

actüa™

Learning for Change™
Découvrir pour demain™

Literature Review

Report for CEMF

2003



Part 1: CONTEXT AND BACKGROUND

This paper is the result of a partnership between Actua, a national non-profit organization which promotes science and engineering to youth, and the Canadian Engineering Memorial Foundation, an organization dedicated to promoting women in engineering studies and careers. By providing program and research funding, the CEMF enabled Actua to undertake a review of academic and practical literature in the field of girls and women in engineering and science. The purpose of the literature review was to collect information that would dispel some of the myths that continue to persist regarding women and engineering. The main objective of collecting this information was to uncover potential solutions for engaging more girls and women in the field of engineering. We also took the opportunity to outline how Actua's approach is contributing to dispelling these common myths and working to engage more girls in these critical fields.

The literature that was reviewed comes from a variety of sources including websites, educational journals, books, and program impact papers. The myths that formed the basis of the literature review were as follows:

- That women will never comprise more than 20 per cent of the engineering population and that 20 per cent is enough
- That women are only interested in those engineering disciplines where they feel they can help people, such as in environmental or biological engineering
- That the engineering study is a demanding one and most young women either cannot cut it or will not be able to compete with their male colleagues
- That the engineering practice is too rough for women, with 70-hour work weeks and no time for family
- That young girls are not good in math and science subjects and so they will never either graduate or, if they do, they will not be good engineers
- Engineers have little impact on society

Part 2: INTRODUCTION

As scientific and technical literacy become increasingly important to function in our society, it is vital that all young Canadians have access to education and careers in these fields. Many groups continue to be underrepresented in the fields of engineering and science and the focus of this literature review is to shed light on the continued under-representation of women. While women represent 52 percent of the population, they have never represented more than 25 per cent of science, engineering and mathematics undergraduate students or 20 per cent of career scientists or engineers. In some cases, like computer science programs and information technology careers, these numbers are declining (Camp and Fisher as cited in Chan et. al, 2000, 1; Frize and Mc-Ginn-Giberson, 1995, 9; Kelly, 2003, A5). It is not for lack of ability that girls avoid the fields of science, engineering and technology, but it is because of their perceptions about these fields. When asked about reasons for not entering these fields, girls and young women have stated many things including: perception of difficulty, lack of knowledge about science, engineering or technology, perceived social status of these professions, stereotypes (including the notion of these fields as masculine), and lack of role models (Anderson, 1996; Hiscocks and Zywno, 1998).

This paper will concentrate on dispelling myths and stereotypes of women in science, engineering and technology while presenting a review of current literature and research on this topic. First, it will provide information on where these myths come from, through a historical portrayal of women and an overview on common stereotypes. Subsequently, it will offer statistics, information and possible solutions related to the topics of education, careers, home and extra-curricular activities, and role models. Lastly, it will discuss the work Actua is doing (through the National Girls Program) to increase girls' awareness and confidence in science, engineering and technology across Canada. Throughout the paper, the myths that form the basis of this literature review, as described in the context and background section, will be written in bold.

Part 3: WHERE DO MYTHS COME FROM?

Historical portrayal of women: Before beginning the analysis of the current myths and stereotypes, and statistics surrounding girls and science, engineering and technology, it is important to have an understanding of women's role in science, engineering and technology throughout history. For hundreds of years, women have long been contributors to our society through their participation in science, engineering and technology (for several hundred years) as scientists, mathematicians, physicians, computer programmers, astronauts, technicians, inventors, teachers, nurses, midwives, farmers, research assistants, designers, and factory workers. However, many standard histories of engineering rarely acknowledge the contributions of women to the development and spread of modern technologies. Furthermore, theories of "biological difference" between the sexes have been used throughout history to justify discrimination and bias (APASE, 1995, 13). As a result, many women faced enormous challenges in their personal and professional lives. Despite these challenges, they have made significant contributions to scientific research, achieved firsts in their fields and furthered the advancement of women in non-traditional areas of activity (National Library of Canada, 2002). For example:

- In the seventeenth-century it is believed that Native women, familiar with local plants and animals, were responsible for providing a wealth of medicinal information to European scientists (Status of Women Canada, 1997).

- Women in rural Ontario laid the cornerstone of the dairy industry in Canada through their development of cheese-making technology in the latter part of the nineteenth-century (Status of Women Canada, 1997).
- Some of the first computer researchers, programmers, and experts were women (Shortt, 1998, 89). Ada Lovelace (1815-1852) is seldom mentioned in historical accounts. Her status as quite possibly the world's first computer programmer is obscured by the shadow of Charles Babbage (1791-1871), who is credited with being the sole inventor of proto-computers, and, as a result, the "father" of the modern computer (Millar, 1998, 19).

Just as it was in the past, it is still common for women to participate in early stages of new scientific and technological fields, but once a field becomes successful and financially viable, women are excluded from decision-making positions (Shortt, 1998, 89). Due to a wide range of reasons, women continue to be left out.

Stereotypes: There are many kinds of stereotypes children learn early on that promote the idea that science and technology is something boys do (Howard, 2003, 2). A stereotype is defined as an ordering process (to do with representation and categorization of people), a "short cut" (simple and easily grasped), referring to "the world", and expressing "our" values and beliefs (Lippmann as cited in Dyer, 1993, 11-14). A stereotype is taken to express a general agreement about a social group and the most important function of a stereotype is to maintain sharp boundary definitions (Dyer, 1993, 14, 16).

- **Mad scientists, train drivers, and computer geeks:** Stereotypes such as the mad scientist (a crazy, white male scientist, with wild gray hair) and the computer geek (nerdy guy with glasses and short hair) are widely entrenched in our culture (Shaw, 1999, A8). Images of the mad scientist or the nerdy computer hacker turn women away from these fields because these images do not fit with their notions of themselves as women (Shortt, 1998, 91). In line with the stereotypical images, representations of "scientific experts" (in advertising and entertainment) are predominately male (APASE, 1995, 19). With men shown as dominant figures in science and engineering, girls get the message that they do not belong. This leads to a catch-22 problem that if the field appears male-dominated, then women are hesitant to enter into it (Irvine-Halliday and Nowicki, 1995, 129). All members of society need to help girls get rid of the idea that science, engineering and information technology are industries for geeks or boys only (Kelly, 2003, A5).
- **Dry, lifeless, anti-social:** Science and engineering also have a false reputation for dry, lifeless endeavours (Irvine-Halliday and Nowicki, 1995, 129). As girls grow older, they appear to associate science and engineering with unpopularity and view laboratory work (working in a science or computer laboratory) as asocial (something you do on your own; rarely working with others), therefore leading to an asocial life (Shortt, 1998, 91). Girls perceive jobs in engineering or technology related fields to be jobs spent in a cubicle all day with nothing but the company of a machine (Shaw, A8, 1999). Girls tend to imagine that engineers, computer professionals, or those who work heavily with information technology live in a solitary, antisocial world. This is obviously an alienating and incorrect perception (AAUW, 2000).
- **Perceived masculinity of engineering:** The most common stereotype comes from the actual design of the technology. Male powers and interests shape science, engineering and technology and therefore they are not neutral but gendered (Gill and Grint, 1995, 10). Also, there is the idea that when men predominantly use certain technologies and tools, then maleness becomes part of the definition of those technologies. Research has shown that females are uncomfortable interacting with machines that have been considered male toys (Shortt, 1998, 91). Therefore, if

engineers are male and maleness is a part of the culture of engineering, then it is tough for women to enter the profession (Franklin, 1999, 8). These are deep-rooted representations and are one of the reasons why it is so difficult for women to enter “non-traditional” jobs. The masculinity of engineering and technology will only be changed by the inclusion of more women into the design process (Gill and Grint, 1995, 12).

Social barriers due to stereotypes may start as early as birth and continue at all levels of the education system to perpetuate the myth that science, mathematics and engineering are fields of study for men. When girls come up against a series of obstacles, they get the message that they are not wanted in these fields (Saunders 1995, 147; Sonnert, 1995, 6). Thus, by high school graduation, a small number of women are left in the pool of candidates qualified to enter into engineering at university (Frize and Mc-Ginn-Giberson, 1995, 9).

Part 4a: EDUCATION

Much of the research is focused on the topic of education which is expected because the significant research done on the treatment of girls in the classroom and because the school system is a critical stepping-stone to careers. Without an education in science, engineering or technology, women will not be able to enter those fields in the working world. Women’s educational experiences in school (elementary school through to post-secondary) are of the utmost importance if they are to complete their education (Anderson, 1995, 98). The attitude with which our educational institutions approach teaching science material is in itself very gender bias and therefore discouraging for females. Girls often feel excluded from the learning experience due to sex-biased talk present in classrooms and instructional materials, even if the sexist language is used without malicious intent (Swann as cited in APASE, 1995, 23). After examining the gender biases with which teachers enter science classrooms, as well as the numerous stereotypes present in science textbooks and curriculum, we realize that it is not the girls, but the way we teach science, and indeed the science that we teach, that need to change (APASE, 1995, 7).

Statistics: Female students in many of the science and engineering fields face the reality of being a small minority in their laboratories and classrooms (Carter and Kirkup; McIlwee and Robinson as cited in Anderson, 1995, 98). Not only are the numbers low (and declining in some cases), but women arrive at engineering programs with lower levels of self-confidence than men. It is important to examine the following statistics about female enrolment in secondary school math and science classes and post-secondary science and engineering programs in order to dispel the myth that **girls are not good in math and science so they will never either graduate, or if they do, they will not be good engineers.**

- **Elementary and secondary school:** At an early age, girls outperform boys in both science and math subjects (Sadker, 1994, 95). Even in middle school grades (grades seven through nine) there are very few differences between boys and girls in math achievement. In fact, one study found that both boys’ and girls’ attitudes toward science is most positive during grades six and seven (Kahle and Rennie as cited in APASE, 1995, 16). These statistics automatically defeat the myth that **young girls are not good in math and science subjects.** However, it is somewhere around age 13 that girls begin falling behind in science course enrolment and science test scores (APASE, 1995, 16). By grade eight a gender gap has occurred in boys’ and girls’ attitudes about whether or not what they learn in science class is useful in everyday life and the slight advantage

girls once had dramatically disappears by grades 11 and 12 where math achievements definitely favour boys (APASE, 1995, 16; Campbell, 1986, 516). The recent Organization for Economic Co-operation and Development study states that Canadian 15-year-olds were among the top six countries in math and science literacy (Japan and South Korea came out on top) but, of that group, Canadian males performed 10 per cent better than Canadian females (OECD, 2003).

It is also during these years that girls' self esteem especially erodes and they are often bombarded with messages from boys, teachers, parents, and even other girls that, brains and femininity are incompatible (Greenberg-Lake and Peltz as cited in Frize and Mc-Ginn-Giberson, 1995, 9-10). The low self-esteem of adolescent girls has a huge impact on their school performance, and it makes many girls insecure about their own judgment and intimidated to compete with boys and/or to excel in front of them (Ms. Foundation for Women, 1998, xxii-xxiv). As a result, even the high achieving girls often act less intelligent than the boys with whom they interact (Kelly, 2003, A5) and start opting out of math, science, and technology courses as the subjects become electives (APASE, 1995, 17). The option not to take these classes acts as a barrier to young women when they are making post-secondary and career choices and therefore keeps them out of engineering (Hacker as cited in Anderson, 1995, 98). Girls who begin to think they are not capable of accomplishing great things end up stunting their intellectual growth and squandering their talents (Ms. Foundation for Women, 1998, 38). Overall, research shows that girls' interest and involvement in math, science, and technology declines with each year they remain in school (Shortt, 1998, 92; APASE, 1995, 17).

- **University undergraduate:** The drop of interest in elementary and secondary school leads to less women entering science, engineering and computer science programs at the post-secondary level. According to Statistics Canada (1998), out of the 22,822 Canadian University graduates from engineering, applied science, mathematics and physical science, only 25.5 per cent were female. This is especially astounding when compared to the higher overall number female University graduates that year (100,127 female vs. 71,949 male). The numbers of female graduates were higher in all faculties other than engineering & applied science (21.1 per cent female) and mathematics & physical sciences (31.2 per cent female). Although there is intense demand for highly trained people in information technology areas (and this is predicted to continue for at least the next decade) participation by women is currently low in all levels from undergraduate training to the workforce. The percentage of female undergraduate majors in computer engineering and computer science has declined from 30 to 40 per cent in the 1980's to 15 to 20 percent today (Camp and Fisher as cited in Chan et. al, 2000, 1).
- **University post-graduate:** Women are also still strikingly behind men's accomplishments at the higher-end levels of post-secondary education (Shortt, 1998, 92). In 1990, women earned 47 per cent of master's and 32 per cent of doctoral degrees in Canada, but only 13 per cent of master's degrees in engineering and six per cent of doctorates (Stout as cited in Weidler, Kubanek; Waller, 1996, 1).

Perceptions and ability: The above statistics do not reflect girls' ability to do math, science or engineering, but reflect their perceptions about their ability, and role, in math, science and engineering. The low, and declining, numbers of women in engineering are often attributed to the inherent inability of girls to do well in math, science, engineering and technology subjects. But, it is not for lack of ability that girls do not continue with math, science and technology courses – it is due to the perceptions of their ability to math science and technology at school. The differences in how girls and boys perceive their own ability to perform in math and science (at all levels of education)

are due to deeply embedded differences in how our school system approaches the education of the two sexes. A 1990 Canadian provincial mathematics assessment of grades four, seven and 10 found girls at all levels are less confident than boys about their ability to solve problems, even when their achievement is similar (Dole, 1992, 6).

At the university level, when asked why they have chosen a science, mathematics or engineering as a major, men were almost twice as likely as women to cite 'being good at mathematics and/or science in high school' as their reason for choosing the major. Whether they were actually better prepared or skilled than women entrants is not the issue. What matters is that many more young men than young women felt confident in their readiness to undertake higher level science and mathematics (Seymour and Hewitt as cited in Chan et. al, 2000, 8). Others have found that girls are concerned that science and engineering are not humanistic (Wong, Sjoberg and Imsen as cited in APASE, 1995, 7). Women want to know how studying engineering will enable them to help others; they fret more than men when their grades are not as good as they were in high school; and they dislike learning in isolation, preferring to work in teams and be part of a larger social network in their schools (Howard, 2003, 1).

Lack of information: Another common challenge is the lack of information about engineering presented to students. Science and engineering fields can be intimidating to girls and women due to the lack of information (or indeed overabundance of misinformation) available on these fields to society at large (Binkley, Mikawoz and Sherriff, 1995, 107). With little or no (or incorrect) knowledge of the actual work of scientists and engineers, women are not attracted to the fields. Included in the lack of information is the myth that **engineers have little impact on society**. It is important that girls have the correct perception of engineers and promote their contributions to society. Women go into engineering at university not because they know what real scientists and engineers do, but because they excelled in science and math in high school (Anderson, 1995, 98). For these women, theoretical mathematical excellence compensates for their lack of hands-on "tinkering" experience, which is what draws men to the discipline (McIlwee and Robinson as cited in Anderson, 1995,98).

Teachers: The perceptions that girls have are often confirmed by the, often subconscious, way teachers and professors respond to females and males in the classroom. The perceptions and actions that teachers perpetuate, although teachers are most likely unaware because it is not necessarily an act of discrimination but one of cultural norms entrenched in society, do persist throughout all levels of education and are transmitted to the students (Kelly, 2003, A5). Teacher-student interactions in science and math classrooms are no different from those in other classrooms. At all levels of math, teachers initiate more academic contact with boys – even when girls and boys initiate the same amount of teacher contact (Campbell as cited in APASE, 1995, 22). Most teachers will subconsciously pay less attention to girls than boys and offer each different kinds of support (Haggerty as cited in APASE, 1995, 22). Due to social stereotypes that underestimate girls' intelligence, some teachers believe (even in the earliest school years) boys are better in mathematics and science, even when girls are getting better grades and equal scores on standardized tests. It is not uncommon for teachers (or adults overall) to think that boys possess innate mathematical and scientific ability and girls have to try harder to achieve (Sadker, 1994, 95). These beliefs affect the way teachers interact with girls' and boys. Teachers can discourage in subtle as well as overt ways. They can perpetuate stereotypes with comments like "You're too pretty to be a math whiz," and they can reinforce the status quo by not challenging fellow teachers who feel girls don't belong in advanced math and science. (Campbell and Storo, 1994).

Studies of classroom interaction show that girls and boys are treated differently with boys dominating classroom interactions (even when they make up a minority of the class) (Haggerty as cited in APASE, 1995, 22). The following chart shows the different responses to boys and girls actions in the classroom:

Boys are allowed to speak out without raising their hands	Girls, when they do speak out, are quickly scolded
Boys receive more praise for intellectual and creative accomplishments	Girls are more often praised for things like neatness and organization
Boys are asked more direct questions, more open-ended questions, and more complex and abstract questions	Girls are asked more memory recall questions
Teachers respond to boys questions with information and encouragement	Teachers are less likely to respond to girls with explanations

(Grant as cited in Kelly, 2003, A5; AAUW and BCTF as cited in APASE, 1995, 22)

If teachers and professors are convinced that science is an unfeminine profession, they may tend to give greater attention and rewards, such as prizes and scholarships, to boys rather than girls (Sonnert, 1995, 6). Girls, especially smart girls, learn to underestimate their ability (Sadker, 1994, 95). The following story demonstrates a teacher's reaction to a female students' enthusiasm for an engineering activity:

*Ioannis N. Miaoulis, a former Dean of the School of Engineering at Tufts, visited a Massachusetts middle school to teach kids about engineering. He showed them how the size of a straw made a difference in how quickly a child could make a milkshake disappear. One girl became very excited at the idea of doing a project about the efficiency of straws and the time it took to drink the shake, and Miaoulis was ready to help. Then the girl's teacher took him aside. "Don't pay attention to her," the teacher said. "She's going to be a hairdresser."
(Howard, 2003, 2).*

High-achieving female science students are even more likely than male students to cite high school teachers as important in their decisions to major in science (Gilbert and Pomfret as cited in APASE, 1995, 8). However, it is not common for school guidance counsellors to discourage high school girls from thinking of math or science as a possible university major (Lawton as cited in APASE, 1995, 23). Many parents, teachers, and career counsellors place more importance and expectations on career plans of boys than on those of girls and show more concern for the overall performance of boys (Frize and Mc-Ginn-Giberson, 1995, 9).

It is also important to note that at the secondary and post-secondary level, math and science teachers are predominantly male (Weidler, Kubanek & Waller, 1996, 22 and APASE, 1995, 22). Statistics vary, but research generally shows that only three per cent of teachers of information technology in grades eleven and twelve are female, 14 per cent of the nation's science faculties comprise women, and women account for only three to 10 per cent of engineering faculties at Canadian and American universities (AAUW, 2000; Howard, 2003, 1; NOW 2001; Shaw, 1999, A8; WISE 2000).

Teaching styles: Another challenge girls face in science and math classes is the way the subjects are taught and the resources used to teach them. There is a substantial body of documentation showing how teaching, research, and practice in most areas of science and technology follow essentially male patterns of being hierarchical, authoritarian, competitive, and exclusive (Franklin, 1999, 102). Girls do not flourish in this environment and instead are inspired by and learn much better in collaborative and cooperative environments with emphasis on small group work (King and Peart as cited in APASE, 1995, 22; Eastman, 1995, 161).

Also, science material is most often taught with a narrow technical focus, without any link to societal realities and relevance, and certain myths present in the field propagate a masculine view of excellence that is prejudicial to women's success and to their integration into the fields (Caplan, CCWE, NABST, as cited in Frize and Mc-Ginn-Giberson, 1995, 10). Teaching styles used in high school and post secondary science classrooms are even more male centred than elementary classroom environments as most of the teachers in these higher level science classes are male and often prefer the traditional lecture/presentation/demonstration style of lecturing (King and Peart as cited in APASE, 1995, 22). Even the experiments science teachers choose generally focus on things boys are more likely to be interested in, like cars and rockets (Lawton as cited in APASE, 1995, 22). When the courses are 'humanized' with some societal context, they will certainly be attended by greater numbers of women (Frize and Mc-Ginn-Giberson, 1995, 12).

Textbooks: Not only are teaching practices geared to boys, textbooks used in classrooms, both at the secondary and post-secondary level, often portray women and men in traditional stereotyped roles, a reality that is further reinforced by the lack of female science faculty, and therefore lack of female role models in traditionally male fields (Frize and Mc-Ginn-Giberson, 1995, 11 and Backer as cited in APASE, 1995, 23). In science textbooks, Caucasian men appear in significant science roles more often than do children, members of minority groups or women (Powell and Garcia as cited in APASE, 1995, 23). In fact, only one-seventh of all illustrations of children are girls and women are often underrepresented in post-secondary science textbooks (Ms. Foundation for Women, 1998, 97). In addition, examples and references given usually relate to masculine interests (Frize and Mc-Ginn-Giberson, 1995, 11) and pupils are exposed to almost three times as many stories with boys as heroes as stories with girls as heroes. Boys are more often portrayed as clever, courageous, creative, and resourceful, while girls are shown to be compassionate, dependent, and docile (Ms. Foundation for Women, 1998, 97).

Part 4b: EDUCATION – SUGGESTIONS AND POSSIBLE SOLUTIONS

By using the following solutions, teachers, professors and all educators will defeat the myth that ***studying engineering is demanding and most young women either cannot cut it or will not be able to compete with their male colleagues.*** Changing perceptions, catering curriculum and teaching styles, sending out realistic messages, and giving girls a chance will bring down the systemic barrier that many women currently face.

- **A message to girls:** First of all, a strong message needs to be given to girls and to society— girls who want to have challenging and rewarding careers in just about any field need to know they must take the math courses and earn the grades they need to get ahead (Ms. Foundation for Women, 1998, 101).
- **Familiar and comfortable:** Girls need to become more familiar and comfortable with engineering. To do this is it important to introduce concepts and methods involved in problem-solving (engineering) into the existing science and mathematics courses at secondary level and introduce basic notions that pertain to the various engineering fields to bring these fields closer to the students at a critical time when they are considering their careers (Frize and Mc-Ginn-Giberson, 1995, 11). If engineering is introduced at this stage, girls might be more likely to consider it as their choice of study.
- **Modified teaching approaches:** It is also important that teachers modify their teaching approaches, and work hard to diminish the culturally ingrained stereotypes present in classrooms (especially math and science classrooms). Teachers need to be made aware of the gender bias that's present in classrooms, so they can change their own attitudes, which are often cultural rather than discriminatory. In order to provide teacher with the appropriate tools to deal with the issues of gender bias in classrooms, gender sensitivity training should be provided for all elementary and secondary school teachers as well as university professors. This training would explain the use of gender-inclusive language in classrooms, and help with the selection of textbooks that do not portray women and men in traditional stereotyped roles and include profiles of women scientists, engineers, and mathematicians. Also, the use of a cooperative learning and teaching style creates a positive environment and team work with which women are comfortable (Brooks as cited in Frize and Mc-Ginn-Giberson, 1995, 11-12). The content and delivery must create a positive image for young women and equalize some of the imbalance that currently exists in the system. Relating topics to societal realities is also effective (Brooks, Frize and Ontario Women's Directorate as cited in Frize and Mc-Ginn-Giberson, 1995, 12). The curriculum should develop multidisciplinary topics relating to the quality of the environment and the quality of life; examples are: biophysics, environment engineering, biomedical engineering, bio-resource and water resource engineering. All of the above will provide girls with self-confidence in an area from which they have been discouraged (directly or indirectly) to participate (Frize and Mc-Ginn-Giberson, 1995, 11). Schools must examine ways in which the climate, the culture, teaching style and curriculum can be modified to integrate women's needs (Frize and Mc-Ginn-Giberson, 1995, 9).

This does not mean that **women are only interested in those engineering disciplines where they feel that they can help people, such as in environmental or biological engineering.**

This myth shows a lack of understanding about the engineering profession and the many different aspects of all types of engineering, including helping people. To make all disciplines of science and engineering careers more appealing to young women they need to see how of scientists and engineers apply their knowledge to the benefit of humankind, to solve problems, and design the world we live and work in (Frize and Mc-Ginn-Giberson, 1995, 11). Instead of automatically dismissing most engineering fields as ones that are of no interest to women, it is important to have a full understanding about engineering, engineers, and their accomplishments. When girls are aware of the many different options in engineering and see they align with things that are important to them as women, and important to society, they will have a better chance of choosing engineering as a career.

- All-girls environments:** Another effective approach to help girls become more comfortable and confident in traditionally male dominated fields is to create all-girls classroom environments where girls can learn and participate with more confidence. Girls who are in all-girls classes say it allows them to be themselves (Sadker as cited in APASE, 1995, 35). These classrooms are free from social stereotyping, and they provide an environment in which girls do not feel uncomfortable to succeed in fields where boys are usually expected to dominate (Vockell and Lobonc as cited in APASE, 1995, 35). For example, in co-ed environments boys monopolize laboratory equipment and other curriculum materials (APASE, 1995, 34), and in computer laboratories, boys have been found to ‘aggressively’ exclude girls from computer use or confide them to ‘helper’ roles (APASE, 1995, 24). Glen Ellis, a professor at the all-girls Smith College in the United States, knows the importance of an all-girls engineering classroom. Smith College instituted an engineering program three years ago, and when the school surveyed the students they learned that relationships are important to women, as is social relevance. The curriculum was then designed accordingly. As a result, instead of offering the standard lecture course, at Smith, students work in groups and help decide what will go on in the classroom. When a course in introductory mechanics is taught, students don’t merely learn how to solve problems, they are taught the subject matter in the context of societal issues. The efforts have paid off. There are 21 students in the junior engineering class and double that in the first-year class, which will enter the program this fall (Howard, 2003, 2).
- Role of universities:** At the post-secondary level, there are a few things universities can try. One role the university can play is in advising women in engineering. Many students end up quitting engineering programs during their first two years because they find it dull. However, at this point, many students have not even taken any engineering courses because the standard curriculum first calls for courses in calculus, physics and other sciences. One suggestion is to give students earlier exposure to engineering concepts and provide tutorials or short courses used as an introduction to hands-on experiences with engineering (Howard, 2003, 2). Universities can also learn a lesson from college system that helps women build technical self-confidence by providing hands-on experience as part of the curriculum (McIlwee and Robinson, 1992, 54).

Part 5: CAREERS

Gender stereotypes associated with science and engineering are carried over from elementary and high school science classrooms, to university lectures, and all the way to the workplace. The gap between young women and men in science becomes progressively greater at each succeeding stage of the education process and beyond, into the realm of employment (Status of Women Canada as cited in APASE, 1995, 17).

Statistics: Women represent 52 per cent of the population but due to the presence of subtle (and sometimes not so subtle) barriers, they are under-represented in some fields, and most notably in Engineering (Frize and Mc-Ginn-Giberson, 1995, 9). In Canada, approximately 20 per cent of the nation’s physical scientists are women and fewer than four per cent of women are registered as professional engineers (Howard, 2003, 1). Also, according to Census Canada data for 2001, women only make up 27 per cent of the 410,000 IT professionals in Canada and this number appears to be shrinking (Kelly, 2003, A5). These statistics show that women face a male dominated and quite often sexist work environment (Wentling as cited in Turnbull-Spence and Whittaker, 1995, 215).

This is concerning if one thinks of how a workplace is shaped by its employees. The male dominated professional engineering is an environment that is unwelcoming to women and one where women have few opportunities to create and participate in a community of women in the field (Camp, 1996, 122).

There is a myth that **women will never comprise more than 20 per cent of the engineering population**; and that **this 20 per cent figure is acceptable**. This 20 per cent figure is absolutely not acceptable because it does not account for the ideas and contributions of half the population; and it seems only logical that they would be involved in decisions affecting what kind of society we live in (vanBeers, 1995, 222). It is also important to consider that when it comes to today's computer culture, the bottom line is that while more girls are on the train, they aren't the ones driving (AAUW, 2000). In order to improve this situation we need to set a new standard for gender equity. The new benchmark should emphasize scientific and technical literacy including girls' mastery of analytical skills, computer concepts, and their ability to imagine innovative uses for technology across a range of problems and subjects (AAUW, 2000). Gender equity means using technology proactively, being able to interpret the information technology makes available, understanding design concepts, and being a lifelong learner of technology (AAUW, 2000). In order to balance out the gender inequality in engineering, a much higher number of females need to enter the engineering fields and more women need to advance to positions of leadership in the engineering fields.

Another barrier is that women in traditionally male-dominated professions, such as engineering, typically earn less and face more obstacles than men (APASE, 1995, 21). Female engineers and computer scientists often report isolation, anger, lack of respect, sexual harassment, and limited career advancement opportunities in male dominated fields (APASE, 1995, 21). In some cases, women tend to be channeled into stereotypical work classifications within the engineering profession (Carter and Kirkup & Cockburn and Ormond as cited in Anderson, 1995, 98).

Reputation: Aside from the barriers women face in science, engineering and technology careers, there is also the reputation that these careers have for including 100-hour workweeks – something that is not appeal to women who want to have families (Shaw, 1999, A8). This also contributes to myth that **the engineering practice is too rough for women, with 70-hour workweeks and no time for family**. Corporate management often believes these myths and doubt women's willingness or ability to handle both work and family responsibilities. This extends to questioning the future reliability of single women (CWSE, 1994). Women scientists and engineers in this position perceive others doubts and questions of commitment and often lose self-esteem and career confidence (CWSE, 1994). Upper management needs to be taught these perceptions are unfair and treat women employees with the same dignity and respect as their male co-workers. Correct information about the true nature of the jobs of scientists and engineers needs to be promoted to young girls including testimonials from women in the professions.

Part 5b: CAREERS – SUGGESTIONS AND POSSIBLE SOLUTIONS

In order to see a change in the area of careers, young girls need to first be excited about these careers and have realistic expectations about them.

- **Awareness:** The first thing to do is to make girls and young women aware of what science, engineering and computer science careers are really like (Shaw, A8, 1999). This includes letting them know about the many different kinds of jobs that involve science, computers and technology, what these jobs entail, and whom they will be working with. When asked about their future careers, factors important to girls include interesting work, future job security and contribution to society (Vickers et. al, 1995, 84; Honey et. al, 1991). Girls need to see how scientists and engineers apply their knowledge to the benefit of humankind, to solve problems, and design the world we live and work in. This makes science and engineering careers more visible and appealing to young women (Frize and Mc-Ginn-Giberson, 1995, 11).
- **Creation of networks and communities of women:** For women who are already in science or engineering careers, it is important that they have the opportunity to create networks, communities and support groups with other women. There are many different groups and online communities that have been created to form communities of women in male dominated fields such as science, engineering and technology and also combat misrepresentations and attract more women to these fields. Two examples of communities for women in engineering are Wired Women <<http://www.wiredwoman.com>> and the Systems Mailing List <<http://www.systems.org>>. Both offer support groups for women including mailing lists, online communities and local chapter events. These communities allow women to discuss issues that are important to them (career and personal issues) and also are a way to promote science, engineering and technology careers to other women and girls.
- **Technical skills:** Technological skills empower men in the work force. It is therefore essential for women to have these skills if they wish to improve their employment and income in the Canadian workplace (Anderson, 1995, 98). Technology jobs are destined to be the most lucrative jobs in the next century, and girls need to be ready to compete for those jobs (Ms. Foundation for Women, 1998, 103) and fill the information technology job shortage. Women are an untapped source of talent to lead the high-tech economy and culture (AAUW, 2000).

Part 6a: HOME AND EXTRA-CURRICULAR

Crucial processes of gender-role socialization take place in the family (Sonnert, 1995, 8). What children (both girls and boys) learn about gender at home is central to their ideas about their scholastic abilities and career options and those of their peers (APASE, 1995, 3).

There is a great deal of evidence that confirms the fact that gender-specific social expectations play a role in limiting girls' capacity to be creators, shapers, and producers of technology. From a very early age, boys are expected and encouraged to learn about machines, tools, how things work, and are given the opportunity to dismantle technological objects and toys (Honey et. al, 1991, 4). Studies have also shown parents normally invest their science enthusiasm in their sons, for whom they buy more math and science-related toys and more computers (Campbell as cited in APASE, 1995, 19; Sanders, 1995, 151). Girls, in contrast, are not expected to know about technical matters and are often encouraged to be merely consumers and users of the technology (Honey et. al, 1991, 4). Therefore, girls spend much less time playing around on computers when they are younger than boys (Howard, 2003, 2).

In addition to buying home computers for their children, parents also support enrollments to summer camps. In a survey of 23 computer camp directors, it was found that female enrollment declined with age (Miura & Hess as cited in Sanders, 1995, 151). It is extracurricular opportunities like these that may provide girls with a chance to become familiar with computers in a non-stressful environment, as well as “catch up” to boys experience levels (Shortt, 1998, 92-93).

Part 6b: HOME AND EXTRA-CURRICULAR – SUGGESTIONS AND POSSIBLE SOLUTIONS

Girls need to be educated about computers and given an opportunity to become familiar with how they work and how they can best be utilized because an understanding of science and technology leads to the possibility of choosing engineering in university and as a career (Shortt, 1998, 92). An obvious solution is to give daughters the same opportunities as son’s including improving girls’ access to the home computer and enrolling girls in science and technology camps. The following are other suggestions and possible solutions:

- **The family computer:** The creation of a family computer is a great idea to help girls feel more comfortable with technology. This family computer should be put in a centralized location and girls should be given equal access with their brothers (Shaw, A8, 1999). Parents should think about shared or family-centred activities on the computer, rather than viewing its use as an individual or isolated activity (AAUW, 2000). Equally important as access to the computer is the software available. Make sure there are software packages and games that appeal to girls (Chan et. al, 2000, 9). Girls and boys also tend to enjoy different types of computer games. Girls do not seek the fast-paced conquering adventure games that attract boys and instead view computers as something to learn with (Shortt, 1998, 91). In fact, many girls find computer games boring, redundant, and violent (AAUW, 2000). Girls have clear and strong ideas about what kind of games they would design—games that feature simulation, strategy, and interaction. These games would appeal to a broad range of learners—boys and girls alike (AAUW, 2000) and are suitable on a family oriented computer.
- **Science and engineering camps:** Parents should also enlist their daughters in science and engineering summer day camps. These camps introduce science and apply science experiments to elementary and secondary school students; giving them an introductory idea of the world of science, engineering and technology (NCDEAS, 1995, 27).

Overall, parents need to be a positive influence, avoid stereotyping, and challenge their daughters (as much as their sons) to develop their full potential. They should encourage their daughters to take optional math and science courses at high school and go to the highest levels of education in science and computer science (Shaw, A8, 1999). A surefire way to inspire daughters is to make certain she has plenty of opportunities to read about women of diverse achievements (Ms. Foundation for Women, 1998, 38).

Part 7: ROLE MODELS AND MENTORS

Girls learn what it means to be a woman by watching women (Ms. Foundation for Women, 1998, 3). They are fascinated with real adult women because they want cues about what to be like when they grow up. With no one to look up to and emulate, girls do not see themselves as future scientists and engineers (Howard, 2003, 2; APASE, 1995, 7).

The lack of role models is a very important issue to address. In our media-saturated society, girls get bombarded with *unreal* images – not only of how a woman looks but also of how she behaves and how she’s treated and what she can expect to do in life (Ms. Foundation for Women, 1998, 138). Girls do not have as many science, engineering and technology role models compared to other professions, such as business, medicine or law (Hiscocks and Zywno, 1998). Without role models, girls have no one to look to up making it hard to imagine themselves as scientists or engineers. Even in formal education, where teachers and professors act as role models, there are fewer female science and technology teachers at high schools as well as a low number of female engineering professors at universities (Hiscocks and Zywno, 1998).

Part 7b: ROLE MODELS AND MENTORS – SUGGESTIONS AND POSSIBLE SOLUTIONS

There is a need to make women in science, engineering and technology more visible to girls. One way to do this is to create mentor programs that expose girls (and society overall) to women role models. The following are other suggestions and possible solutions:

- **Mentorship programs:** Mentorship programs are essential in order to provide girls with a more positive view of science and engineering and in turn achieve gender balance in the next generation of professionals (Paris-Seeley and Reed, 1995, 67). The development and delivery of mentorship programs is a very effective way to reach out to young girls and has been suggested as a way to improve the recruitment and retention of women in science, engineering and technology (Turnbull-Spence and Whittaker, 1995, 215). Mentor programs are an effective way to address the low numbers of visible women role models and show girls that women can, and do, enter the fields of science, engineering and technology. Mentor programs break stereotypes by showing science, engineering and technology as viable and exciting careers for girls and allowing girls to see women in science, engineering and technology who are competent and confident (Shaw, A8, 1999). If women are to participate equally in engineering geoscience, both boys and girls need to meet women successfully pursuing careers in math, science and engineering (Paris-Seeley and Reed, 1995, 67).
- **Talk to girls early!** It is important to start talking to girls in grades four, five, and six (APASE, 1995, 8). Having female engineers and scientists come and interact with them at this crucial age can have a significant impact on their future school and career choices. One of the most successful efforts in schools has been to invite women engineers and scientists into the classroom to talk to girls about their work and history with math and science (Ms. Foundation for Women, 1998, 101). Girls can relate to female scientists visiting their classrooms much better than to the stories and photos of ‘wacky’ male scientists that they are presented with through the traditional educational system.
- **Student ambassadors:** University students also make excellent ambassadors for promoting science and engineering to elementary and secondary school students (Pittioni and Stanton, 1995, 73). Elementary and secondary school students will relate to university students because they are closer in age and in life interests. These types of personal connections are very important in a mentor relationship.
- **“Real” scientists and engineers:** Speaking to, and having relationships with real female scientists enables young girls to ask questions and become more familiar with their future career choices. It also provides them with encouragement and support that is needed to eliminate

barriers (Frize and Mc-Ginn-Giberson, 1995, 11). Having a mentor is a great benefit to a girl's life (Ms. Foundation for Women, 1998, 69).

Women scientists and engineers must continue to be role models in order to achieve gender balance in the next generation of professionals (Paris-Seeley and Reed, 1995, 67). Science and engineering professors, as individuals, are often actively involved in a variety of community and professional association programs aimed at stimulating interest in science and engineering (NCDEAS, 1995, 28).

Part 8: ACTUA'S APPROACH

Actua recognizes the critical need to encourage girls to enter science, engineering and technology when the organization noticed a decline in the participation of girls at summer camps between the years of 1993 to 1997. In response to this challenge, Actua created the National Girls Program.

The National Girls Program is a set of specialized Actua initiatives targeting young girls across Canada. The original program was launched in 1998 as a national strategy to increase the participation rate of girls at Actua day camps. In 2000, it became a dynamic collection of programs and awareness building activities being delivered across Canada. The objectives of the National Girls Program are:

- To instill confidence in girls in all areas, but especially in science, engineering and technology
- To provide role models for girls in the areas of science, engineering and technology
- To break stereotypes surrounding girls in science, engineering and technology
- To make an impact before girls attitudes have formed
- To facilitate discussion between girls about issues important to them

National initiatives: Nationally, Actua offers a variety of initiatives and programs to help members with their all-girls initiatives, including the following:

- **Training:** Actua offers gender issues training at both National and Regional meetings to all staff and volunteers. It is important that our members have an understanding of the importance of offering specialized initiatives for girls. Training includes:
 - Presenting current research and statistics surrounding the topic of women in science, engineering and technology
 - Tips and suggestions on how to offer supportive and creative environments that nurture participants (girls and boys!) self-esteem and confidence in their ability do to science, engineering and technology
 - Different pedagogical approaches and learning styles that work for girls' and boys' (in both co-ed and all-girls environments)
 - Training to help them become mentors and share their stories about what it means to be a scientist and engineer
- **Resources:** Through our online Intranet, Actua provides a variety of resources for members to help them run all-girls initiatives. These resources include frequently asked questions (about why Actua offers all-girls initiatives), a collection of projects and activities to use during all-girls initiatives, links to other organizations running similar initiatives, copies of research papers completed on the benefits of all-girls environments, and also descriptions on what other Actua members are doing to help increase the number of girls participating in Actua programs. We are also very interested in creating a resource for parents to provide them with research and statistics and help them encourage their daughters to pursue science, engineering and technology careers.
- **All-girls evaluations:** Actua has recently completed the third year of a research project aimed at evaluating the impact of our co-ed programs on the attitudes and behaviours of the camp participants across Canada. With the success of our evaluation of the co-ed camps, we became interested in the creation of a formal evaluation of our all-girls programs. There is a significant need for research into the impacts of all-girl environments on attitudes and career choices of girls.

Results of researching this new approach will guide future programming and identify key success factors for attracting girls and young women to science, engineering and technology careers. In the summer of 2003, we collected some data from the all-girls programs across Canada and we have started the process of data cleaning and data analysis. Actua is looking forward to learning more about the impact of our all-girls initiatives through the all-girls evaluations.

- **Funding:** In order to help Actua members offer fun, hands-on, programs for girls, Actua has created a new Girls Fund. This fund is designed to support any all-girls initiatives that members are running, including existing and new girls programs. This year the fund supported:
 - Creation of new overnight camps for girls
 - Expansion of current overnight all-girls camps
 - Creation of new Girls Clubs
 - New sessions added/more girls reached at existing Girls Clubs
 - New all-girls weeks offered at camp (some camps even offer multiple all-girls weeks and all girls weeks for a wide range of age groups)
 - Delivery of career conferences for girls
 - Workshops offered to Brownies, Girl Guides and their leaders
 - All-girls open house (to show girls what camp is like)
 - Mentor sessions at all-girls initiatives delivered by female scientists and engineers

- **Girls Mentorship Program:** Actua recognizes the need for female role models in the science and engineering fields. In order to increase the number of positive role models available to girls, Actua has started a new national Girls Mentorship Program with an online mentoring and group-mentoring components.
 - **Online mentorship component:** This mentor format offers both a casual or informal mentor setting with a possibility for more interaction. This everyday type of mentoring is valuable because it makes women in science, engineering and technology more visible to girls. Girls who visit the site will form a casual “relationship” (look up to a mentor who is featured) with the mentor. There is also an opportunity for girls to e-mail a mentor who is featured on the Actua site creating a closer and more personal relationship. By featuring women profiles online we are making women in science, engineering, and technology more visible to participants in all-girls clubs and camps (they will be visiting the site during their time at clubs or camps), but also to any girl who visits the Actua site.
 - **Group mentoring:** Offered to participants at Actua camps and clubs. Group mentoring occurs when a number of mentors serve together as a resource for a defined group of girls with similar expectations. These mentors will bring a variety of information about the diversity of careers available in science, engineering and technology. We want all-girls club and camp participants to realize the many options they have in science, engineering and technology and by presenting them with a number of mentors who will interact with them in a group mentor format. This form of mentoring will help change the perceptions of science, engineering and technology for the girls by allowing the girls to meet many different mentors who will tell them about the many realities of science, engineering and technology. Also, the collaborative community environment the group mentor approach will take is a comfortable learning setting for girls and will help improve the impact of the Mentor program. Actua instructors are enthusiastic and knowledgeable undergraduate science, engineering and computer science students. They also receive training on how to share their stories and be positive and inspiring mentors to campers.

Local community based initiatives: Locally, Actua members offer a variety of all-girls initiatives including girls' clubs, all-girls science and technology camps, girls' conferences and career fairs, workshops, and special all-girls events.

- **Girls' clubs:** Throughout the year, many Actua members offer all-girls science, engineering and technology clubs where participants meet once or twice a month to work on projects and interact with scientists and engineers (through the Actua Girls Mentorship Program).
- **All-girls science and technology camps:** During the summer, many Actua members hold all-girls weeklong and overnight camps. These camps offer specialized curriculum for girls and also include a mentorship component (through the Actua Girls Mentorship program).
- **Girls' conferences and career fairs:** Throughout the year, Actua members organize special conferences and career fairs for girls. These conferences and career fairs are offered in many formats, but their common ground is offering advice on careers (and therefore education) in science, engineering and technology, and also includes mentor presentations from a variety of women scientists and engineers.
- **Workshops:** Actua members are proud to offer fun, hands-on workshops for community organizations such as Brownies, Girl Guides, Boys and Girls Club, and Big Sisters, etc. Members also offer special workshops for all-girls schools.
- **Special events for girls:** Many members offer exciting special all-girls events and community activities including science evenings, parent-daughter workshops. Members have also formed strong relationships with local community groups such as the Boys and Girls Clubs, Big Brothers-Big Sisters, Girl Guides, and local YM-YWCA's and regularly deliver workshops and special initiatives to these groups.

Our outcomes: Our approach is working! Last summer, just over 4,000 girls were engaged in all-girls activities (all-girls weeks, overnight camps, clubs, and other all-girls community outreach) through 45 specialized initiatives. Since 2000, over 175 specialized initiatives have been delivered reaching over 16,000 girls across Canada. The number of girls participating in Actua camps has increased by 23% as a result of these programs. Also, in our initial pilot evaluation of the all-girls programs we found that in post camp surveys 88 per cent of respondents felt that camp was more enjoyable because it was for girls only and less than five per cent of respondents indicated that they would prefer a co-ed camp rather than an all-girls camp if returning to camp next summer. By engaging girls, parents, teachers, and community groups we have increased public awareness of the importance of attracting girls to science, engineering and technology.

Part 9: CONCLUSION

We live in a world defined by and dependent on engineering, science and technology. Participating as active citizens will require a solid basis in these fields in order to truly understand the implications of new advancements. Canada also needs a talent source from which to draw for future innovations in engineering and science and by making science and engineering relevant to young people it will increase in interest for them, and thus provide an increased likelihood that they will pursue it as a career option. Females, and all underrepresented audiences, must be engaged in developing their science literacy, in order for them to become independent, responsible citizens able to compete in the knowledge economy. It is true that women view math, science, engineering and technology more positively than they did a decade ago and they also find greater acceptance from their male classmates but the fact remains that women are still significantly underrepresented in these fields. The amount of advancement achieved by women should not be used as a justification to curtail the efforts needed to achieve equality in the fields of science, engineering and technology. As this paper demonstrates, the current perceptions and statistics surrounding girls in science, engineering and technology show the myths and stereotypes are still affecting women's access and entry to these fields. The work of organizations such as Actua must continue with new techniques and new programs. Many of the solutions offered in this paper will help girls and women open doors that have been traditionally been closed to them. The great contribution of women to engineering, science and technology lies precisely in their potential to change the technostructures by understanding, critiquing, and changing the very parameters that have kept women away from these fields" (Franklin, 1999, 104). It is extremely important to encourage girls not only to use engineering, science, and technology, but also to design, create, and contribute to our society.

BIBLIOGRAPHY

American Association of University Women (AAUW). (2000). Tech-savvy: Education girls in the new computer age. <http://www.aauw.org/research/girls_education/techsavvy.cfm>.

Anderson, Inter. (1995). "The social construction of female engineers: Strategy for equitable university education for female engineering students". In More than just numbers: Papers and initiatives. New Brunswick.

Anderson, Inger J. Tveten. (1996). Issues in recruitment and retention of female engineering students. University of Saskatchewan.

Association for the Promotion and Advancement of Science Education (APASE). (1995). Unmixed messages: Strategies for equitable science education. Sonnert, Gerhard. (1995). APASE: British Columbia.

Azab Powell, Bonnie. (Fall 2002). "Women in engineering: An eye on the numbers". Forefront. <<http://www.coe.berkeley.edu/forefront/fall02/women.html>>.

Binkley, Laura, Irene Mikawoz and Barbara Sherriff. (1995) "University of Manitoba access program for WISE". In More than just numbers: Papers and initiatives. New Brunswick.

Camp, Jean L. (1996). "We are geeks and we are not guys". In L. Cherny and Elizabeth R. Weise (Eds). Wired women: Gender and new realities in cyberspace. Seal Press: Seattle. 114-125.

Campbell, Patricia B. and Jennifer N. Storo. (1994). Making it happen: Pizza parties, chemistry goddesses and other strategies that work for girls and others. U.S. Department of Education.

Campbell, Patricia B. and Jennifer N. Storo. (1994). Girls are... boys are...: Myths, stereotypes, and gender differences. U.S. Department of Education.

Chan et al. (2000). Gender differences in Vancouver secondary students' interests related to information technology careers.

Committee on Women in Science and Engineering (CWSE). (1994). Women scientists and engineers employed in industry: Why so few?. National Academy Press.

Douris, Christopher. (May 25 1995). "Engineer defying stereotype". The Liberal. 3.

Dyer, R. (1993). The matter of images: Essays on representations. Routledge: London, England

Eastman, Caroline M. (1995). "Accommodating diversity in computer science education". In Rosser, Sue V. (Ed.) Teaching the majority: Breaking the gender barrier in science, mathematics, and engineering. Teachers College Press: New York. 160-168.

Franklin, Ursula. (1999). The real world of technology: Revised edition. Toronto: House of Anansi Press Limited.

- Frize and Mc-Ginn-Giberson. (1995). "Breaking the glass ceiling in engineering education: The next challenges. In More than just numbers: Papers and initiatives. New Brunswick.
- Gill, Rosalind and Keith Grint. (1995). "Introduction". In grint, Keith and Rossalind Gill (Eds) The gender-technology relation: Contemporary theory and research Taylor & Francis: PA.
- Hiscocks, Peter D. and Malgorzata S. Zywno. (1998). Discover Engineering Summer Camp for high school girls at Ryerson Polytechnic University – A recruitment strategy that works. Ryerson Polytechnic University.
- Honey, Margaret et. al. (August 1991). Girls and design: Exploring the question of technological imagination. Technical Report Series – Centre for Technology in Education – Technical Report No. 17.
- Howard, Marjorie. (2003). From milkshakes to computers: Opening the doors to women in engineering.
- Irvine-Halliday, Dave and Ed Nowicki. (1995). "Women in engineering at the University of Calgary: A paradigm shift". In More than just numbers: Papers and initiatives. New Brunswick.
- Kelly, Sean. (March 14, 2003). "Conference probes girls' aversion to IT". The Daily Gleaner. A5.
- Mahood, Linda. (Winter 1993). "Reconstructing girlhood: Putting 'clever' girls in science". Canadian Woman Studies. 13(2), 91-93.
- Mcllwee, Judith Samson. (1992). Women in engineering: Gender, power, and workplace culture. State U. of New York Press: Albany.
- Millar, Melanie Stewart. (1998). Cracking the gender code: Who rules the wired world?. Second Story Press: Toronto.
- Ms. Foundation for Women and Sondra Forsyth. (1998). Girls seen and heard: 52 life lessons for our daughters. Penguin Putnam Inc. New York.
- National Library of Canada. (2002). Celebrating women's achievements: Canadian women in science. <<http://www.nlc-bnc.ca/2/12/h12-400-e.html>>.
- National Organization for Women (NOW). (July 2001). <<http://www.now.org/eNews/july2001/072301science.html>>
- Organization for Economic Co-operation and Development. (2003). Report on education. <http://www.cbc.ca/news/background/education/oecd_2003.html>.
- Paris-Seeley, Nancy and Sheri Reed. (1995). "K-12 education initiatives – Bridging the gap". In More than just numbers: Papers and initiatives. New Brunswick.
- Pittioni, Sonia and Deirdre Stanton. (1995). "You bet I'm an engineer". In More than just numbers: Papers and initiatives. New Brunswick.

Rigoglioso, Marguerite. (Spring 2002). "Women in engineering: A roundtable discussion". Forefront. <<http://www.coe.berkeley.edu/EPA/forefront/sp02/women.html>>.

Sadker, Myra and David. (1994). Failing at fairness: How our schools cheat our girls. Touchtone: New York.

Sanders, Jo (1995). "Girls and technology: Villain wanted". In Rosser, Sue V. (Ed.) Teaching the majority: Breaking the gender barrier in science, mathematics, and engineering. Teachers College Press: New York. 147-159.

Shaw, Gillian. (April 27, 1999). "Girls aren't computer geeks". The Vancouver Sun. A8.

Shortt, Denise M. (Winter 1998). "Gender and technology: Looking to the past". Canadian Woman Studies. 17(4), 89-93.

Silver, Carla. (January 28, 1996). "Parents can get kids excited about science, math". The Liberal. 23.

Sonnert, Gerhard. (1995). Who succeeds in science? The gender dimension. Rutgers University Press: New Brunswick.

Status Report from the National Council of Deans of Engineering and Applied Science (NCDEAS). (1995). In More than just numbers: Papers and initiatives. New Brunswick.

Status of Women Canada. (1997). Women's History Month: Discovering women in science and technology. <http://collection.nlc-bnc.ca/100/200/301/swc-cfc/womens_history_month-e/d1/whm97-e.html>.

Turnbull-Spence, Catherine and John Whittaker. (1995). "The effect of mentors on female engineers". In More than just numbers: Papers and initiatives. New Brunswick.

van Beers, Anne M. (1995). "Women and the culture of engineering: Occupational socialization and success". In More than just numbers: Papers and initiatives. New Brunswick.

Vickers, Mary H, et al. (May 1995). "Do science promotion programs make a difference?". In More than just numbers: Papers and initiatives. New Brunswick.

Women in Science and Engineering (WISE). (2000). <<http://www.carleton.ca/cwse-on/>>.