# Obstacles to Gender Parity in Engineering Education

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## Abstract

Low rates of women's enrolment in engineering programs has been identified as a global problem within the general concern to enable women to attain parity in education in all areas. A Western women in engineering meta-narrative is identified which contains a complex of obstacles that typify the situation of Western women. The question is asked whether this meta-narrative can be used to guide comparison between the problem of women in engineering in the West, particularly Canada, and women in engineering in China and India. In reviewing the considerable literature devoted to understanding the obstacles to gender parity in engineering education in the West, as well as a range of statistics concerning women's education for China and India, it is concluded that national comparisons are difficult. It is suggested that research should proceed by identifying comparable institutions of engineering education in the three countries in order to gain insight into the possible gendered nature of engineering as a profession in each setting. Review of extant literature from China and India indicates that there is a shared factor of concern with the access of girls and women to education given the high value placed on their labor contribution in the home and also, a number of unique factors typical of each setting.

## Introduction

Traditionally low enrolment rates of women in engineering programs in the United States, Canada, the United Kingdom and the European Union have been accounted for by what can be termed a Western women in engineering meta-narrative. Borrowing and paraphrasing Englund and Leach's (2000:126) definition growing out of the critique of modernity as a basis for the interpretation of local meanings, a meta-narrative constitutes a set of assumptions about a given phenomenon only some of which may be enunciated in a given context. Numerous studies of women in engineering programs in the West thus imply all elements of this meta-narrative while perhaps foregrounding one or two. A cornerstone of this discourse is the assumption of the male-female duality and the identification of engineering as a 'masculine profession' as a result of the identification of technology itself as masculine. A further dichotomy of a female orientation of caring and social involvement and a complementary male orientation of abstract and instrumental thought leads to a concern with the importance of gender in engineering pedagogy and an inevitable 'chilly' social climate for women in engineering programs. The solution to this disadvantaged position for women is seen as an increase in the proportion of women in the profession. Early literature talks about a 'critical mass' set at a particular percentage that would allow women to reshape their position and experience fewer career obstacles, although more recent writing has been more cautious (Etzkowitz et al 1994; 2000).

Kantor's (1977; Gupta and Sharma 2003) concept of 'tokenism' seems to embody many of the features of the Western women in engineering meta-narrative.

Although not discounting the importance of rates of women's enrolment in engineering programs as worthy of concern, the comparison of these rates is itself problematical. It is especially suspect outside of the Western countries in which the meta-narrative evolved. The problem is a familiar one and one that Englund and Leach (2000) address within the context of ethnography. The problem lies in uncovering the variability that similar rates of enrolment conceal within different cultural and historical contexts. For example, it may be asked of two diverse national settings what combination of factors have come together to result in similar rates and what local meanings account for them? Thus the tension between modernist interpretations and local particularities surfaces in the problem of women in engineering globally, as well. The disentanglement of imposed assumptions from empirical realities is particularly crucial in this case as policy initiatives on the part of professional organizations, development bodies and governments must be tuned to effective management. The parachuting of a Western developed women in engineering meta-narrative into non-Western settings would result in the same kind of dissatisfaction and frustration witnessed in response to the parachuting of the gender and development discourse into vastly different cultural settings internationally (Cornwall, Harrison and Whitehead 2004).

The complexities of preparing for comparison involve a number of considerations. First among them is the evolution of gender studies in general to encompass a relativization of both male and female, to include studies of masculinities. This is witnessed not only in the focus on maleness cross culturally (Connell 1995) but also in the growing feminist critique of an exclusive focus on women in development in general (Cornwall 2000; Chant and Gutman 2005). Secondly, social science theory has moved to a study of process as underlying social identities characterized by the inclusion of theoretical works in gender studies that render gender as performance and not a fixed attribute of the individual (Bourdieu 1977; Foucault 1978; Butler 1993). Gender is currently understood as contextually and historically contingent, culturally constructed and performed. This movement to a constructivist approach is also evident in current research on men and women in relation to technology.

Lohan and Faulkner (2004:320-323) review the evolution of approaches to the study of gender and technology. They identify four streams. The first is women in technology which

asks the critical question of why there are so few women in technology which underlies the question asked here of why so few women in engineering. The second strand has to do with women as users of technology and is termed by the authors 'women and technology.' The third stream departs from the use of the term 'woman' and focuses on gender instead 'signaling an insistence that technology as well as gender should be understood as socially constructed.' It is important to note here the parallel in the evolution of this terminology with that in the study of women in the development field. The well-known shift from a women in development approach to a gender and development approach comes to mind with the recent turning to the masculinities literature. The fourth stream is that of men/masculinities and technologies which the authors see as posing a major challenge to feminist perspectives but also complementing them. Locating themselves in the tradition of feminist technology studies, the authors characterize this approach as constructivist and post-structuralist. Gender and technology are thus seen as mutually shaping and coproduced, as are technology and society. There is a tension in this tradition between 'a structuralist emphasis on the historical roots and durability of cultural equation between masculinity and technology, and on the other hand, there is the anti-essentialist refusal to see either technology or men as necessarily about control and domination' (Lohan and Faulkner 2004:322). The men/masculinities and technologies approach has a diverse empirical focus and attempts to study the stability of the relationship between men and technology while at the same time destabilizing the relationship by 'exploring contexts in which new relationships between masculinities and technologies might be developing.' The value of incorporating the men/masculinities and technologies literature in our discussion is that it problematizes universal assumptions about masculinity and allows for the specification of local and contextual variants.

One goal of this article is to establish the degree to which rates of women's enrolment in engineering programs in India and China are comparable to those in the West, specifically in Canada. Although it was not possible to locate statistics that were completely comparable that is compiled for the same purpose and under the same conditions, sufficient documentation representative of general trends is available. A second goal is to establish whether the Western women in engineering meta-narrative can guide comparison. What are the areas of possible convergence between the situations of women in engineering in Canada, China and India? What factors indicate significant departures? This will be accomplished through a preliminary review of available literature on women in engineering in these two countries set against a thorough

discussion of the literature on women and engineering in the West. Contained within this literature are solutions to the problem which have grown out of a specific feminist orientation and are deeply rooted in particular formulations of gender and technology. For example, Henwood (1996) is critical of the UK Women in Science and Engineering Program on the basis of the liberal feminist assumption of free career choice. She argues for the compelling power of heterosexual identity construction in the context of these professions Henwood's case study will be presented as an exemplary case of the Western women in engineering meta-narrative. Based on data collected a generation ago, her research will be placed in contrast with research conducted at the University of Guelph's School of Engineering in 2003-2004. In many ways this School can be seen as an exemplar of the most positive context for the training of women engineers. With the Ontario regional Chair for Women in Science and Engineering based at the School, a brief description of the Canadian program of regional Chairs for Women in Science and Engineering will be provided. Then moving into the international arena, preliminary observations about obstacles to gender parity in engineering education in India and China will be made.

The University of Guelph research focused on the gendered responses of students in two required courses, drawn from the various programs. Parallel qualitative research concerning professional identity on the part of women students was carried out in order to determine if obstacles to enrolment and advancement were perceived on the part of women students. Although the University of Guelph research does suggest that the association of technology and masculinity does play some role in the conduct of students in the design courses and in the program more generally, the question remains whether the association between masculinity and technology is a universal one that can be seen as an explanation of the low levels of women's enrolment in engineering programs globally. The literature on Indian women engineers provides a detailed picture of some of the social and cultural factors that determine enrolment in engineering programs on the part of women but the question of the relationship between women and technology is not directly broached. Similar to the literature on China, the issue is treated more in terms of women's participation in university education and research in general only that the Chinese literature is significantly dominated by official government statements about the profession as a whole. Does this mean that the association between masculinity and technology does not hold in these settings or is responded to in a different way? This must be seen as a

future research question for which the following discussion will lay a ground work. The mechanism used to enable discussion of such a potential comparison is the consideration of extant literature relating to the problem of women in engineering in these two countries including rates of enrolment in programs and of participation in the profession against the backdrop of women's access to education and participation in the professional workforce.

The commonalities between India and China are well documented. Both are mega-nation states experiencing high rates of economic growth and demand for skilled and professional workers. Both are typified by large populations newly experiencing a modernist life style and large populations anticipating such a transition while still largely confined to subsistence and unskilled labor. The role of the association between technology and masculinity can not be estimated here but certainly gender constructs of a historical and cultural character can be identified as bearing on women's entry into science and technology fields, and academia more generally. Finally, in as much as there is a familiarity and simplicity in the explanation of low rates of enrolment of women in engineering in Western countries as a result of the association between technology and masculinity, such a view has itself been superseded by a more dynamic understanding of the relationship between gender and technology itself. The explanation of low rates of enrolment on the part of women in engineering programs because engineering is a masculine profession harkens back to the women in technology tradition which problematizes women as simply not fitting into the profession (Lohan and Faulkner (2004:320). Faulkner (2000:88), writing in the current feminist technology tradition, sees a two way shaping relationship between gender and technology with 'technology as both a source and consequence of gender relations.' The particular association then between gender and technology is a product of a particular social and historical context which is generated through everyday practice and may be configured similarly across a particular geographical range typified by a common historical and cultural heritage. There is no reason to expect that this association will have the same force in China or India or be configured in the same way. Indeed, this preliminary consideration of factors associated with particular rates of women's enrolment in engineering programs in these two countries acts to open up the possibility of a future more detailed and nuanced consideration of the association between gender and technology in those particular settings. Further, the consideration of the context of variable enrolment rates of women in engineering programs in Western countries and in India and China will suggest policy initiatives

suitable to the factors seen as affecting them. Initially though, it is necessary to demonstrate the importance of our concern with women in engineering as a global problem.

**Women in Engineering as a Global Concern**

The low enrolment of women in engineering programs can be seen as an aspect of the unequal access of women to education in general. The third Millennium Development Goal is to 'Promote gender equality and empower women.' This will be accomplished through the elimination of gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015. [1]. Although some feminist scholars have been critical of the exclusive focus on education as the means to empower women and to achieve gender equality (Eiben 2005), it is clear that women's access to education must be seen as a basic human right fundamental to the well-being and development of their communities. Further, restriction of women's access to particular forms of professional training in the areas of science, engineering and technology, has been identified by professional organizations, multilateral development organizations, business interests and the academy as critically wasteful of human resources demanded by a technologically complex and specialized global economy.

In a comprehensive report entitled *Women for Science* published by the InterAcademy Council (2006), the problem is introduced as follows:

> But while women constitute half of humanity, even in countries where they have ready access to higher education, the number of women studying mathematics, physical science, and engineering remains drastically below parity with that of men. Talented and capable women are essentially turned away from these and other fields, and the few who persist typically find themselves isolated and marginalized. As a result, the overall participation of women scientists and engineers in the workforce continues to be very limited, and these professional women seldom reach the pinnacle of the hierarchy – at universities, in companies, or anywhere else. (InterAcademy Council 2006:ix).

Identifying this gender gap as having 'egregious moral implications' as well as practical concerns, the report proposes a number of plans of action. Propounding a similar global perspective, the recent report published by UNESCO (2007) calls upon the expertise of a host of social actors in identifying the complex of problems involved, as well as in implementing necessary strategies to counteract the current trends. There is a sense of urgency in relation to the perceived development of science and technology over the past 50 years and as this level of

[1] http://www.un.prg/milleniumgoals/#)

growth is maintained the demand for a significant increase in the number of researchers both male and female is anticipated.

Progress has been made in moving women into tertiary education in recent years, but overall the improvement in the fields of science and technology have been disappointing and uneven. High levels of women's enrolment in undergraduate programs do not translate into similar levels in graduate and Ph.D. enrolment. Even though women now comprise more than half of the undergraduate students in many countries, they are still underrepresented in science and technology fields. In Canada and in many countries of the European Union between 52% and 67% of undergraduate degrees are awarded to women. Although women's enrolment in engineering programs has increased it is still skewed in favour of more 'feminine' specializations. In a period of twenty years, women engineering undergraduates in the United Kingdom increased from 7% in 1984 to 14.5% in 2005. Their distribution in the various fields of specialization however remained highly uneven. Women made up 32% of chemical, process and energy engineering students while they represented only 8% of mechanical engineering students.(InterAcademy Council 2006:12). In the United States the number of Ph.D.'s gained by women has steadily increased in the areas of biological sciences, chemistry, mathematics, physics and engineering over the past four decades. The order of the enumeration of these areas actually represents a move from the highest to the lowest values. Although the percentage of Ph.D.'s granted to women in the 1960's in engineering has moved from less than 1% to just below 20% in the present, in the same period the percentage of Ph.D.'s granted to women in biological sciences has moved from about 16% to just under 50%. (*ibid* 13). In Canada, in 2004-2005 just over 50% of doctoral graduates were women and interestingly, there has been a 49% increase in women graduates from computer and information sciences and from mathematics in a one year period.

The most disturbing trend is that in all settings, women engineers represent the smallest proportion of graduates and the smallest number of higher degrees in the science and technology areas. Further, they are least likely to be represented at the senior levels of researchers. In the European Union, whereas the proportion of men and women is roughly equal across disciplines at the start of 'tertiary programmes that lead to an advanced research qualification (Ph.D.), they diverge by 80% in the 'single highest grade/post at which research is normally

conducted'(InterAcademy 2006:16). The career paths of women and men in research differ radically.

Not only do women students comprise a small proportion in engineering programs but it is generally conceded that women in engineering 'leak' out of the career pipeline at various stages. The percentage of women students in engineering is not matched by the percentage of women engineering professors and senior researchers. Nor does the number of undergraduate engineering students relate in any way to the percentage of women professional engineers in industry. According to the Women In Engineering Advisory Committee of the Ontario Society of Professional Engineers, in 2001 23% of students in engineering programs in Ontario were women, while only 7% of professional engineers in Ontario were women.[2]

This problem of women in engineering is one that has elicited a range of programs and services on the part of professional engineers' organizations, industry and United Nations organizations. Through a plethora of conferences, workshops and pod casts and other media, often organized through a variety of partnerships between corporations, professional organizations and United Nations agencies, girls are encouraged in to engineering programs and professional women engineers and students address the issues confronting them in their advancement. Most prominent among these organizations is the World Federation of Engineering Organizations (WFEO). In its online newsletter it reports on these activities and promotes an image of contemporary engineers which is at once development oriented and internationally committed. This image reflects the views of a proportion of professional engineers and is by no means reflective of professional engineers as a whole. There is diversity in the profession, no doubt associated with specialization, generation, geographic location and possibly gender. But it is significant that at least a proportion of the professional population presents itself as deeply implicated in the future well being of the global community. An example of this sort of activity is the Engineering for a Better World Program launched through a partnership between the UNESCO Division of Basic and Engineering Sciences and the World Federation of Engineering Organizations. The purpose of the program is to 'promote capacity building in engineering and technology for poverty eradication, secure and sustainable social and economic development' .. A further example of this orientation is found in the November 2007 issue of the WFEO e-News. Discussing the aftermath of the International Conference on

[2] http://www.un.prg/milleniumgoals/#)

Engineering Education held in Portugal in 2007, a commentator describes the conference as follows,

> It constituted a forum, with near 500 participants coming from 57 countries, where innovative ideas and creative experiences could be shared between colleagues from all over the world. One of its conclusions was undoubtedly that the advancement of technology and engineering is a necessary and previous condition for the progress in the global economy on the quest of the fulfillment of human self-respect.

The application of engineering expertise to local problems of underdevelopment is also witnessed by numerous reports in the newsletters on the activities of voluntary organizations such as Engineers without Borders or Engineering for Developing Communities.

Faulkner (2000:105-6) discusses the old enlightenment image of the engineer as conquering nature through the construction of monumental roads, dams and bridges. WFEO's image of the profession is not so clearly devoted to the monumental but it is equally noble. In keeping with the spirit of the times, it focuses on the diversity of the local and personal in solving community problems through the application of technology. This is witnessed both by the faith in contemporary information and communication technology as itself engendering local development and in the importance of international voluntarism in solving community level technological problems.

The professional engineering community is also concerned with the gender imbalances in its ranks. This position is exemplified in the Carthage Declaration announced by the participants in the International Colloquium on 'Empowering Women in Engineering and Technology' held in Tunisia in June 2007. Following are the principles agreed to:

1. Increasing the participation of women in the fields of engineering and technology will benefit all communities world wide.
2. Encouraging women to join the profession of engineering and technology will contribute to the advancement and enrichment of the world.
3. Maintaining a large percentage of women as engineers and technologists will actively contribute to the economies of all countries.
4. The participation of women in the field of engineering and technology will be retained and augmented. (issues of child care, maternity leave, day care and salary parity)

5. The participation of women engineers and technologists in top managerial positions across the world will introduce a new outlook on leadership.
6. The creation of a favorable women environment requires at least 35% women participation at all levels of any organization, including top managerial positions.

It is against this background of a commitment to the inclusion of women and an understanding of the importance of the profession in attaining global development goals that the obstacles to gender parity in engineering will be addressed in this article. Is there something about the profession of engineering itself that acts as an obstacle to the recruitment and maintenance of women professionals? If so, what is it about engineering that first of all does not attract women into undergraduate programs and then causes them to leave at more advanced levels? An affirmative answer is provided by the Western women in engineering meta-narrative which was briefly introduced. Viewing engineering as a 'masculine' profession speaks both to the history of the discipline and to the comfort of dualities. This view has been developed by Western feminists and is based on observations and research conducted in Canada, the United States, United Kingdom and the European Union. At base is a purportedly historical and cultural association between technology and masculinity. Does this association determine the low rates of enrolment on the part of women in engineering programs? Acceptance of such an explanation would determine measures for remedial action. Both the rationale for the association between masculinity and technology will be explored, as will proposed plans of action that will act to attract and retain more women in the profession.

**Engineering as a Masculine Profession**

Engineering can be seen as a masculine profession in two ways. The first is as an exemplification of the masculine nature of the Western Enlightenment's scientific enterprise itself and thus based in a particular epistemology. Feminist scholars have criticized the abstract, objective nature of scientific knowledge, proposing alternative approaches. These positions developed as a post-modern critique of Western science and emerged almost two decades ago addressing issues of domination and inequality. Harding (1991) argues for the validity of knowledge from a feminist standpoint asserting that the powerless have a less distorted view of the world then the powerful. Holding a position outside the social order, the knowledge claims

of women have the advantage in terms of the social context of their production. Haraway (1991) although equally critical of the objective, 'God's eye', view of traditional science, proposes that individuals hold several different perspectives on the world and that these change with time and context. She argues for the advantage of taking into account several positionings with several perspectives on a particular problem as producing a more valid objectivity. Longino (1990), on the other hand, argues for a 'contextual empiricism' that connects truth claims to the available evidence and recommends that scientists use their political beliefs to guide their theoretical positions.

It is one matter to critique a cultural tradition of knowledge production, but it is another matter to see the faults of this tradition somehow embodied in a particular profession. There is what has been called contradictory gendering in engineering knowledge and practice and dichotomies that appear to typify engineering as a whole are found enacted within engineering knowledge and practice itself. For example, the distinction between the craft or technician engineer who works on the artifact in the workshop and the mental work of the graduate engineer who works in a clean office far away from the messiness of the workshop, can be seen as reiterated in the concrete, contextual problem solving style associated with women and the more abstract, intellectual approaches associated with men (Faulkner 2000:95). As pointed out by Wajcman (1991), this opposition when enacted by men is class based and tied to the mind/body dichotomy, which itself suggests the male/female opposition. Although it may be argued that this general classification of engineering with a masculine abstract and objective science bears on the issue of low female enrolment, the more productive tact is in the exploration of the social dynamics of gender performance as accounting for the low enrolment of females in engineering programs which are simply numerically dominated by men.

There is a considerable literature that examines factors contributing to women's low enrolment in engineering programs. In a review article focusing on the various explanations given for women's lack of enrolment in science, technology, engineering and mathematics programs, Blickenstaff (2005) enumerates nine commonly held. The explanations range from biological differences between men and women, which he quickly discounts, to lack of appropriate role models for girls in the form of women scientists/engineers. Other causes that he cites are a pedagogy of science that favors male students and what has been called a 'chilly climate' for girls/women in science classes.

In considering the causes of women 'leaking out' of the engineering career pipeline, key findings of early research demonstrate that there is a major difference between university and workplace culture in the profession of engineering. McIlwee and Robinson (1992:50) argue that this is a result of faculty setting the culture in the university while professional engineers themselves set it in the workplace. The necessary academic skills to perform well at university are more suited to women than the aggressive, technical focus of workplace culture. McIlwee and Robinson (1992:21) argue that what places women at a disadvantage in the workplace setting is their tendency to avoid 'aggressive displays of technical competence' which is seen as a requirement for success in the workplace. The authors also point out that males most commonly cite interest in tinkering as their motivation for entering the program (*ibid* 13). Dryburgh (1999:670) observes that females often perform better in the academic setting than do males. The enjoyment of tinkering on the part of males draws on the embodied pleasure taken in the workings of machinery, and is discussed by Mellstrőm (2004) as a powerful locus of male socialization and bonding both in relation to automobiles and computer technology. This type of activity tends not to be indulged in by girls as they grow up nor by adult women.

Early work, such as that of Hacker (1981), tended to identify a strong masculine/feminine dualism in university programs with greater prestige given to masculine qualities, such as scientific abstraction, than to feminine ones characterized by the value placed on personal and humanistic relationships. Rosser (1990) argues that women have an approach to science which is more holistic and has a global scope. Also, earlier studies such as Franklin's (1985:9) note that female students frequently deny the existence of sexism in the university environment. Flynn et al. (1991:460) argue that women have been socialized in the engineering classroom to be more loyal rather than critical which supports Franklin's contention that female students are "trying so hard to become part of the 'tribe' ".

More recent research has moved away from the epistemological dualism of Hacker (1981) and Rosser (1990) and focused on the actual gender dynamics of academic programs. For example, a comparative study of degree programs conducted in seven European Union countries, identifies current thinking in the area as follows:

> It is not a deficit in abstract thinking, etc. by women that drives them away from technology, but the content and climate of technical institutions, referred to as an atmosphere of 'dominant masculinity' (Sagebiel and Dahmen 2006:6).

However, all of the elements mentioned thus far appear to form a configuration parts of which are variably realized in research conducted in the last twenty years or so in the United States, Canada, the United Kingdom and the European Union. Although there are differences in the importance of certain factors, the context of the research and class and ethnic identity of the participants, a meta-narrative of women in engineering can be seen as encompassing the range of studies.

*Key Elements of the Western Women in Engineering Meta-Narrative*

Several elements of this meta-narrative are found in the work of Henwood (1996) based on research she conducted in a college of technology in the south-east of England in the mid-1980's. It also illustrates the conditions of Kantor's tokenism. She contextualizes her research as a critique of the Women into Science and Engineering initiative launched in 1984 in the United Kingdom. She conducted interviews with a group of eleven women on a Diploma for Personal Assistants (PA) (a traditional course for women) and a mixed group of six men and four women on a Higher National Diploma (HND) in Software Engineering ( a 'non-traditional' course for women) in order to see if the equal opportunities initiative had influenced their decision regarding future work. She asked the eleven women who were enrolled in the PA program if they had ever considered non-traditional work as in science and engineering. Nine of the eleven women had and gave as their reason for not pursuing this choice as either 'I was not clever enough' or 'I was just not interested.' Henwood (1996:204) speculates that these women first of all assumed technical and scientific work to be very difficult (requiring brains) and put themselves in a group (including other women) who did not have such capacities. When asked directly why they had not chosen such a career, they simply said that they were not interested. Henwood infers that this type of answer served to assert that the women did indeed have a choice, and that they did not find themselves lacking any of the abilities required by the job. Henwood (*ibid* 205) comments that the influence of the WISE discourse which constructs the problem of women in science and engineering as a problem of lack of information in order to make an informed choice, can be clearly seen as shaping this kind of response.

Few of the women in the PA group cited 'the dirty work' of engineering as a reason for not preparing for the profession. Rather, women uniformly said that they would have to work harder than the men in order to 'prove' themselves. This perception was supported by the statements of

the women who had entered the Software Engineering program. Illustrative of this position is the response of a woman engineering technician in the department who stated,

> I was struggling at first, felt I was being watched all the time to make my first mistake, that's four years ago now and it's gone but I do understand when other women say they've had difficulties. It's kind of sly. I can't explain to you how it's done, it's subtle, to show you how incompetent you are. When you do a job, an equal job beside a man, really you've got to do it twice as good as he has. You haven't only got to prove it to yourself, you've got to prove it to him. (Henwood 1996:205).

Women in the software engineering group also commented on the need to not be sensitive to men's overt teasing. Some women mentioned the possibility of sexism and misogyny in a predominantly male program and workplace but then discounted it as 'unlikely' (*ibid*: 207). Most of the SE women downplayed the kinds of problems that they faced along these lines. Henwood observes that the WISE discourse, as she calls it, premises equality between men and women in capabilities for work in science and engineering and sees the problem of low enrolments of girls and women in these programs as a result of lack of knowledge and lack of confidence in entering a highly valued male profession. This definition of the problem, in itself, becomes an obstacle to reversing the trend. Henwood (1996:212) goes on to specify:

> In particular, its limited 'same as men' understanding of equality silences women's voices. If women speak out about their difficulties this only serves to highlight their difference and, in dominant discourse, their inferiority and lack of suitability for this work.

In conclusion, she asserts that we need to understand more about gender, sexuality and work and how they shape each other. By exploring these relationships, she maintains, we will come to understand more about possible approaches to remedy low levels of enrolment on the part of women in engineering programs.

**Research at the University of Guelph**

The University of Guelph is a publicly funded institution and one of 15 universities that offer engineering programs in Ontario. In Canada 25% of the university aged population attend university. Participation rates for females in the Guelph undergraduate program are high: 62% overall for the university and 28% across all streams of the engineering program. The Natural Sciences and Engineering Research Council of Canada/ Hewlett Packard Chair for Women in

Science and Engineering is based in the School of Engineering and the School does have a reputation for being inclusive of women students.

The Natural Sciences and Engineering Research Council (NSERC) is the national instrument for making strategic investments in Canada's capability in science and technology. This includes investments in people, discovery and innovation. One of the ways that NSERC is addressing the under-representation of women in science and engineering is through the regional Chairs for Women in Science and Engineering**.** When the program began in 1989, there was a single Chair-holder based at the University of New Brunswick. After a Task Force review in the mid-nineties, the program was expanded to support Chairs in five regions of Canada: Atlantic, Quebec, Ontario, Prairie and BC/Yukon regions. The mandate of the Chairs program is broad with objectives to address both the need to encourage girls and women into science and engineering careers, and to retain women as valuable contributors to science and engineering. The Chairs are tenured faculty in science and engineering departments and they continue to teach and conduct research while they serve as regional Chair (50:50 split of responsibilities). The Chairs are role models as well as focal points for thinking about the challenges for increasing the participation of women in science and engineering and acting more broadly.

Each Chair plans and implements a five-year program of activities that addresses needs specific to their region. Within their region, each Chair works with networks of educators, community organizations and professional associations. In addition, the five Chairs work together as a national network to share resources and information and to expand the impact of their efforts.

Notwithstanding the presence of these efforts, the familiar pattern of the concentration of women in some streams of the program and the exclusion from others is also evident at the University of Guelph. The percentage of women in the Engineering Systems and Computing program has been below 10% over the past five years. In 2003 the percentage of women was 6% in this program and in 2004, it was 4%. In comparison, the participation of women in Biological Engineering was 59% and 56% in the same two years respectively. Accepting that the link between engineering and masculinity may be a consideration in this instance, Davidson et al (2006:2) speculate,

> It may be the case that the Systems and Computing stream attracts students who are drawn to competitive demonstrations of technological competence, while the other

> streams may represent contexts for the performance of more feminine values of caring for others and working for the common good

Research aimed at evaluating the impact of several changes made to a second year, computer-aided engineering design course, required of all streams in the engineering program at the University of Guelph was undertaken in 2003 and 2004. Changes included the creation of custom computer tutorials, the introduction of a collaborative group project and the addition of a peer-helping incentive. An attempt was made to measure the impact of the changes on confidence and self-efficacy and on the overall collaborative environment using a pre/post test survey model as well as two forms of qualitative research: direct observation and semi-structured interviews. The general findings of this research are summarized by Davidson et al (2006:1).

> -Females had lower computer-use self-efficacy than males but were not 'low' in absolute terms.
> -Females reported significantly lower confidence in using the computer-aided engineering (CAE) software than males at the pre-course survey but this finding was not present at post-course evaluation.
> -Females reported lower self-efficacy in engaging in hands-on work and felt that they had less opportunity to do so.

Associated with this research was a project using the same two qualitative techniques and drawing on the second year design course as well as a fourth year design course required of all Engineering Systems and Computing and Biological Engineering students. Observations of gender dynamics in the fourth year electrical lab and in the computer lab were carried out. A total of 21 in depth interviews were conducted with both male and female students from all three program streams: Engineering Systems and Computing, Environmental Engineering, Water Resources Engineering and Biological Engineering. It is important to point out that both research projects were designed without presenting gender as a variable to participants. This was done to avoid calling attention to women students as abnormal and somehow disadvantaged in the program. Also there was a concern that the overt introduction of gender in the explanation of the research and in the interviews would prejudice the outcomes of the research. The question of how students align themselves with their profession and its dominant ideology as they create a professional engineer identity was investigated (Hayward 2004). Undergraduate training in an engineering program is seen as leading to the development of a professional identity. In the consideration of the relatively high number of women students in at least two of

the streams in the engineering program at the University of Guelph, it was thought that insight into how this shaped the experience of these students as well as the identity of the group as a whole could be gained.

Hayward (2004: 88-106) provides important insights into a number of issues related to the particular nature of an engineering school experience for women under favorable conditions. These insights bear on previous discussions of engineering as a masculine profession. Addressing the issue of professionalization itself, Hayward draws on the work of Haas and Shaffir (1987:4). They define professionalization as a ritual through which the elevated status of a few individuals is legitimized by society. She observes that students interviewed did see themselves as part of an exclusive group. They thought that their course work was more demanding with a heavier work load and more class hours than that of students in non-engineering programs. Several of them saw themselves as an elite group that faced a bright future in terms of earning power and status. This inclusion in a well defined group involved participation in a number of activities that enhanced group solidarity such as frosh week, prank week , the 'iron ring' ceremony, partying and drinking together and wearing School of Engineering clothing.

Some students expressed concern about the negative image of engineers in the larger society. A particular focus was arrogance, competitiveness and resistance to new ideas as identified within the profession culture. Several students expressed an interest in pursuing careers outside of the profession. In a sense they did not identify well with the profession.

It is this image of the aggressive, competitive and technically oriented person that was problematical for many. Such displays, when they occurred, were highly disapproved of by other students the research showed. For example, observations in the machine shop reported a tendency on the part of some male students to dominate the group work setting by preventing others from access to the activity of disassembling an automotive engine. The individuals dominated the main technical activities, avoided help and advice, and pretended to know everything. They were eager to get grease on their hands as a show of technical competence and strove to claim the largest machine parts that were being distributed for individual drawing assignments. Some students expressed disapproval of these aggressive few and questioned the value of rushing to get hands dirty as a group work strategy in place of careful thought and planning. Hayward (*ibid* 93) contrasts this behavior with the electronics lab of the fourth year

course. She observed generally respectful and friendly interaction where women took on leadership roles in groups and were not subject to opposition from their colleagues. She points out the differences in the two settings in that the electronics lab was more structured and did not involve dirty automotive parts. More importantly Hayward (*ibid* 105) makes the following observation,

> In the second year machine lab, where most of the groups were male dominated, there was a presence of aggression, competition, and focus on technical hands on work. These behaviours were not evident in the fourth year electronics lab where all of the groups observed were comprised of fairly equal numbers of male and female students.

The differences between behavior in the second year lab and the fourth year lab could very clearly be related to the greater experience of students with group work at the senior level. However, the presence of a relatively equal number of women and men could be seen as contributing to the overall collaborative and respectful atmosphere of the electronics lab setting.

Arguing against a simplistic gender dualism of values and orientations, Hayward (*ibid* 101) considers the degree to which the relatively high number of women contributes to a greater emphasis on caring values in the three programs. She suggests that a relatively high number of female students tends to normalize the presence of caring values which are excluded from the value set normally respected in engineering culture.

As a result neither men nor women are obligated to conform completely to the masculine culture that rejects values typically associated with women. Indeed, there was evidence to suggest that males were attracted to the biological and environmental streams for the same reasons that women selected these programs. They were concerned that their training put them in a position to address the needs of others and to improve the lives of others. Several men commented that they would not have entered an engineering stream other than the non-traditional one they were enrolled in.

However, there is some evidence that suggests that students in the Engineering Systems and Computing stream align themselves more closely with what is perceived as the traditional masculine ideology of the profession. Males interviewed in this stream did not explain their entry into engineering on the basis of caring values. One female student in this stream complained of not feeling part of the group and of being last to be chosen for the team. Further, there is some evidence that some female students lack confidence in their technical skills.

Women's avoidance of aggressive participation in some technical activities and males' monopoly over them may handicap women as they move into the workplace. There success is measured by technical confidence and not by high academic grades. One female student expressed concern about her technical skills and feared that they were not as good as they could be.

Further, in spite of the sense of inclusiveness of women in various settings and the respect for caring values in the program in general, the dominant attitude of engineering students is one of superiority and disjuncture from the rest of the university population. The attitude can be expressed by the phrase 'Engineers Rule the World' and can be represented as ERTW. Such an attitude is very much a part of the masculine culture of engineering and is subscribed to by both men and women students. Although this attitude may be seen as promoting the development of an exclusive group identity, it discourages a feminist agenda in engineering. During prank week in particular, engineers show their superior sense of self and contempt for the rest of the campus through their disrespectful activities. For example, engineering students broke into the university website and posted a news story proclaiming that engineering students are smarter and better looking than everyone else on campus. Several ERTW signs were painted on campus property. Students in the various labs were observed to be wearing ERTW t-shirts. This superior attitude, the wearing of ERTW clothing, sporadic involvement in external student government, and performing pranks some of which are insulting to non-engineering students, have all contributed to the disconnect that ensures that engineering students are an exclusive group on campus. In spite of the favorable climate for women students in the engineering program, these elements harken back to a tradition where as Franklin observed, women work very hard to demonstrate they are part of the tribe.

Research at the University of Guelph concerning women in the engineering program touches on many elements of the meta-narrative enfolding this issue in Canada, the United States, the United Kingdom and the European Union. A generation after Henwood's (1996) study of traditional and non-traditional training programs for women in a south-eastern English technical college carried out in the mid-eighties, familiar themes are evident: lower confidence and self-efficacy of women in technical skills, aggressive and competitive activity in certain settings on the part of males and the need for women to maintain images of professional solidarity in a masculine culture. But also, it adds to this discourse an affirmation of the

effectiveness of improved engineering pedagogy as a means of developing greater confidence among female students. It suggests as well that there has been some incorporation of the values of caring and concern for others in the engineering ethos of this particular school of engineering. It may be argued that this is a result of the nontraditional nature of the streams of the program or of the higher proportion of women in these programs. It may also be a result of a shift in the values of masculinity in the population from which the students are drawn to encompass a concern and an empathy for others in one's professional ambitions. Nonetheless, the performance of aggressive displays of technical competence has been demonstrated to be situational and thus contingent on a number of factors, one of which is the relative proportion of men and women in the setting and the other of which has to do with the dirty, hands on work of tinkering with machinery. .

Although Hayward's (2004) analysis does not draw on the concepts of the masculinities literature, the interplay between various 'ways of being a man'(Cornwall and Lindsfarne 2004) and woman, and ways of being an engineer are apparent here. The current shift to the recognition of plural masculinities allows the identification of several variants within the engineering program itself. The image of the aggressive, competitive, technically competent male may be seen as a hegemonic masculinity tied to particular forms of power both in the business world and in the world of monumental and expensive development projects (Connell 1998; Elias 2008). It is this form of masculinity which is historically associated with the profession. It is the association of the profession with this form of masculinity that is enacted in the exclusiveness of the engineering students, both male and female, in relation to the larger student body. It is possibly also this hegemonic masculinity which is embarrassing to both some male and female students in the various streams.

A hierarchy of masculinities (Connell 1998) may be seen as typifying this university setting, with the socially engaged and caring male using his technical skills for the social good enjoying a more privileged position than in the work place. This variant echoes in the image projected by the World Federation of Engineering Organizations of a profession deeply implicated in the well-being of humanity through the sharing of technical skills and international voluntarism. As much as Hayward (2004) argues that the presence of a large number of women normalizes 'caring' values in the University of Guelph program, it may be that these caring

values had long since been shared, in the formulation of a specific form of contemporary masculinity supported by the university context, across the traditional gender divide.

Given the assumption of historical contingency of the relationship of gender, work and technology, the particular construction of the gendered character of engineering as a profession in any given context must be traced. The hegemonic masculinity identified in the University of Guelph program may have some connection to the relationship between masculinity and engineering forged in the years of the professionalization of engineering in the United States, 1893 to 1920. Frehill (2004) argues that in these years the masculine nature of the profession was formed against a background of changing notions of masculinity and the changing structure of postsecondary education in the United States. Reviewing an engineering association newsletter and two career guidance volumes from these early years, Frehill (2004:399) concludes that,

> Exclusion of women was important because of common beliefs in the natural inferiority of women that suggested 'real men' were capable of more than 'women's work.' As engineers became more embedded in industrial work organizations, the heroic aspects of the profession became important points of emphasis for engineers writing about engineering—engineers were not what would now be called 'wimpy, nerds,' pushing a pencil and shuffling papers; engineers were real men who played football and persevered in the face of adversity.

This appeal to manliness as a feature of the work of engineers, was maintained in recruiting boys to the profession. Frehill (2004:400) continues,

> Although the work itself had become rather routinized by the early 1900s, the advocates of engineering education carefully crafted discussions of engineering work to appeal to adventurous young boys, emphasizing the manly qualities needed by engineers and manly outdoors training engineering students received. Indeed, one could become a man by enduring hardships associated with becoming an engineer.

Although some of the traits of competitiveness and aggressive displays of technological competence identified in the hegemonic masculinity of the University of Guelph program are present in a turn of the century American notion of manliness discussed by Frehill, the assumption can not be made that this gendering of the profession at a particular historical moment and place has persevered in a neighbouring country until this time.

## Women's Enrolment Rates in Engineering Programs in India and China

There is no reason to assume that this Western meta-narrative of gender and engineering will be able to encompass situations found in India and China. The review of available comparative statistics begs contextual questions. In attempting to understand the particular, there is always the danger of globalizing models interfering with local detail. This is especially the case with China and India, which historically represent several ancient traditions, have unique and complex modern histories and encompass an array of indigenous cultures and ethnic populations. Gender regimes themselves can be expected to draw on unique historical configurations and the establishment of Western style universities followed complex trajectories of modernization. There is little hope of finding comparable studies to the one carried out at the University of Guelph at comparable institutions in either of these two countries, let alone any significant literature addressing questions of the mutual constitution of gender and technology.

Further each country's plunge into the global market, following upon dramatic liberalization of either controlled or protected economies, has created a demand for labor skilled in technology and engineering. Rapid growth and development of markets have raised grave issues of the integrity of the environment and regionally variable rates of development have displaced labour markets and instigated wide spread migration and regional inequality. For all of these reasons, the goal of integrating women into the profession of engineering in order to both meet the complex needs of the growing economy and to address key developmental issues in both countries takes on a particular urgency. For all of these reasons, it is necessary to address the situation of women in engineering in both of these settings in an informed a manner as possible. The goal here is less to compare the obstacles that prevent women from attaining an engineering education in these two countries than to enumerate the considerations that would underlie the formulation of a basis of future comparison. By examining the rhetoric in which the problem is phrased and touching on the various types of literatures that approach its formulation, it is hoped to establish such a basis.

**India**

Although the rate of women's enrolment in science and engineering programs in Indian universities in 2001 has been reported as 21.5%, roughly comparable to the American and Canadian rates, the framing of the problem draws on a different rhetoric. The Indian National Science Academy (2004) frames the question of women in science and engineering in terms of a

development issue bearing on the access that girls and women have to education at all levels. Two types of observations are made about these obstacles. On the one hand, there is an emphasis on the importance of the labor of girls and women in the household particularly in terms of contributing to household subsistence. The need for the labor of girls in poorer households is seen as preventing girls from completing primary and secondary education. Women's domestic labor also enters into the identification of the problem of the triple burden for women who have attained professional training. There is the triple burden of domestic work, professional work and then, the fighting of male chauvinism (Indian National Science Academy 2004:4). Both the demands of the family on the labor of girls in poorer households at the primary and secondary level and the difficulties of progressing in a professional career are seen as part of male chauvinism and traditional value orientations that prioritize women's contributions to society in terms of marriage and service to the family.

Gupta (2007) in discussing women in doctoral education in science and engineering foregrounds the traditional devaluation of women in education in general. She points to the values of purity, seclusion and gender segregation that marked Hindu society. In spite of the dramatic changes that Indian society has undergone, she sees an ideological continuity. She points to the feminization of pure sciences that is taking place in India and elsewhere as tied to the higher levels of women's participation. For example, 32% of enrolments in physics in Indian universities are women. Gupta (*ibid* 512) makes the link with the feminization of universities in other parts of the world as well.

Her study does highlight the degree to which women in engineering have to prove themselves in a largely male environment. She points out that in the most prestigious institutions such as the Indian Institute of Technology, women are underrepresented at all levels. Only 14% of registered candidates for the Joint Entrance Examination necessary for entry into the prestigious bachelor of technology program were women in 2004. Only 10.4% of masters candidates were women and 11.3% of Ph.D. candidates in science and engineering were women. However, citing a study of women engineers, she shows that 75% of them ranked in the top 10% of their high school class or junior college class.

In an interesting study of patriarchal household structure and women's participation in engineering and science, Mukhopadhyay (1994) demonstrates that educational decisions for women are family decisions as education has become both a necessity and a vehicle for social

mobility in contemporary Indian society. She underscores the complexity of the Indian educational terrain typified by a hierarchy of institutions ranked on prestige and highly competitive entry requirements. This is particularly the case in engineering education. Parikh and Sukhatme (2004) identify four types of engineering training institutions each of which produced different percentages of women graduates in 1998: the most prestigious and least accessible are the IIT's which turned out 3.2% women engineering graduates; the regional engineering colleges produced 9.2% women graduates; government engineering colleges produced 17.2% women graduates and the private engineering colleges, 13.1%. Mukhopadhyay (1994:109) argues that as educational achievement of sons and daughters are differently viewed by the family, different strategies and calculations are involved in making decisions that would enable a son and a daughter to follow a particular stream of education. The achievements of a son promise greater benefits to the family while the achievements of a daughter may have little impact on family fortunes in the long run. The families of a gifted daughter may be less inclined to invest in her success at a prestigious engineering institution given the expected lesser return than in a less gifted son. Only in cases of very wealthy families do women seem to progress to their full potential, as their economic contribution to future household needs would be unnecessary. Other factors that enter into family decisions to educate daughters are the social value of women's seclusion and considerations of future employment as well as the benefits of engineering education in the marriage market determined by dowry demands.

Finally, one feature of the Indian setting that has to be carefully approached is the high degree of variation in rates of enrolment on the part of women in the different states of the country and in different types of institutes of higher training. The Inter-Academy Report (2006:12) points out the dramatic variations in enrolment between the more developed states of India and the less developed ones. For example, although 40% of university places are filled by women nationally, their representation in 2000-2001 was nearly 22% in engineering and technology and 40% in science. But in the State of Kerala, women's college enrolment approaches 65% and women engineering and science majors constitute 31% of the total. It is interesting that in a state which is known to be unique in its high rates of social development and status of women in general, entry into engineering programs should also exceed national norms.

Parikh and Sukhatme (2004) point out that 80% of the stock of women engineers were located in the southern states in the early nineties with Kerala standing in the lead.

In general, the literature on the problem of women in engineering is relatively well developed in India. The statistical documentation of rates of enrolment in engineering programs and the discussion of the detail of factors producing these rates can be attributed to a large population of educated social scientists and engineers, both male and female, who are interested in these issues. There is a strong indigenous feminist movement which addresses the problem of women in engineering from the perspective of liberal feminism. Also, and significantly, India boasts a large population of social scientists that publishes in English and which is familiar with the basic outlines of the Western women in engineering meta-narrative.

**China**

In contrast, there is little academic literature concerning the problem of women in engineering in China. Available information about rates of enrolment in engineering programs and proportions of women engineers is restricted to newspaper accounts and the official statistics provided by the All-China Women's Federation. Indeed, this organization is the official source of information about all aspects of Chinese women's lives. It reports that in the year 2000, 42% of students in colleges and universities were women, while 56.6% of students in polytechnics were women. The proportion of female teachers in these institutions were comparable in that 38.2% of university and college teachers were women, while 44.9% of teachers in polytechnics were women. It is significant that the proportion of variation between the percentage of students and teachers in these institutions is much less than reported in Western countries.[3] The same source reports that in 2001 41% of professional and technical personnel were women. These statistics must be seen against a background of adult male illiteracy of 9% and adult female illiteracy of 22% in 1999.

The situation of women in engineering in China is typified by high rates of participation usually reported in the range of 35% or over. In this way China has reached the proportion of women in the engineering profession set as a goal by the Carthage Declaration. Some reports

[3] http:www.women.org.cn/english/english/fact/mulu.htm

paint an extremely optimistic picture of the participation of women in science and engineering. For example, this report appearing in the *People's Daily* is typical[4] :

> By the end of last century China had had 9.88 million female engineers—about 36.9 percent of all engineers in China, among whom 87 are female academicians—5.1 percent of all academicians in China. Hu Qiheng, vice-chairman of China Association of Science and Technology, made the remark when delivering a speech at the World Engineers' Convention 2004 & Female Forum held at Shanghai International Conference Center.
> "Women can hold up half of the sky of science and technology in China!", said Shen Shuji, vice-chairman of the All- China Federation of Women. It is a historical progress for women to strive for equal rights in education and development. Since the founding of the New China female engineers have been very active in China's hi-tech areas.

Clearly, this achievement has to be linked to the emphasis on gender equality throughout the Maosist period. Some have written about this period in promoting an erasure of gender under the Maoist regime with a submersion of women's concerns in public space in the discourse of class struggle. The Cultural Revolution (1966-1976) further obscured gender by equating looking feminine with looking bourgeois. In spite of the rhetoric of equality fundamental issues such as the double burden were not addressed and the prevalent sexual hierarchy was obscured by the appearance of women at work outside the home. In the nineteen eighties and nineteen nineties the market economy produced hypersexualized images of women in the public sphere catering to male interests as well as the development of a mass of women consumers.

Instrumental in the struggle for equality throughout the Maoist period and into the present is the All-China Women's Federation. Founded in 1949, it is a mass organization dedicated to the advancement of Chinese women of all ethnic groups in all walks of life. Its mission is to represent and to protect women's rights and interests, and to promote equality between women and men. However, in spite of the optimistic rhetoric of the newspaper story, Chinese women, as elsewhere tend to leak out of the pipeline at higher levels of training and in terms of leadership positions. The female leadership ratio in the China Association for Science and Technology is impressively high as of 2000. For example, women constitute 59.65% of directors among member bodies and 15.38% of director-generals. Among member institutions, women made up 28.67% of Division

[4] http://WAIS.stanford.edu/ztopics/week120104/china_041201_womenengineers.htm

Chiefs and 15.15% of directors. They comprised 6.25% of the academicians in the Chinese Academy of Engineering as of 1999 (RESGEST 2006). The same report documents a growth in the proportion of women entering undergraduate programs of study from 36.43% in 1995 to 43.95% in 2002. A similar increase can be seen in the growth of the proportion of women graduate students. In 2000 the proportion was 33.35% while in 2002 it grew to 37.33%.

Some observers have noted that Western influence itself may be a danger to women engineers in China. As quoted in the *Canadian Consulting Engineer* (Jan/Feb 1995)

> With China's rapid expansion and increased contact with foreigners, western attitudes actually threaten the country's women engineers. "Foreign companies don't take women engineers seriously," says Shao Tong, Ph.D., a 28-year-old who works as a senior design engineer for a Chinese telecommunications company in Beijing. "Besides, the foreign companies don't have any women engineers."

There are significant constraints working on the attainment of educational parity of women in China (RESGEST 2006). Still three quarters of female students in colleges and universities come from urban areas, while only a quarter come from rural areas. Large scale migration into urban areas including on the part of potential students poses a serious challenge to higher institutions in managing the new arrivals. Traditional values also work against women. The oft stated adage that 'men work outside the home and women work inside the home' still carries cultural weight. The preference for male children as well as the willingness of the family to invest in male children's education, leave many women literally out of the picture. Employment pressure in this vast economy tends to marginalize women and economic conditions work in favour of educating boys in opposition to girls.

Although there is little academic literature on women in engineering in China, it is expected that this literature will grow. It must be remembered that the Cultural Revolution (1966-1979) closed Chinese universities and interrupted the learning of foreign languages. Still Chinese scholars are turning to issues having to do with engineering education and with urbanized labour markets in contemporary China. Programs promoting exchange among foreign and Chinese scholars are enabling dialogue which will allow various concerns to develop a Chinese variant.

## Conclusions

The global problem of women in engineering resonates with the development goals of enabling women to attain parity in various types of education. The proportion of women in engineering programs in the West is consistently low. This low rate has been explained by a Western women in engineering meta-narrative based on the assumption of a fundamental dichotomy between men and women, thus typifying engineering as a masculine profession. In reviewing the key elements of this meta-narrative, the dynamic and contingent nature of gender constructs in relation to both technology and the larger society has been made evident. Using the link between masculinity and engineering as an explanation for the under representation of women in the profession needs to be justified in each case as a multitude and variety of factors contribute to this situation..

In reviewing the extant literature on women in engineering from China and India, a number of things became clear. Whereas the Western women in engineering meta-narrative focuses on gender exclusion both the literature concerning India and China see gender exclusion as a function of more fundamental development issues such as the demand for girls' and women's labor in the subsistence household, the preference for the education of boys where girls and women are simply not valued and the clear limitations of an underdeveloped infrastructure. The role of government policy is clearly demonstrated in the high numbers of women engineers in China as well as the importance of a powerful, national women's organization. The Indian literature, more integrated into the Western women in engineering meta-narrative, suggests the workings of a number of other factors such as class and considerations of the marriage market as entering into the decision of women undertaking engineering training.

But more importantly, in structuring the comparison on the basis of rates of women's enrolment in engineering programs, there is no question that comparable rates are due to the interaction of quite diverse social, cultural and economic forces.

The 35% rate of enrolment in engineering programs in Kerala and the roughly similar proportion of women engineers in China say quite different things about each situation. It thus appears advisable to compare rates of enrolment not between nations but between comparable institutions in each of the three nations. The variety of training institutions in India was noted and the composite figure of the proportion of women engineers in China obscured the variety of forms of training by distinct colleges and polytechnics that produced them. This localized comparison must take into account the character of engineering as a profession in that particular

setting. In speaking of engineering as a masculine profession, the history of the development of that profession within that country as well as of university and technical training institutions would be seminal.

The term meta-narrative, regarding the way the problem of women in the engineering profession has been constructed in the West, is borrowed from an anthropological discussion of the tensions between explanation of what appear to be like phenomena. Particularly, Englund and Leach (2000) warn us in culturally and historically distinct places, using either an assumption of a shared modernity or an assumption of distinct tradition is no longer adequate to grasp the local meaning of occurrences. Most problems recognized at the global level, share aspects of both. In approaching the comparison of the complexities of women's enrolment in engineering programs in India and China, the particular histories of modern engineering education as well as the cultural configuration of gender regimes developed through the interaction of traditionalism and modernity must be grasped in order to provide valid interpretations for the development of appropriate policy initiatives.

[1] http://www.un.prg/milleniumgoals/#)
[1] http://www.un.prg/milleniumgoals/#)
[1] http:www.women.org.cn/english/english/fact/mulu.htm
[1] http://WAIS.stanford.edu/ztopics/week120104/china_041201_womenengineers.htm

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Published by the Forum on Public Policy