Re-Thinking Diversity in Engineering Education: Implications for Everyday Socio – Economic Issues.

Dlodlo, Mary

NUST

http://ir.nust.ac.zw/xmlui/handle/123456789/616

Downloaded from the National University of Science and Technology (NUST), Zimbabwe
International Conference on Gender Mainstreaming at Higher Education Institutions

Conference Proceedings

16th & 17th September 2014

Elephant Hills Resort, Victoria Falls, ZIMBABWE

Compiled and Edited by: Professor Londwe Nkiwane, Eng. William Msekiwa Goriwondo, Dr Gwendoline V. Nani and Mr Thabani Mpofu

September 2014
Re-Thinking Diversity in Engineering Education: Implications for Everyday Socio – Economic Issues.

Dlodlo, Mary and Shava, George, N
Department of Technical Teacher Education
National University of Science and Technology
P.O. Box, AC 939, Ascot, Bulawayo, Zimbabwe.
mary.dlodlo@nust.ac.zw

Abstract

There are many ways of understanding the gap in engineering and achievement separating female and male students studying engineering. This paper offers our perspective. First, the paper discusses in broad terms the relationship between everyday engineering knowledge and ways of acquiring knowledge and ways of knowing as viewed in the field of engineering education. The paper also considers two perspectives on the question of engineering practice. One perspective examines the relationship within the early period of engineering practice and the other perspective looks at ultimate continuity. We locate our own work within the latter tradition and suggest a framework for understanding the everyday socio – economic practices of female and male practices from diverse backgrounds as a resource in engineering learning and teaching education. We conclude with a discussion of implications of this new conceptualization for research in engineering education and learning.

Keywords: Re-thinking, diversity, engineering, education, female, male, socio-economic.

1.0 Introduction

This paper draws on literature to discuss key issues regarding the relationship between gender inequality and higher education. The paper examines aspects of education that exhibit the most pronounced gender disparities and focuses on how females in higher education interface with gender equality in engineering education. The paper highlights areas that call for careful scrutiny such as lack of prior knowledge in engineering, deprivation of access to engineering, disempowerment, culture and discriminatory gender policies.

The year 2015 is upon us and the education remains focused on gender disparities by seeking to close the gap separating female and male students in engineering. The teaching and learning of engineering occurs in higher education and achievements in engineering are realised during and at completion of higher education. Today, there is growing interest in society for young women to take up careers in engineering. This is shown by the policy advocacy and affirmative action for enrolment in higher education institutions. Research has focused on gender differences in the preparation of male and female students, career orientation, parental influences and attrition (Jacobs 1996).

In re-thinking on gender equity in higher education, it is important to consider the earlier gaps in primary and secondary education which feed higher education with engineering candidates. Over the past fifteen years, eliminating gender disparities at all levels of education has been the main goal (Kabeer 2005). This has also been emphasized in the Zimbabwe National Strategic Plan for education of Girls, Orphans and other Vulnerable Children (2005 – 2010) for school quality improvements and building of girl- friendly schools in communities. Achieving this goal has been indicated by closing the gender gap in education at all levels, increasing females’ access to
education and their achievements, and women’s access to the three resources which are education, employment and participation for the achievement of gender equality in engineering and other fields (Kabeer 2005). Each of these resources has the potential to change women’s lives, but in each case it is the society which decides access to each resource that will determine the extent to which achievements are realised. For example, today in higher education both female and male applicants are generally enrolled into engineering programs. This is a step welcomed by society. If young women are enrolled and can study engineering they acquire knowledge and are empowered. Empowerment in this context means that the women can make choices and can change their lives (Kabeer, 2005). This research recognizes that women have been underrepresented in engineering.

2.0 Engineering Knowledge

In this paper engineering, is a profession central to resource use and development. Engineers are called upon to apply scientific and design technologies to solve problems found in the environment. According to Huntzinger, Hutchins, Gierke and Sutherland (2007) a modern engineer needs to be equipped with knowledge and skills to manage uncertainty of engineering situations by possessing creative problem solving skills and to be able to evaluate their solutions in practical situations. Engineers use knowledge to design and construct systems that are used by society. In addition, engineers use equipment and engineering knowledge that enable sustainable development. Huntzinger, Hutchins, Gierke and Sutherland (2007) point out that both female and male engineering student need to develop high level cognitive and critical thinking skills for solutions to technical problems. The researchers go on to say that successful integration of principles and methods into engineering curricula requires a systematic change in the approach to education, methods of teaching and societal values. However, critical thinking skills, and the ability to evaluate and utilize information are often not advanced in the secondary school curriculum as female and male students are not expose to design and technical solutions to problems. When female students are entering higher education and engineering in particular they are ill equipped to deal with engineering problems found in society.

In order for engineers to fully participate in designing and developing new technologies, they are required to evaluate and apply previous knowledge from multiple disciplines obtained from school subjects such as mathematics, economics, social sciences and environmental sciences which are taught in schools. This suggests a change in the intellectual culture, by addressing engineering as a subject from its grass roots especially secondary education. This means paying attention to a course focused type of secondary education compared to the present holistic approach in which knowledge and process are woven throughout the school curriculum (Bordogna, Fromm and Ernst 1993). This point to a new approach of systematic change in terms of classification of school subject components focussing on students’ potential from earlier levels unlike the present system in which high school students are passed through a general curriculum that does not prepare them to be engineers. Although there is a great need for engineering education reform in schools.

Felder and Brent, (2005) point out that the female and male student acquire engineering knowledge differently as they exhibit different patterns of intellectual development. Research studies indicated that (a) women were more receptive to information and men exhibited mastery patterns and questioned information, (b) women were interpersonal and based judgements on intuition and personal feelings and men were logical and procedural in thinking, and (c) women established inter individual patterns and relied on caring and understanding of others’ positions as basis for judgement while men showed individualistic and relied on logical thinking (Felder and Brent 2005). However, in studies by Felder and Brent (2005) found that at the highest levels such as in the final years of study both female and male students recognized knowledge as contextual and could make their own judgements.

2.1 Access to Engineering Education
Aikman and Unterhalter (2005) point out that while there was wide support for achieving universal education in primary by 2015, the target for Millennium Development Goal (MDG) 3 on gender parity in primary and secondary school by 2015 was never met. This means that there has been no parity or equal proportion of female and male entering and completing schooling. There was increased parity in enrolments in primary education between girls and boys in Zimbabwe and Malawi (Swainson 2000). However, the same study also found that in Zimbabwe fewer girls than boys complete primary school. Swainson (2000) further reported that in Zimbabwean secondary schools, girls’ participation was lower than that of boys in junior secondary school. UNICEF (2003) in Aikman and Unterhalter (2005) estimated that 54% of the girls in Sub Saharan Africa do not complete primary education and only 17% of girls went on for secondary schooling. Swainson (2000) also reported that at A-Level more girls than boys achieved a pass in arts and biology subjects. This has created the first gender gap in secondary education in engineering related subjects.

Access to engineering begins with access to education. One way of thinking about access in education is in terms of completing primary and secondary and the ability to exercise agency or to make choices (Kabeer 2005). As Kabeer, (2005) further pointed out that, when young people are not educated through lower levels before higher education, they are “disempowered” and cannot make choices freely to change their lives. This is because empowerment is rooted in how they see themselves and their worth. Conditions for making choices to progress in life include the ability to meet basic needs, overcoming poverty and the capacity to make meaningful choices about careers and for females to perhaps consider becoming engineers.

2.2 Empowerment towards Engineering

According to Moser and Moser (2014) gender empowerment in any field including engineering is described as the promoting women’s participation in decision making processes, as well as making sure that women are empowered to put issues on the institutions’ agenda. Empowerment is also associated with resources and achievement (Kabeer 1999). Kabeer (1999) explains that what is important to empower women through resources which are preconditions, agency or ability to choose, a process towards achievement and achievements which are the outcomes of the process. This means that conditions need to allow for provision of resources, choice and achievement. Resources include financial and material resources, human and social resources or support all of which enhance the ability to exercise power acquired through social relations in various institutions such as the family, schools, market and community (Kabeer 2005 and Kabeer 1999).

Families take the first step to allocate resources between female and male students. They often support the boy child more than the girl child (Nkhoma (2011, and Randell and Gergel (2009). In supporting the male children, families are making future claims about the boys and expect them to be able to make better choices when they finish their education (Kabeer 1999). Schools’ rules and norms give a certain amount of power by determining the technical subjects that secondary schools’ students study through streaming students and allocating subjects to female and male students in an arbitrary manner. Female students who may want to take up careers in engineering are not given room to exercise their freedom to choose careers in engineering as the design of the curriculum and its implementation does not recognize females entering the engineering market.

Agency and resources support achievements in the way they influence the students’ quality of life. Empowerment through education can contribute to the achievement of one’s goals whereas disempowerment has negative consequences (Kabeer 1999 and Kabeer 2005). For example, reaching O-Level and A-Level by both female and male learner is regarded as evidence of achievement, progress and empowerment for further studies. Achievements by women have been emphasized due to the need for economic efficiency and the high social investment in education (Swainson 2000).
Teachers in secondary schools in Zimbabwe have different attitudes towards female and male students, on the basis that boys need engineering careers and girls take up nursing and teaching careers by confining the latter to arts, Food and Nutrition and Fashion and Fabric subjects which prepare them for ‘caring professions’ so that they can sustain families (Kabeer 2005) and non-engineering careers. Huntzinger et al (2007). By allocating girls in the mentioned technical subjects, teachers tend to be dismissive and discouraging towards girls who may want to take up engineering careers and give more classroom time to boys who usually are more demanding (Kabeer 2005). This less hidden curriculum in education also mirrors social inequalities by denigrating domestic activities to girls.

Swainson (2000) found that in tertiary education in Zimbabwe, Malawi and Tanzania, women were less than one-third of total enrolment and were concentrated in arts and social sciences and their participation in technology subjects was limited. This confirmed gender stereotyping in the curriculum which portrays girls as less capable in industrial work and reinforces gender roles in society. Shackleton, Simonis and Riordan (2005) found that at the University of Cape Town (UCT) families and friends discouraged females who were attracted to engineering by suggesting that they would never make it as engineering was very tough and not meant for ladies. Female students on engineering studies at UCT who participated in the research further reported that they were “unprepared” for the work on the courses they had chosen and that it was generally “difficult” (Shackleton et al 2005:6). In addition, students in the same engineering department at UCT expressed feelings of isolation and had fears about their personal safety, and gender related challenges.

2.3 Empowerment through Learning and Teaching Styles

2.3.1 Gender Equality and Policies

Gender equality is a term that is stable in its use in social science, science and engineering. There is consensus that it gender equality refers to the recognition that women and men have different needs and priorities and should be provided with equal conditions for realizing their full potential so that they can contribute to national development (CIDA 1999 in Moser and Moser 2014). Moser and Moser (2014) stress that components of gender mainstreaming to be enshrined in a gender policy include; having a dual strategy of addressing issues with targeted actions, empowering women, a combined approach by stakeholders and shared responsibility to responsibility and gender training among others.

Education policy in Zimbabwe has made efforts to narrow the gender gap by increasing enrolment in 1990s. Moser and Moser (2014) found that while most institutions have put gender mainstreaming policies in place, implementation has remained inconsistent. The re-introduction of fees due to the devaluation of the Zimbabwe dollar and the recession in the 2000s raised the costs of education at a time when incomes were eroded (Swainson 2000). Although most parents in the last two decades believe in that education is important for girls they found it necessary to spend more on boys who would support them in future (Gordon 1995 in Swainson 2000; Global Campaign for Education 2005). In so doing, parents have re-emphasized support to the boy child and not the girl child. In a case study in Zimbabwe, Malawi and Tanzania, Swainson (2000) found that political and bureaucratic factors constrained the implementation of gender policies in tertiary institutions.

The Zimbabwe National Strategic Plan for Education Girls, Orphans, and Other Vulnerable Children (2005 – 2010), has attempted to implement gender policies and promote girls’ enrolment and achievement in primary and secondary schools through Policy Advocacy, School Quality Improvements in Child – Friendly Schools and Community Capacity Development, Service Delivery and other strategies. The Ministry of Higher Education has not had a broad gender policy apart from a study on the participation of women in engineering and science that has been implemented (Swainson 2000). In addition, UNICEF that works mainly in primary schools has not been...
successful in encouraging the Ministries of Primary and Education and Ministry of Higher Education to collectively tackle gender inequalities through teacher training colleges (Swainson 2000).

2.4 Culture

Culture and social obstacles have contributed to gender inequality in higher education. In Zimbabwe, Swainson (2000) reported that feminism that tried to bring some gender reforms into development organizations has met resistance from Ministry of Education officials who saw it as an agenda for western countries that would influence the culture of the country. This has led non–governmental organizations diverting assistance away from education. Aikman and Unterhalter (2005) emphasize that in an education system that lacks dimensions of equality and does not develop capabilities by providing freedom of learners such as freedom to participate freely, and does not tolerate female learners to develop their identities it is hard to achieve gender equality. These researchers propose that gender equity be practised through the curriculum in classrooms, laboratories, lecture rooms and workshops by schools and higher education institutions.

2.5 Safety and Security

Causes of gender inequality have been attributed to poverty, shortage of facilities and household chores done by girls, having to choose to pay fees for the boy child by parents and insecure learning environments in learning institutions. Research emphasizes the importance of safety and security for girls and young women in the community and in lecture rooms, laboratories and workshops, as well as the provision of safe accommodation (Global Campaign for Education 2005; and Randell & Gergel 2009). This stresses the fact that it is important to protect female students commuting especially late after evening lectures. Lack of accommodation on campuses and having to commute in higher education institutions has contributed to low enrolment in higher education just like in secondary schools. Negative and dangerous college environments in departments and campuses adversely affect female students and deprive them of valuable study time leading to gender inequalities.

3.0 Model for Addressing Gender Inequalities in Engineering Education

Addressing gender inequalities in engineering is now part of what society refers to as ‘institutional change” Rao and Keller 2014). This involves changing the unhidden and hidden practices towards engineering by addressing issues that contribute to gender inequality. These include access, gender policies, school curriculum and cultural norms and beliefs. In higher education changes insti tutions means adapting curriculum programmes, policies, structures and all the practices that discriminate against women.

Rao and Keller (2014) have suggested what needs to be changed are individuals’ access to resources, formal institutional policies, cultural norms and exclusionary practices and women’s and men’s consciousness as shown in Figure 1.
Sustainable change to engineering education reflects empowerment of individuals especially women, more access to resources by the disadvantaged female group, institutional change in all elements of the institution and making interventions in areas identified to be causing gender inequalities in institutions or departments in order to empower those who are not empowered. Change also means re-examining and diversifying the curriculum with regards to selection into engineering programmes to empower women, changing cultural norms and practices so that they are more inclusive as well as changing the mind set of women and men.

The paper also identified forces of social change that are interrelated and have prevented women from entering engineering education as political access, financial resources, disempowerment, engineering knowledge structures and cultural systems. For examples female students with high points from high schools, who qualify for engineering, prefer commercial subjects rather than engineering (National University of Science and Technology 2012). Rao and Keller (2014) suggested gender analysis by re-examining social accountability, formal and informal pressures and empowerment that may impact on female students’ not achieving success in engineering. They have proposed a diversified gender analysis by examining these forces as in Figure 2.
Figure 2: Evaluating Social Change Forces

Rao and Keller (2014) elaborate on the dynamics between top–down and the horizontal forces of change that impact on gender equality which may apply to engineering education. They say usually, there is discomforts in institutions of higher education if they have to deliver operational mandates and at the same time shift away from traditional practice in order accommodate women’s interests. Subrahmanian (2004) in Rao and Keller (2014) suggests analysing gains and failures of gender mainstreaming in order to capture tangible and intangible gender equality outcomes.

One critical change strategy on gender equality is institutional change of programmes which should focus on demand and supply of the equation of institutional change. On the supply side of the equation the program would address the shifting opportunity structures towards equality for women, like changing entry qualifications, capacity building at national, regional and continental level in order to respond to women. The demand side means strengthening women’s awareness on agency, voice mobilization and their influence on institutions to hold those responsible accountable (Rao and Keller 2014). The researchers further explain that institutional change is about policy adoption and gender mainstreaming. Aspects that prevent women from exercising their voice within the institutions include political access systems, which may not be active, accountability systems which are distantly placed from institutional change for gender equality, cultural systems in society at work outside the institutions.
which prevent women from fully participating in engineering and cognitive structures whose norms and values may be gender biased.

It comes as no surprise that most faculties and departments are led by men, who unknowingly or knowingly block gender equality in the interest of promoting quality (Rao and Keller 2014). As Acker (1990) in Rao and Keller (2014) point out that, most leaders are people who hold men’s values which tend to be maintained in faculties or departments and do not work towards gender equality but rather towards individual identity. In addition, the male leaders hold stereotypical attitudes about women. In this situation, there is need to generate power to change faculty and departmental leadership in higher education by breaking the web of internal politics, institutional culture, processes and introduce interventions.

Few men will devote resources to effective gender equality unless there is political pressure to do so. Where there are no women’s constituency to exert enough pressure for gender equality, change will not take place. Secondly, every day bargaining skills in use of power for access to resources is built on positions and assets of the male leaders (Rao and Keller 2014) who may hold keys on in conducting selection of students into engineering because they have the information, technical skills and material resources.

Institutional culture is about the collection of values and ways of doing things as the culture defines, what is valued. This is also what is important to teach in engineering program’s’ content because of its capacity to make things happen in the engineering subjects. As Felder and Brent (2005) reported that male and female students learn differently at the lower levels of knowledge acquisition but in the same way at higher levels. This suggests that in order to promote learning in engineering female and male students need to be treated differently when teaching them at lower levels of engineering programmes. Culture is powerful to make work on gender equality valued as part of the organization’s work. This may exclude consideration of women’s interests and needs. Organization’s processes turn the politics, culture and political pressure into action through program policies and service delivery whether there are enough resources or not. Resources and knowledge are the grease of organizations’ processes which may require gender analysis and strategy of gender related projects.

Program intervention is the fifth aspect of power. It is the area where politics, culture and process converge for service delivery or not in the teaching and learning of engineering. Gender equality challenges good practice, cultural norms and selection process for example by lower entry points and subject standards. However, organizations must transform for women’s empowerment and put gender equality on their everyday agenda by skilful and politically influential individuals. This also calls for the creation of enabling environments of women’ groups within organizations. This will make access, choice and resources available for gender equality (Rao and Keller 2014).

### 4.0 Implications for Gender Equity in Engineering

Literature indicates lack of empowerment of female students towards engineering. While higher education is encouraging inclusivity in engineering, the secondary school curriculum does not fully support or allow girls in using engineering tools and machinery. Secondly, the informal pressures that exist outside higher education institutions such as culture and traditional practice in the design and building industry do not recognize female civil engineers as site managers but only as workers. In this way, women engineers cannot be promoted to management positions and therefore will remain as ordinary workers.

A concerted effort by all stakeholders in the distribution of resources and empowerment of female students is paramount so that they can diversify their choices. A change in the mind set to expose female learners to a wide
range of engineering, design and technology schooling early in their education is necessary to encourage females to take up engineering careers.

5.0 Conclusion

In conclusion, in the political, economic and social environment, gender equality in engineering education needs different stakeholders to come together and build a firm foundation from the grass roots on knowledge concepts that are needed to encourage women into engineering. Transforming gender equality requires different institutions which include schools, society, teacher education colleges and higher education to work together on gender equality so that more women can be empowered to take up engineering careers and contribute to national development.

6.0 References


National University of Science and Technology (2012) Vice-Chancellor’s Annual Report Department of Information & Public Relations.


