Toward Feminist Science Teaching

by Irene Lanzinger

L'article de Irene Lanzinger explore comment les sciences sont conçues pour exclure les femmes dans notre société. Il faut trouver des façons différentes d'enseigner les sciences dans nos écoles afin d'encourager l'examen de ses bases sociales, politiques et historiques sous-jacentes. Ces méthodes doivent être moins hiérachiques et patriarcales et du même coup assurer aux femmes une participation accrue.

The social, historical and political factors that play a role in the construction of gender and science are reflected in the images of gender and science that schools reinforce. Feminist critics of science (Keller, 1986; Harding) would argue that these images reflect the androcentricity of science and play a role in the exclusion of women from the physical sciences. The task for feminist educators then is to imagine alternative methods of teaching science—methods designed to both alter the masculine image of science and make the physical sciences more inclusive of women.

Schools and the image of science

It is at school that we learn what science is and does. The white, middle-class, male bias of science is part of the societal *status quo* that is communicated by the school system. The hierarchy of the sciences is also taught. "Softer" biology is at the bottom and often taught by women. "Hard" mathematics and physics are at the top and almost always taught by men. As one moves up this hierarchical scale, the subjects require more objectivity, logic, and rationality—all qualities girls have been socialized to believe they do not possess. More mathematics is also required at the "higher" levels of the science scale. The media have aided the school system in convincing girls of "superior male mathematical ability." (qtd. in Eccles and Jacobs) The perception persists in spite of the fact that nearly half of all bachelor's degrees in mathematics are awarded to women (Fehrs and Czujko)—a figure three times higher than that in physics. Consequently, the numbers of girls choosing a particular science declines dramatically from virtually equal numbers in biology to very small numbers in physics. A male chemistry teacher in Britain describes this hierarchy:

> Biology has never been short of capable and even outstanding girls. My answer is that the subject remains descriptive and more susceptible to rote learning than physics or chemistry. Girls remain conned into thinking that such intellectual activity is their forte. Chemistry has had a few female stars. They, in my opinion, resisted or ignored the social pressure which implies that chemistry is a man's world—aggressive acids, nuclear power, menacing odours and some mental gymnastics needed to cope with the mole.... Physics has had even fewer girl successes. Here, however, the masculinity of the subject is more strident—electronics, speed, pressure and mathematics. (qtd. in Kelly, 1981)

School science courses mirror the public perception of science as objective, rational, and unbiased. They fail to include the social, historical, and political forces that form science. Any historical context referred to by high school science texts is peopled virtually entirely by men with the possible exception of Marie Curie. The many women who have made significant contributions to science throughout history remain invisible. (Rossiter; Abir-Am and Outram) The philosophy and politics of science are ignored completely. Students are often taught scientific theories as though they were truths rather than modifiable attempts at explanation of a very complex natural world. They are also taught that science brings technological progress along with the popular, public, Western myth that technological progress is intrinsically good (Rothschild) though some challenges to this may spring from the recent interest in environmental education.

There are many agents of androcentric science within schools. Biased textbooks, both those used in the classroom (Kelly, 1987) and those used in teacher education (Sadker and Sadker) contribute to the image of science held by both students and teachers. Teachers of science, ninety per cent of them men in British Columbia (Ferguson), have succeeded in and accepted traditional science. Real science—big industrial, military science—supported by capitalist politics and designed to promote and advance corporate interests is a long way from the classroom. This is not to say that teachers do not often provide examples of a military, industrial nature to their students. These examples, however, are viewed as applications of "pure" scientific research rather than examples of how military and corporate interests influence scientific research. The science taught in schools is an idealized version of real science albeit no less androcentric in essence.

Patriarchy in science classrooms

Schools provide a patriarchal context for the teaching of an androcentric science. Schools are places in which men lead and women follow. Smith gives statistics for Canada that show that 96 per cent of high school principals are men. Lott gives similar statistics for the U.S., where 93 per cent of high school principals are men and 99 per cent of school superintendents are men. At the bottom of the school pyramid, the secretaries, teachers aides and cafeteria workers are, in vast majority, women. As Smith puts it: "Power and authority in the educational process are the prerogatives of men." (29)

More than any other academic discipline, science has developed a discourse not intended for women. The language of science is one of control, domination and mastery—a language replete with technical terminology. In this language of science, the object of domination is nature (synonymous with women) and the dominating force is science as represented by men. It is not surprising that, contrary to the stereotype of verbal girls and mathematical boys, boys dominate classroom discussion.

> Most teachers claim that girls participate and are called on in class as often as boys. But a three year study we recently completed found that this is not true; vocally boys clearly dominate the classroom. When we showed teachers and administrators a film of a classroom discussion and asked who was talking more, the teachers overwhelmingly said the girls were. But in reality, the boys in the film were outtalking the girls at a ratio of three to one. Even educators who are active in feminist issues were unable to spot the sex bias until they counted and coded who was talking and who was just watching. Stereotypes of garrulous and gossipy women are so strong that teachers fail to see this communications gender gap even when it is right before their eyes. (Salamon and Robinson)

We can expect this domination by boys to be most extreme in the science classroom and most likely it goes completely unnoticed, or is accepted as natural by the science teacher. The result is that in high school most girls choose to pursue other academic areas. Those girls who do persist often feel isolated, overwhelmed, and ignored. (Kelly, 1981)

Science is a discipline based on experiment. Whereas most teachers might be surprised to learn that boys dominate classroom discussion, they would probably readily admit that boys dominate the laboratory. Boys have learned to feel comfortable with mechanical toys and consequently mechanical tools. Boys transfer skills learned from mechanical and construction toys to laboratory equipment a good deal more easily than girls graduating from dolls and Little Miss Make-up. For girls, already isolated and dominated in the classroom, this adds yet another hurdle in the path of scientific knowledge.

Studies in the United Kingdom (Kelly, 1987) have shown that in single sex schools, girls are significantly more likely to study physics and mathematics even though girls' schools often have less than adequate laboratory facilities. In a study done in a co-educational school in which boys and girls were separated for mathematics the girls' attitudes and achievement in mathematics improved. These studies give some evidence that girls participation and performance in science might be influenced by gender hierarchies that exist in co-educational classrooms.

The social and historical construction of science is an integral part of understanding the nature of scientific knowledge.

Alternative ideas about teaching science

Many writers have pointed out the impossibility of the existence, even the conceptualization, of a feminist science in an androcentric society. (Keller 1986; Harding)

> How can we even begin to conceptualize science as nonmasculine, as somehow transcendentally pure and objective (nongendered), when most of written civilization—our history, language, conceptual frameworks, literature—has been generated by men? Who is the authority that, standing above the fray, has guaranteed that science alone is untainted by androcentric biases and patriarchal concepts and methods? (Bleier, 15)

Even if all science teachers were committed to feminist ideals they could not teach about a feminist science that does not exist. Indeed, the advisability of attempting to form a feminist science raises many important questions. (Harding; Keller 1986; Bleier) Teachers can, however, learn to include a feminist perspective on science. What is possible is the discussion of ways of balancing the inequities in the classroom, of shifting the balance of power. Bias in textbooks and curricula can be reduced, or where it inevitably exists, can be commented on and discussed with students. Science can be made more palatable to female students. Feminists within the school system must content themselves with working for changes to bring the physical sciences within the "comfort zone"[1] of the young women in their classes.

Students arrive in the high school science classroom with a strong sense of gender identity and a sense of what is appropriate behavior for their particular sex. This gender identity inhibits equity for boys and girls in the science classroom. The attempt to eliminate gender stereotyping in all schools is a necessary prerequisite to the equitable teaching of science in high schools. Young girls need to believe that the pursuit of a scientific career is appropriate and desirable.

Teaching "real" science

A major task of science teachers is to teach a more realistic version of science, as opposed to the idealized version usually presented to students. This idealization of science leads to the blind acceptance of scientific information. Perhaps even more dangerously, it leads to acceptance of the quasi-scientific information generated by advertising companies who claim, for example, that foods that are cholesterol-free must therefore be good for you, Ivory soap is 99 per cent pure, and a particular brand of disposable diapers will leave a baby's bottom completely dry and rash free. Teaching an idealized version of science leaves our students ill-prepared for an adult world in which they will be bombarded with contradictory scientific information and need to assess this information to make political and practical decisions. For students who find science difficult the picture of a perfectly rational, objective science works to undermine their confidence. Since there can be nothing wrong with science there must surely be something wrong with them.

Science teachers need to admit that science is constructed by social, political, and historical forces and as such is biased. All science is practised from a particular perspective and to varying degrees reflects that perspective. The teaching of science should include a discussion of various epistemological bases for science and how these have influenced what kind of knowledge is produced by science. Students should be required to investigate what the fundamental assumptions of science are and should be encouraged to discuss whether or not they believe that these assumptions are historically or socially determined. The social and historical construction of science is an integral part of understanding the nature of scientific knowledge.

A discussion of how science is influenced by the worldview of the scientist and how science reproduces social power relationships (Fee) should be included in the study of science both in high schools and in universities. There are many examples of how scientists include their own world view and social values in their conclusions. Students should be exposed to these not as examples of "bad" science but as examples of how scientists' expectations influence their work. The "confirmation" of the homunculus theory provides a wonderful example of this. Microscopists of the seventeenth and eighteenth centuries, including the great van Leewenhoek himself, saw tiny men, complete with arms and legs, when sperm were viewed under the microscope for the first time. Lest students believe that this could not happen today, primatology provides a more recent example. In the study of primates in the 1950s and 1960s females remained virtually invisible. If they were observed, they were seen to fit the cultural expectations that the scientists had for female human beings. Only recently has the behavior of female primates been recognized to include leadership, dominance, aggression and initiative. (Bleier)

The teaching of "real" science involves not only the recognition that scientists' observations and conclusions are coloured by prevailing cultural norms but that virtually all aspects of the scientific enterprise are influenced by these norms. From the wording of hypotheses, through data analysis and interpretation, to publication and popularization of results, every stage of production of scientific information is subject to political influence. Apart from causing blatant errors in scientific findings, the androcentric bias of science also has a more subtle influence on the construction of theories. In biology, the master molecule description of DNA as a molecule with ultimate power and control over all aspects of a cell or organism is an example of how the prevailing hierarchical values of an androcentric culture manifest themselves in scientific theories. A study of the differences between this approach and the approach of Barbara McClintock, who had the ability to "dwell patiently in the variety and complexity of organisms," (Keller, 1983: 207) might convince students that the method by which science is done is neither immutable nor objective.

> ***A more realistic vision of science might convince students that the position of women in science is a consequence of the dominant ideology of science.***

A more realistic vision of science might convince students that the position of women in science is not inevitable but a consequence of the dominant ideology of science. It should also encourage them to be more skeptical and analytical in their approach to scientific information. The goal of science educators should be to give their students the tools of scientific criticism, just as teachers of English hope to give their students the tools of literary criticism. Debates on scientific controversies, critiques of scientific papers and a study of the often misleading way in which statistics are used are all methods that might be used to encourage a critical attitude toward science—a recognition that science represents "simultaneously true and contradictory multiple realities" (Bleier) rather than one incontestable reality.

The existence of a more realistic, critical attitude toward science in the classroom need not detract from the fact that in large part, the science we have today works. That is, it often very accurately predicts laws that govern our natural world. Though science often seems to be motivated by the desire for power, domination, and maintenance of the *status quo*, individual scientists are often motivated by a desire to seek knowledge of the world around us. This commitment to knowledge of the world is one shared by scientists and science teachers alike. What science teachers need to recognize and to teach is how these commitments "are fueled and elaborated, and sometimes also subverted, by the more parochial social, political, and emotional commitments (conscious or not) of particular individuals and groups." (Keller, 1986: 11)

While students are unaware of the political nature of scientific work, they also hold negative and quite false images of what scientists are like and how they carry out scientific research. Research in science ideally requires imagination, creativity and a passion for knowledge of the way the world works. Much modern scientific research is done in teams of relatively normal people working co-operatively. The perception on the part of students, however, is that scientists, particularly physicists and chemists, are strange-looking men who work in isolation in lonely laboratories filled with weird and dangerous equipment. It is not surprising that most young women never give physics or chemistry a fair chance as a career goal.

There is an elegant, aesthetic aspect of science that is often completely lost in introductory courses in the physical sciences. These courses have a strong tendency to teach students to mimic the problem-solving technique of the instructor and completely ignore the beauty of the underlying concepts. In a study of very capable academics taking first year physics and chemistry courses the comment was made that these courses consisted of "too many scales and not enough music." (Tobias) If science is to have wider appeal, science classrooms should be structured to reflect the co-operative, creative and aesthetic aspects of science.

Alternatives to the classroom hierarchy

The classroom is, for the students, the immediate, personal experience of the hierarchical, patriarchal school system and society. In dividing our students by gender, class, and academic ability we reproduce for them the gender and class hierarchies of our social system. At the top of the social system of the classroom is the teacher, in theory if not in practice, the holder of knowledge and power. The traditional classroom with teacher as authority and student as vessel reinforces predominant social structures. The correspondence between the classroom hierarchy and the larger social hierarchy places the white, male, middle-class students above other students. If female students and racial minorities are to have equal voices in the classroom the hierarchical structure needs to be modified.

Science classrooms should be structured to provide an atmosphere of shared investigation as a more realistic reflection of the way in which scientific research is actually done. Though teachers obviously know more, even often know the probable results of the investigations, they should be eager to show that they do not know all the answers and that they can often learn from the students. The realization that some of the theories of science raise unanswerable, philosophical questions will help to temper the myth of the all-knowing scientist and with it the myth of the all-knowing science teacher. The teacher must share with the students the risktaking process of theory formulation.

The focus of the teachers' work should be to draw out or give birth to the knowledge that the students already possess. The teachers make contributions to the gaining of knowledge, a kind of labour coaching for the student, but "it is always clear that the baby is not theirs but the student's." (Belenky *et. al.,* 218) There is a need to reject the models based on power and domination both in science and in the classroom. In a system in which a model of connected teaching replaces the model of authoritative teaching, the science classroom has the potential to become a non-threatening place for all students.

The connected class provides a culture for growth—as Elbow says, a "yoghurt" class, as opposed to a "movie" class (in which students are spectators). The connected teacher tries to create groups in which members can nurture each other's thought to maturity. Based on this model a science classroom becomes a place where "no one apologizes for uncertainty" because this is part of the process of "evolving thought" and theory formulation—a place of community rather than hierarchy. (qtd. in Belenky *et. al.,* 221)

The idea that women have particular "ways of knowing" that are in some ways in opposition to, or at least different from, masculine "ways of knowing" is very much a feminist standpoint position. (Harding) It raises the question of whether proponents of "women's ways of knowing" are really advocating replacing one set of gender loyalties for another. The goal of feminist science educators should not be to replace teaching strategies based on men's ways of knowing with ones based on women's ways of knowing but rather to expand educators' repertoire of teaching methods to include strategies that recognize both the influence of gender on learning styles and the ways in which the school system has neglected certain learning styles. This kind of expansion of the ways we allow students to come to scientific knowledge mirrors the expansion of the epistemological bases of scientific knowledge proposed by feminist critics of science. (Keller, 1986; Harding) Personal, political, and social factors play a role both in the forming of scientific knowledge and in the learning of that knowledge by students. Science educators, as well as scientists, need to recognize a variety of ways of knowing as valid approaches to gaining knowledge of nature.

Schools reproduce both the hierarchical, gendered structure of society and androcentric science. The forming of a different kind of science classroom requires a reconceptualization of the nature of scientific thought as well as a redefining of gender roles. In a society constructed by and for men this seems a daunting task. It begins with the recognition, on the part of both teachers and students, of the ways in which gender ideology has had an influence on both science and the school system.

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[1]Sheila Tobias used this term at the American Association of Physics Teachers' Conference in Vancouver in June 1991 while reporting on the study referred to later in this paper. (8)

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AMANDA EASON

After the Argument

One wants to hold the other at
the precise moment the other leans away.
I exaggerate. I mean this table
is long and I sit frail
and empty at the end.
The silent movie left me tight-mouthed.

See, I can be silent too.
A fountain is a river
pumped backward against itself.
So it is with voice.
The actress would not speak, I have
exempted myself from the stage.

Speak, and wrap the night
around your partner who will not give in.
He, on this small point remaining firm,
refusing. And (perhaps mistakenly) I
took this for a sign. Quietly
slipping away eel-like into the silk

of the night. Every noise is him
coming to check: Let me crease the stones
from your shoulders, smooth them to silk.
Instead: The crocuses in the windowbox
have died, he said. And she noticed
he was right, their petal-tips had rotted.

How long can I bear the cold,
toes turned onto their knuckles
and the deaf actress singing in my head.

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