys often totally dominate the group activity making it impossible to identify the girls' capabilities. Having girls as group leaders or participants in classroom demonstrations serves two functions. It builds up their confidence and also gives boys the opportunity to see girls as equal contributors in the science class. A definite link has been established between the level of confidence in science and achievement (Hart Reyes & Padilla, 1985).

Everyone enjoys the feeling of success - it's a great motivator. Design activities in which success can be achieved readily. Breaking down an assignment or experiment into steps will make it much easier to tackle. Helping students to realize that failure is a common occurrence in scientific endeavors is equally important. Sources of encouragement could include relating stories of frustration in science, which have lead to great discoveries, or reminding them of cures still waiting to be found, such as for diabetes and cancer (Shapiro, Kramer & Hunerburg, 1981)

k. Take into account prior experience

Teachers need to take into account the prior experience and knowledge of the students. Examples should be drawn from the experiences of both girls and boys. In an electricity unit, for example, repairing a hair dryer, a curling iron, or completely wiring a dollhouse could be included as well as repairing a race set. This must be done without sex-stereotyping, however. The idea is to spark the interest of both sexes by introducing items they have experienced. The students should be encouraged, however, to explore all items (Erickson & Erickson, 1984).

1. Encourage girls to participate in extra-curricular science activities

Clubs that have predominately male membership such as rocketry or astronomy could be sex-segregated initially, with a separate girls and boys time, and then integrated later on. Girls could be encouraged to enter science fairs by having both older girls and boys speak to the class on projects they had done previously.

2. **"Provide math and science experiences that children, especially girls, may not have had elsewhere."**

At the elementary level, observing children's play patterns and discussing them with parents can help provide children with activities which they are lacking. In order to strengthen their spatial ability, girls in particular need to be encouraged to manipulate construction materials, to play with blocks and puzzles and to participate in sports (Shapiro, Kramer & Hunerburg, 1981; Skolnick, 1982). The teacher must ensure that girls as well as boys are participating in these activities. To avoid being too obvious, participation in activity centers could be planned on a rotational basis. Both the boys and the girls will benefit from such an arrangement. Boys, too limit themselves in their play. Even at the kindergarten level they have learned what is appropriate play for them and "girls' activities" such as dressing up or playing house are often avoided. By insisting that the children experience all the activity centers, a healthy balance will be struck, in which boys and girls alike will learn appropriate ways to socially interact through "house" and "store" as well as challenging their cognitive ability by participating in the "puzzle corner".

Students should be required to include estimations when working with measurement. This enables them to envision the distance, volume or the mass, prior to going through the measuring steps. It encourages them to stop and "think" about what they are doing, rather than just going through the motions of doing it.

Most children enjoy helping their teacher operate audiovisual equipment. Be certain that girls as well as boys have an opportunity to learn how they operate. Developing such competency with equipment helps develop a confidence around technology which would otherwise be sadly lacking (Shapiro, Kramer & Hunerburg, 1981).

3. **"Help other adults understand the importance of math (and science) education for both girls and boys".**

Children need to be made aware of the importance of math and science to a broad variety of jobs and careers so that both boys and girls can make choices in the future which will provide them with the widest range of options possible (Fennema, 1983; Hart Reyes & Padilla, 1985; Kahle, 1985; McNeill Kavrell & Petersen, 1984; Post-Kammer & Smith, 1985; Steinkamp, 1984; Zerega & Walberg, 1984). In a study of career aspirations and expectations of high school girls, undertaken by Glaze (1980), over one-half of the girls stated they didn't know about the occupations available to them to make a well informed career choice. To avoid the firm establishment of stereotypes, it has been recommended that occupational portrayal begin as early as age six years (Marland, 1983).

Within the classroom itself, teachers must discuss their subject area in relation to career planning. Obtain entrance requirements to technical schools and universities and post them up in the classroom. Encourage students to clip out newspaper articles on science careers to bring to school, discuss them with the class and put them up on display. Enthusiastically discussing the relevancy of science to the students' futures may encourage many of them to consider a career in the sciences, who had possibly not considered it before.

The encouragement of all influential adults in a child's life - parents, teachers and school counsellors - is essential. Teachers play an essential role in raising parental awareness of the importance of math and science to their children by initiating parent-teacher evenings to discuss career options for their children (Glaze, 1980; Highman & Navarre, 1984; Shapiro, Kramer & Hunerburg, 1981). A concerted effort can be made in these evenings to include examples of women in science and math careers. With parents of elementary-aged girls it could be pointed out how parents could stimulate their inquisitiveness and problem solving skills through toys, games and play. The influence of family members in transmitting attitudes and effecting career choices has more of an impact on students than that of the school counsellor (Matyas, 1985).

The role of the school counsellors, however, cannot be underestimated (Marland, 1983). Counsellors must relate the importance of math and science courses to career choices and encourage females to take computers, drafting, electronics, etc. (Delamont, 1980;

Highman & Navarre, 1984; Kahle, 1985). The availability of financial assistance should be pointed out to all students (Glaze, 1980). Information should be readily accessible regarding entrance requirements to universities and technical schools. Colorful bulletin board displays which portray women in non-traditional roles could be most effective in reducing stereotypes. A career week could be planned in the school which emphasizes non-traditional careers for girls. Guest speakers, women who are in those non-traditional careers, could be invited to speak to classes during that week. Canvassing to Junior High schools should emphasize the importance of the academic sciences and maths to a variety of careers. The entire focus of the school counsellor should be to make students aware of the broad range of career options available to them and to encourage them to choose courses which will enhance their options rather than limit them.

4. **"Become better informed about math, science, and technology"**

Elementary teachers generally have a strong background in language arts, reflecting the reading and writing emphasis of the lower grades. As a result of this emphasis, teachers have only the minimal number of science courses required for their degree. The development of science lessons can therefore, cause high anxiety - to the point where they are often omitted altogether. This negative attitude towards science can be inadvertently transmitted to the children, a situation that is exacerbated by the fact that most elementary teachers are female. The danger with this association is that girls could come to the conclusion that science is a male field because women don't have the ability to do it (Science Council of Canada, 1984). It is imperative that elementary teachers increase their knowledge in science especially as it relates to society and technology (Kahle, 1985; Skolnick, Langbort & Day, 1982; Stage, 1986). Girls are generally interested in seeing connections between their work in math and science and the lives of people, this interest must be capitalized upon. In recognition of the positive influence of pointing out the relevancy of science to students' lives, the Science Council of Canada recommends a 50 per cent emphasis on Science Technology and Society (STS) curriculum at the elementary level (Science Council of Canada, 1984).

<u>CONCLUDING REMARKS</u>

Are there any signs that intervention programs actually change the attitudes and course selection patterns of female students?

A program in the U.S. entitled <u>Multiplying Options and Sutracting Bias</u> was directed towards Junior High students and ran for two years, 1977-78 and 1978-79 (Fennema, 1983). The researchers found that Grade 9 students of both sexes increased their plans to study math in high school and college ($p < .01$), perceived the usefulness of math ($p < .05$) and had lowered attributions of failures to lack of ability. Also, the extent to which males perceived math as a male domain decreased. Considering the pressure that males exert on females in adolescence this was a most welcome spin-off.

Boulanger (1981), as cited in Kremer (1984), investigated fifty-two studies which examined the quality of science instruction variables in classes ranging from grade 6 to 12. The researchers found significant positive cognitive outcomes due to pre-instructional strategies. Kremer (1984) also cites Guttentag & Bray (1976) who, in their work with students from kindergarten to Junior High, found that attitudes concerning sex role behavior, that are linked to home environment and culture, can be successfully modified in the school.

Sadker & Sadker (1985) headed a Washington study in which sixty teachers received four days of training to establish equity in classroom interactions. The spin-off from this clinic was that the overall teaching effectiveness of the participants improved dramatically.

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It is clearly evident that educators have a major role to play in combatting attitudes that restrict individuals on the basis of gender from reaching their full potential. The case for gender-free instruction is strong, but it fails to offset the pervasive influence of sex stereotyping that exists outside the classroom. More appropriately, to use a term coined by Houston (1985), we need to adopt a "gender-sensitive" perspective - one that "...pays attention to gender when it can prevent sex bias or further sex equity" (p. 366). Through the adoption of a gender-sensitive approach to instruction, one acknowledges the existence of gender restrictions and can therefore work to counter-act this influence in the classroom. "The point, after all, of the struggle for sex equity in education is to provide the opportunity - the equal opportunity - for growth and development in self-chosen ways to women as well as men" (Greene, 1985, p. 41).

The critical step to removing the psychological and sociological barriers which can effectively block girls from entering the sciences is to first acknowledge their existence. Once we are able to see the barriers, the task of dismantling them is straightforward. But the barriers must become visible - they cannot be dismantled if we blind ourselves to their existence. It is essential that we, as educators, take off our blinkers to increase our vision and bring the barriers into view. With such a focus our female students are bound to achieve - this time <u>because</u> of the education system not in spite of it.

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APPENDIX A

WOMEN, GIRLS AND SCIENCE - READINGS FOR STUDENTS

(* Canadian)

*Allison, B. & Lawrence, J. (1975). Doctor Mary's animals. Toronto, Ont: D.C. Heath. ("Women At Work Series"). (Elem)

*Allison, B. & Lawrence, J. (1975). Ready for take-off. Toronto, Ont: D.C. Heath. ("Women At Work Series"). (Elem)

Behrens, J. (1984). Sally Ride, astronaut: An American first. Chicago, IL: Regensteiner Publishing. (Gr. 3-6)

Bowman, K. (1976). New women in science. Mankato, MN: Creative Educational Services. (Upper elem/Jr. High)

Brandt, K. Marie Curie: Brave scientist. Troll Series Books. (Gr. 4-6)

Emberlin, D. (1977). Contributions of women: Science. Dillon. (Gr. 7-12)

Facklam, M. (1978). Wild animals, gentle women. HarBrace. (Gr. 7+)

Fisher, M. (1973). Jacqueline Cochran: First lady of flight. Garrard. (Gr. 3-6)

Fox, M.V. (1981). Jane Goodall: Living chimp style. Dillon. (Gr. 3+)

Fox, M.V. (1984). Women astronauts: Aboard the shuttle. New York: Julian Messner. (Upper elem/Jr. High)

Genett, A. (1975). Contributions of women: Aviation. Dillon. (Gr. 6+)

Gleasner, D. (1983). Breakthrough: Women in science. Walker. (Gr.6+)

Goldreich, G. & Goldreich, E. (1979). What can she be? A computer scientist. New York: Lothrop, Lee and Shepard. ("What Can She Be Series"). (Gr.K to 5)

Goldreich, G. & Goldreich, E. (1979). What can she be? A geologist. New York: Lothrop, Lee and Shepard. ("What Can She Be Series"). (Gr.K to 5)

Goldreich, G. & Goldreich, E. (1979). What can she be? A veterinarian. New York: Lothrop, Lee and Shepard. ("What Can She Be Series"). (Gr.K to 5)

Gutman, B. (1982). Women who work with animals. Dodd. (Gr. 5+)

Haber, L. (1979). Women pioneers of science. Harcourt Brace Jovanovich. (Gr. 5-9)

Latham, J.L. (1973). Elizabeth Blackwell: Pioneer woman doctor. Champaign, IL: Garrard. ("A Discovery Book"). (Gr. 3-6)

Latham, J.L. (1973). Rachel Carson: Who loved the sea. Champaign, IL: Garrard. ("A Discovery Book"). (Gr. 3-6)

Lee, M.P. (1976). Ms. Veterinarian. Westminster. (Gr.3-6)

McLenighan, B. (1979). Women and science. Raintree. (Gr. 4-8)

Mondey, D. (1982). Women of the air. Silver. (Gr. 4-7)

O'Conner, K. (1983). Sally Ride and the new astronauts. New York: Franklin Watts. (Upper elem/Jr. High)

*Ray, J. (1978). Emily Stowe. Don Mills, Ont: Fitzhenry & Whiteside. ("The Canadians" series). (Jr. High/Sr. High)

Skurzynski, G. (1981). Safeguarding the land. New York: Harcourt Brace Jovanovich. (Jr. High/High School)

*Wild, M. (1984). Elizabeth Bagshaw. Markham, Ont: Fitzhenry & Whiteside. ("The Canadians" series). (Jr. High/Sr. High)

*Wilson, M.C. (1977). Marion Hilliard. Don Mills, Ont: Fitzhenry & Whiteside. ("The Canadians" series). (Jr. High/Sr. High)

Torjesen, E. (1984). Comet over Nantucket. Friends United. (Gr. 4-6)

APPENDIX B

PRACTICAL SOURCES FOR SCIENCE TEACHERS

(from SKOLNIK, LANGBORT & DAY (1982))

Allison, L (1976). Blood and guts. Boston: Little, Brown and Co.

Allison, L. (1977). The sierra club summer book. San Francisco: Sierra Club Books/ Charles Scribner's Sons.

Amery, H. & Littler, A. (1976). The funcraft book of magnets and batteries. New York: Scholastic Book Service.

Beck, D. & McNeil, M.J. (1976). The funcraft book of flying models: Paper planes that really fly. New York: Scholastic Book Service.

Cobb, V. (1972). Science experiments you can eat. New York: J.B. Lippincott.

Cobb, V. (1979). More science experiments you can eat. New York: J.B. Lippincott.

De Caro, M.V. (1980). The gray's anatomy coloring book. Philadelphia: Running Press.

Goldstein-Jackson, K., Rudnick, N., Hyman, R. (1978). Experiments with everyday objects: Science activities for children, parents, and teachers. Englewood Cliffs, NJ: Prentice-Hall.

Herbert, D. (1980). Mr. Wizard's supermarket science. New York: Random House.

McCoy, E. (1979). The incredible year-round playbook: Fun with sun, sand, water, wind and snow. New York: Random House.

Nickelsburg, J. (1976). Nature activities for early childhood. Reading, MA: Addison-Welsey.

Simons, R. (1976). Recyclopedia: Games, science equipment, and crafts from recycled materials. Boston: Houghton Mifflin Co.

Van Deman, B.A. & McDonald, E. (1980). Nuts and bolts: A matter of fact guide to science fair projects. Harwood Heights, IL: The Science Man Press.

White, L.B. (1975). Science toys and tricks. Reading, MA: Addison-Wesley.

ACTIVITY PACKAGES

Buller, D., De Lucchi, L., Knott, R.C. & Malone, L. (1980). Outdoor biology instructional strategiesL (OBIS). Nashua, NH: Delta Education.

Humbolt County Office of Education (1975). Green Box. Eureka, CA: Humbolt County Office of Education.

Menard, S. (1979). How high the sky? How far the moon? Washington, D.C: U. S. Department of Health, Education, and Welfare, Women's Educational Equity Act Program. (program can be obtained from: Education Development Center, 55 Chapel Street, Newton, MA 02160).

Sly, C. & Whitely, M. (1979). Using wild edible plants with children. Berkeley, CA: Instructional Laboratory, School of Education, University of California.

Steinberg, B. (1982). Spaceship school (rev. ed.), San Rafael, CA: Marin County Office of Education.

DON'T FORGET TO CHECK-OUT AUDIO-VISUAL MATERIAL AT YOUR LOCAL LIBRARY OR NFB DISTRIBUTOR

(There are films available on women and science careers such as Miss Goodall and the Wild Chimpanzees, etc. As well as having a motivational impact, interspersing such films in your science lesson will help increase your students' awareness of optional career choices).