Segregation by gender in technology and engineering education - in search of a one-size-fits-all solution

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ABSTRACT: Gender-specific debate is thought to have gained momentum at the time women faced a prehistoric loss of power. The end of matriarchy - *rule of the mother* - weakened the recognition of women's role in the society to the extent that a woman's role was thought only to be to bear and rear children. In regaining their position in society through the feminist movement, the fight for gender equality has been, in some cases, radicalised to the point of creating an anti-male environment, especially when the traditionally male-dominant field was under scrutiny. Clearly, women are under-represented in the engineering and technology profession, as well as its research and education. It is acknowledged that the discussion is polarised and therefore does not aim to identify which sex has better abilities or a *best-fit* within the engineering and technology field. Instead, this paper attempts to look at the bigger picture and, while recognising the gender-specific differences, capitalises on them for the benefit of everyone, irrespective of their sex.

INTRODUCTION

Gender factors are a topic of heated debate - especially with regard to engineering and technology education. According to the present situation in tertiary education, women are usually under-represented in engineering and technology. The situation is even worse when it comes to the number of women who actually work within the engineering and technology profession. In this professional field, gender segregation is distinctive not only vertically (indicating the clustering of men on the top of occupational hierarchy) but also horizontally (showing male dominance at the same occupational level). According to data recently presented by Engineers Australia, *women engineers currently represent less than 7% of the engineering workforce in Australia - one of the lowest participation rates of women across all professions* [1].

There is growing worldwide interest in gender-specific matters. Research is being carried out so as to identify and develop efficient practices for attracting, recruiting and retaining women in studying engineering and technology education. As well, investigation is underway in analysing the causes of employment segregation for men and women in the labour market; this to develop and implement specific policies for improving the situation. There are various funds, scholarships and grants that facilitate and inspire participation of women in projects, which relate to engineering and technology education, practice and research. It has to be acknowledged that the former UNESCO International Centre for Engineering Education (UICEE), based at Monash University, Melbourne, Australia, was at the forefront of addressing this problem by establishing a *Women in Engineering Education Scholarship* scheme that enabled and supported engagement of women in engineering and technology research.

There are various campaigns and initiatives aiming at identifying and eliminating factors that cause the under-representation of women in engineering and technology. For example, in 2003 the French Research Ministry endorsed an agreement called *Mission for Gender Parity* [2]; Engineers Australia announced 2007 as the *Year of Women in Engineering* [1]; and there are other current and upcoming activities and events that reflect growing concerns about gender and women in engineering worldwide.

However, the popularity of this topic is based on women's movements back in the early 20th Century. Many societies were established by women engineers for women engineers. While the establishment of some societies dates back to the late 1910s and the 1990s, for example, the British *Women's Engineering Society* (1919), Swedish *Society of Women Engineers* (1950), American *Committee on Women in Science, Engineering and Medicine* (1990), their work and contribution to helping women reach their full potential in engineering and technological fields became distinctive and widely recognised only recently.

Many matters need to be resolved in order to change the image of women in engineering and technology. There is still a strong stereotype that women do not fit in the engineering and technology profession. Harvard President Lawrence

Summers once suggested that women are innately less qualified than men to succeed in mathematics and science careers. This remark has fanned the flames on women's capabilities - *whether they have the right stuff to succeed - not only in grey matter, but also in ambition, stamina and priorities* [3].

GENDER MATTERS

For centuries, the gender debate has challenged women's capacity for success. Men and women are different. These differences are in strength, endurance, perception, reactions, etc. After all, they are influenced by different hormones, and not necessarily to the disadvantage of women. For example, *oestrogen*, a female hormone produced by ovaries, *is proved to be a critical hormone in ensuring proper brain function* [4]. But it does not suggest that the male brain functions improperly. It was discovered that *an enzyme divides the sex hormone* testosterone *into its components, one of which is oestrogen, to assist men with healthy brain function* [4]. Hence, there is no doubt that male and female are equal in terms of brain capacity and function. The only difference is that something, which is a part of female nature, would require additional processing in the male body. Using brain scan technology, which produces the neuro-images of brain activity, Ruben Gur and others have noticed that *in the resting female brain, we find just as much neural activity as in the male brain that is solving problems* [5].

Gur has also asserted *we are still the same animals. We haven't changed physically since we were roaming the savannahs. We haven't really changed in our brain. So, all those differences that we were evolved into are still here* [6]. Hence, there are gender-specific mental representational systems that clearly identify and reveal behavioural differences in men and women. For example, McGuinness and Pribram have discovered that men have better daylight vision than women [7]. They also have faster reaction time from mid-childhood on; even as infants, they tend to be more interested in objects than in people and they are more skilled at gross motor movements. Men excel in a wide range of skills involving the perception of depth in space, an ability which gives them an edge in mechanical tasks. Women, however, have more sensitive taste and they are more sensitive to touch, have better hearing, are less tolerant of loud volumes or repetitive sounds, and have better night vision than men. From infancy on, women excel in many verbal skills, are better in *manual dexterity* and fine co-ordination, and process information faster, particularly in tasks that require rapid choices. Women are less distracted by sights while listening, more accurately perceive *subliminal* messages, and are better at remembering the names and faces of people with whom they were in contact [7].

In other words, men and women are different in the way they perceive and process information. There is a strong gender difference in preference for visual or verbal mental processing style, and it also depends on the neurobiological differences between males and females. Gur has noticed that in spite of men's brain size, which can be 10-15% larger than women's, the latter *have more fibres that connect the two sides of the brain together in an area called the corpus callosum. That would mean that there is more tissue available for transferring information between the two sides of the brain. That's why we think women have better inter-hemispheric communication* [6]. This neurobiological feature is suggested as the reason why women predominantly use a verbal mode of processing information, while men utilise a visual mode.

Recent research by McGuinness revealed that on average girls learn coherent speech as much as a year before an average boy [8]. It was also found that in reading and writing girls have a lifelong advantage in fluency. Girls have better hearing skills from birth than boys and tend to read and spell by sound, while boys are more likely to rely on sight [8]. Surprisingly, despite obvious communicative advantages, women's language is considered weak, subordinate, tentative and trivial. Lankoff has argued that women have a different way of speaking from men - a way of speaking that both reflects and produces a subordinate position in society [9]. This language, according to Lankoff, disqualifies women from positions of power and authority. Moreover, *language itself becomes a tool of oppression - it is learned as part of learning to be a woman, imposed on women by societal norms, and in turn it keeps women in their place* [9].

Researchers in the gender and language field have identified the differences between men's and women's speech and their use of language:

- Women use more precise colour descriptors and discriminate more accurately between different shades of the same colour. They use words such as *beige, ecru, aquamarine* or *lavender*, which are largely absent in the language of men.
- Women tend to avoid speaking in a way that conveys strong emotions and generally use *weaker* expletives than men, *Oh dear!* as opposed to *Damn it!*
- Women use the so-called *empty* adjectives to convey their opinion on matters, for example, *adorable, sweet, divine, charming, lovely*, etc.
- At the syntactic level women use more tag questions, for example: *The film was interesting, wasn't it?*
- Women also use so-called hedges, which signal uncertainty: *sort of, you know, kinda*. This makes women's language sound less assertive than men's.
- Women's speech, in general, is characterised by correct grammar and polite forms, for example: *I will not* instead of *ain't*.
- Women are more often using rising intonation even in statements, especially when responding to questions, which makes their speech appear insecure and uncertain [9-11].

It is important to know the factors that segregate genders and capitalise on the differences. For example, the results of the above-mentioned research that identifies weak characteristics of women's speech should be used for planning communication training for engineering and technology students in such a way that will change the use of language and language behaviour to the advantage of women. Acknowledgement of gender differences and bringing it to students' attention should not only help female students in engineering and technology develop other speech habits that will make their language straightforward and powerful, but also teach male students how to interpret women's language characteristics. This is especially significant because the engineering and technology field is male-dominant.

There are various theories associated with the deficit in language framework, which will be *particularly influential in the development of assertiveness training* and *other forms of* language remediation *that are intended to make women become more effective communicators, and to speak more like men* [12][13]. It is about time that these theories were put into practice in engineering and technology education. Developing engineering and technology programmes should be based on gender-inclusive principles.

CLOSING THE GENDER DIVIDE

It can be assumed that generally education is male-orientated because it was the utmost privilege of men. While women's role was to bear and rear children, men were benefiting from education and developing their skills for bread-winning. Early education was mainly run by men for men. The time has changed but certain features of previous establishments remain, especially in engineering and technology education. Enough said by the number of lecturers represented by women as opposed to men at engineering and technology courses.

Nevertheless, not everything is based on organisational structure or attitudes; it was also identified that men and women have distinctive variations in their learning style. Some still fall into the trap of differentiating between gender mental capacities. There is an emotional debate concerning the gender gap in some disciplines, especially in science and mathematics. Glazer has noted that this debate is fuelled by issues regarding *innate differences* between sexes, as well as theories that claimed women were biologically incapable of reason [14].

Is it truly about biology or predominantly about the differences in learning style? A large body of literature provides a comprehensive review of gender-specific learning styles:

- Males prefer rational evaluation and logic [15].
- Males tend to be more achievement-orientated [16].
- Females are more likely to use *elaborative* processing, in which they tend to seek personal relevance or individual connections with the material being taught [15].
- Females are also more socially and performance- orientated [16].

In addition, females believe social interaction with other students and self-confidence are very important for successful learning and rank them higher than do males [17]. As well, males are likely to attribute their success in the classroom to external causes, such as teaching, whereas females generally see their success as directly related to their efforts in the classroom [18].

A learning style is defined as individual characteristic ways of processing information, as well as feeling and behaving in learning situations. James and Gardner have asserted that *learning style preferences are the manner in which, and the conditions under which, learners most efficiently and effectively perceive, process, store, and recall what they are attempting to learn* [19].

It is obvious that identifying the learning style preferences within a group of heterogeneous students can help an instructor to address this diversity by implementing appropriate teaching and learning approaches and techniques. Various methods are available for assessing learning style variances. In 1976, for example, Kolb developed a Learning Style Inventory (LSI) to describe the ways people learn and how they deal with ideas and situations [20]. This method helps to identify four basic learning styles, such as *Accommodator*, *Diverger*, *Converger* and *Assimilator* [20]. Kolb has characterised these learning styles as follows:

- *Accommodators* are best at learning from *hands-on* experience (doing and feeling).
- *Divergers* excel in using imagination and brainstorming, combining concrete experience and reflective observation (feeling and watching).
- *Convergers'* dominant learning abilities are focused on finding practical uses for ideas and theories (doing and thinking).
- *Assimilators* are most adept at logically organising and analysing information, building and testing theories, and designing experiments [20].

Another common and popular method, used to identify variances of learning style, is based on sensory modality, which students utilise when learning. The method expands upon earlier Neuro-Linguistic Programming (NLP) models

characterising preferred methods of dealing with information, such as visual (V), aural (A), reading-writing (R) and kinaesthetic (K), collectively known as Fleming's VARK model [21].

The VARK questionnaire is available on-line for free at www.vark-learn.com and it offers 16 statements that describe a situation asking a respondent to pick one or more actions that he/she would take out of four suggested. Each action corresponds with a VARK learning style preference. The total of all four scores ranges from 16 to 64, which identifies individual learning style preferences for utilising one, two, three or all four of the learning channels. This test is easy to take; it is anonymous, does not require a lot of time to complete and the result is calculated automatically.

Fleming has found that about 43% of the population, who have completed the questionnaire on-line, have single style preferences, 27% two preferences, 9% three and 21% have a preference for all four styles [21]. It can be concluded that almost half of the participants utilise only one style for learning. Hence, identifying the specific learning style is a great discovery both for the students and for the educators. It helps to work out that individually customised approach to cementing knowledge and developing skills in what could be an almost effortless way.

Fleming goes as far as identifying activities that correspond with preferable learning styles, which are presented in Table 1 [21].

Table 1: Activities that accommodate VARK learning styles [21].

Visual	Aural	Read/Write	Kinaesthetic
Diagrams	Debates, arguments	Books, texts	Real-life examples
Graphs	Discussions	Handouts	Examples
Colours	Conversations	Reading	Industry leaders (lecturers)
Charts	Audio tapes	Written feedback	Demonstrations
Written texts	Video+audio	Note taking	Physical activity
Different fonts	Seminars	Essays	Constructing
Spatial arrangement	Music	Multiple choice	Role play
Designs	Drama	Bibliographies	Working models

Different combinations of learning activities or modification of teaching instructions and tasks, according to the preferred learning styles of the group, can help students learn best. For example, if a group is predominantly kinaesthetic learners they would best benefit from the inclusion of simulations, role-playing and hands-on activities. For the visual type of learner, the greatest advantage is when the learning is supported by diagrams, schemes, drawings, etc. It works the other way around if a student knows that his/her preferred learning style is visual, then while listening to the lecture he/she could take notes with the elements of visual presentation of information creating a lecture diagram.

It is suggested that utilising the VARK questionnaire at the introductory stage of an engineering or technology course may assist not only the educators in finding ways to improve instructions, but also the learners in enriching their learning experiences. The results of the VARK questionnaire can help students to be aware of their learning style preferences so that they can adjust studying techniques, even when the instruction does not exactly match their preferred style.

In addition, information concerning the dominant learning styles in the group of students is especially valuable for educators because they can choose those teaching approaches and techniques that will meet the learning style preferences of the group. This will help to improve the quality of learning outcomes that the students will achieve by the end of a course, as well as increase students' motivation through their rewarding learning experiences.

CONCLUSIONS

There is an opinion, voiced by Belenky and others, that *conceptions of knowledge and truth that are accepted and articulated today have been shaped throughout history by the male-dominated majority culture* [22]. This implies education is not designed for women. This also suggests most traditional educational curricula and pedagogical standards are based on male bias. Belenky and others have also asserted that *developmental theory has established men's experience and competence as a baseline against which both men's and women's development is then judged, often to the detriment or misreading of women* [22].

Without going to such an extreme, gender factors certainly need to be taken into account for the development of gender-inclusive curriculum and its realisation throughout programmes and courses, especially in engineering and technology education, where male students are in the majority. Therefore, it is important to acknowledge the following gender characteristics:

- Males and females have neurobiological differences, which should not put women's capacities in doubt. On the contrary, women's brain activity exceeds men's due to the influence of oestrogen, which is predominantly a female sex hormone.

- Human mental representational systems are gender-specific, presumably because of the difference in lifestyle and responsibilities that the ancestors had.
- Women are naturally better communicators but their language is generally weak and subordinate because of the way they use language and because of their speech habits, which can be improved if addressed properly.
- Male and female students are significantly different in their learning style preferences, which needs to be recognised in order to tailor a teaching and learning environment.

It is suggested that gender factors are not adequately addressed in the traditional settings of engineering and technology education, which only promote separation of genders in the learning process. Unfortunately, traditional engineering and technology education mostly help males to find congruence between long-established teaching instructions and their learning styles, thus creating an uncomfortable and hostile learning environment for female students.

Hence, rather than trying to make female students adapt to male types of behaviour and learning styles, it is necessary to create an environment that is inclusive of women by utilising the methods and techniques of teaching that will help them to blend into the education process. Moreover, the assertiveness of utilised teaching approaches and techniques will be beneficial for both genders, as they will be provided with the opportunity to learn from each other and, hopefully, discover the means to overcome barriers in communication and break gender stereotypes in the future.

There may be multiple challenges in seeking to understand how to make engineering and technology education become women-friendly. There is a notion that women are under-represented in the engineering and technology profession because traditionally education is congruent to male learning styles and, hence, is insufficient for female students. Therefore, there is a vast field for research in tailoring teaching and learning activities to fit mixed gender groups and assist in enhancing intended learning outcomes.

In other words, gender factors should not be missing when developing courses for heterogeneous but male-dominant groups of engineering and technology students on the basis of gender-inclusive educational programmes. Furthermore, an instructor should be held accountable for the implementation of such approaches and techniques that will encourage and educate women on how to be leaders in their chosen fields of study and professional involvement. In addition, making engineering and technology education more *female-friendly* may also help to attract more women into this profession, which is a task that is lately so rigorously pursued by many societies and initiatives.

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