GENDER DIFFERENCES IN ENGINEERING STUDETNS’ CHOICE OF STUDIES

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ABSTRACT

The Science, Technology, Engineering and Mathematics (STEM) sector is gender biased throughout, in schools, workplaces and academia. The development for gender equality is slow and stereotypes are still male dominated in STEM. The situation is complicated with many influencing factors that have been studied and dealt with for the last decades. To decide what education or training to achieve is among the most important decision in young peoples´ lives. The trend is that more males go for STEM studies while females go for subjects like education, health sciences and social sciences. It is important for engineering as a profession not only to attract both genders, but also to get a better understanding of the influencing factors when young persons are deciding what subject to select for their life. This paper presents an overview of the findings from a study focusing on gender differences in engineering students’ choice of studies and discusses some ideas of what educators can do to change the situation. This topic touches on CDIO Standard 1 (program philosophy), 7 and 8 (new methods of teaching and learning).

KEYWORDS

STEM, Gender differences, Choice of studies, CDIO Standards: 1, 7, 8

INTRODUCTION

The fact that females are underrepresented in Science, Technology, Engineering and Mathematics (STEM) is problematic for society as well as for girls and women, giving them fewer opportunities for career and professional development and good salaries. For a society in need of more STEM skilled labour, to miss out almost half of the young population is a drawback. It is important to develop our understanding of of this gender inequality and get a better overview of what options there are to reduce the lack of interest in STEM studies and career choices among females.

The purpose of this study was to obtain more information on gender differences among engineering students’ choice of studies, the most influencing factor and explore if there was a gender difference their computer use in education and computer skills before they entered the engineering studies. It is of interest to know the attitudes and gender differences among those who have already decided to study engineering and applied engineering. This information could guide us in the effort to recruit not only more females in engineering and applied engineering, but also more students into STEM subjects in general.

LITTERATURE REVIEW

To decide what study line to choose at university can be difficult for young persons. Many factors affect their decisions, e.g. social environmental influences, individuals' goals and interest, stereotypes, role models and media. STEM subjects have been male dominated over the years, while females go into subjects like health sciences (nursing and psychology), social sciences, and education. The situation has slowly improved and females are now better represented in some STEM fields, e.g. the medical and biology fields, but not in others, e.g. computer science and engineering. Many studies have been conducted in the field of gender bias in education, especially in STEM, to come forward with solutions. Thus, females' underrepresentation in STEM is well documented, many advices, models and guidelines have been designed, and projects carried out in order to improve the situation. Despite that, females are still underrepresented in STEM (Ashcraft, Eger, & Friend, 2012; Stoeger, Duan, Schirner, Greindl, & Ziegler, 2013; Liben & Coyle, 2014; Cheryan, Master, & Meltzoff, 2015; Matthiasdottir & Palsdottir, 2016; Funke, Berges, & Hubwieser, 2016).

There are many influencing factors when it comes to academic and career choices as personal perception and beliefs, with roots in people's personal experiences that are influenced by others, and the social environment. Achievement disparities between females and males are sometimes used to explain why women are underrepresented in STEM, but as females' achievements have improved, this is no longer a satisfactory explanation of gender inequalities in STEM participation. Interest was earlier considered a critical factor for educational choices (Benbow & Minor, 1986; Lapan, Shaughnessy, & Boggs, 1996; Su, Rounds, & Armstrong, 2009; van Tuijl & van der Molen, 2016), but a number of factors seem to shape peoples' interest, such as family, friends, school, and media and in fact societies' cultures as well (Eccles et al., 1993). Motivation, which is another factor that is considered to shape interest, has been shown to be strongly related to academic and career aspirations (Robnett & Leaper, 2013). Ability beliefs and giftedness have also been used to explain gender-related participation in STEM. Despite all this, researchers' focus is now no longer solely on personality traits (Stoeger et al., 2013) as gender different participation in STEM is a complex problem with many angles and with roots even in early childhood (van Tuijl & van der Molen, 2016).

There are studies into the influence of parents' expectations and social values, which are believed to explain to some extent why women do not enter STEM studies or leave the field for other more interesting jobs or studies (Preston, 1994). Educational opportunities and occupational choices have been discussed (Hänze & Berger, 2007) and technology self-efficacy and digital skills, which can influence educational choices. Studies have shown that students' STEM self-efficacy beliefs are important when they decide to take on further studies in STEM (Jansen, Scherer, & Schroeders, 2015; Brown, Concannon, Marx, Donaldson, & Black, 2016) and males report higher technology self-efficacy than females (Rohatgi, Scherer, & Hatlevik, 2016). The self-efficacy theory comes from Bandura and emphasises the influence of mastery of experience and vicarious learning experiences (Brown et al., 2016). In addition, access and use of computers in education influences and supports better academic performances, although some studies have demonstrates that this is not the situation in all areas (Paino & Renzulli, 2013).

More influencing factors shape students opinions and interests. The teacher's role is important and their teaching practice affects students' academic self-concepts, but the perceived quality of teaching in mathematics is not in favour of females (Lazarides & Ittel, 2012). Instruction methods are important because they influence students' self-concept. Cooperative instructions are more beneficial than direct instruction for students with low academic self-concept, because it makes them feel more competent (Hänze & Berger, 2007). This shows the importance of positive learning experience to build good STEM self-efficacy among not only females, but also males, to make them more interested in their studies.

In a report from the National Centre for Women in Science and Technology (NCWIT, http://www.ncwit.org), four areas are suggested as important in order to change gender imbalance in computer science: influence of education, students' environment, equalization, the media and the culture (Ashcraft et al., 2012). These areas can easily be applied to STEM.

The first area suggested in the NCWIT report is the role and influence of education, with reference to the influence of teaching and learning, which in STEM subjects is rarely specifically connected to the interests of females. The learning environment in STEM subjects is therefore not particularly encouraging for females. Research has shown the importance of linking study materials to the interests and experiences of students, as well as using active teaching methods that encourage collaboration. Research also suggests, that within technical fields, these methods are not used to the same extent as in many other fields (Ashcraft et al., 2012). It is important to explore teaching methods and see whether they can be changed to attract more students, not just women, but also men who could gain from different teaching methods. In this context, it is worrying that teachers often lack appropriate education in STEM (Ashcraft et al., 2012). Introduction to STEM and what opportunities are available for students after graduation can always be improved, using new media that young people are familiar with, both in primary and secondary schools.

Secondly, the effects of students' environment, the family, the community and the role models are emphasised in the NCWIT report. Females and males often encounter different behaviours and motivation that leads to different experiences early in life. The most important factors in decision-making about learning and career involve females' environment, parents, friends, teachers and the media. When STEM is not part of a positive impression the influence will affect the decision and guide them away from considering careers in STEM (Ashcraft et al., 2012).

It can be argued that women's attitudes within in the profession are important and numerous studies have shown that good models have a positive effect. One way is to get women, who have reached far in this area, to visit schools to show where education in STEM has led them. It is important to get more females to choose STEM in order to have good female models in the field and introduce these role models to younger women earlier in school. (Ashcraft et al., 2012).

Masculinity and gender roles are still strong predictors when it comes to technology self-efficacy (Huffman, Whetten, & Huffman, 2013). Women who are studying STEM subjects have overcome many barriers in their environment and may be less receptive to influence from a stereotypic environment, although Ertl, Luttenberger and Paechter (2017) concluded from their research that even this group is sensitive for stereotypic influence. Schuster and Martiny's (2017) research showed that women anticipate negative feelings in more stereotypical contexts than young men. Creating less stereotypic STEM environment could thus nurture more positive affect among females.

Thirdly, the NCWIT report refers to the influence of equalization, because it can be difficult to be the only female in the group and experiencing the masculine culture one does not belong too (Ashcraft et al., 2012). Cheryan et al. (2017) emphasize how masculine cultures in the

STEM field can build up feelings of not belonging for women, but an early experience of STEM could change the masculine culture, stereotypes and role models. STEM fields have very different cultures (Cheryan et al., 2017) which raises the question of culture in technology, engineering, and mathematics, where women are underrepresented. Students have different educational experiences early on in school, and subjects like math and biology have been a part of the curriculum, but subjects like programming and even physics come later on or even not at all. Research has shown that gender differences in mathematics and other STEM subjects decreases in high school (Sadler, Sonnert, Hazari, & Tai, 2012), which gives opportunity to revise teaching methods and material. This does also support the opinion that introducing all STEM subjects earlier in kids' education influences positive attitudes and that programming should in fact be a compulsory subject at the lower school levels. This could establish a stronger feeling of belonging not only in computer science programs, but also in other STEM subjects where programming is now a part of the curriculum.

Fourthly, the effects of media and culture (Ashcraft et al., 2012). People in computer science, engineering, and physics are frequently shown as more socially awkward males in the media than in other STEM subjects as biology and chemistry. Typical examples are the characters in TV series like "The Big Bang Theory". We all laugh at them. These stereotypes serve as gatekeepers that can push women away from certain subjects and may limit their learning opportunities and career chances. Advertisements can also promote stereotypes, not only the pictures but also the wording that is often masculine, as it splits the world up in a way that is more accepted for men than for women. For some, these nerdy models are appealing, but for others they are not at all appealing. Video games are believed to have had a major impact on the negative trend for STEM, as they were at fist mainly addressed to boys, although now there are more games for girls and hopefully with positive influences.

Some young people, especially men, can like the nerdy male types, but as STEM is also for women we need to make sure that stereotype of engineering is appealing for both male and female. To broaden the STEM image we can use curriculum, role models, STEM environments and the media (Cheryan, Master, & Meltzoff, 2015; Cheryan, Zieger, Montoya, & Jiang, 2017). Both men and women must have a sense of belonging in STEM, but they do not all respond the same way to the stereotypes. Today's stereotypes can attract and scare off both genders, but we need to diversify current stereotypes so that all students believe they fit to the image to be successful in STEM (Cheryan et al., 2017).

The main aim of this study was to see if there were gender differences in students' motives for choosing to study engineering in a sample of engineering and applied engineering students. Secondary aim was to investigate if there were 1) gender differences in computer use in education prior to university, and 2) self-reported computer skills among the students.

METHOD

Participants

An online survey was sent to 554 students in engineering and applied engineering at Reykjavik University. In total 271 (49%) answered, 193 (71%) engineering students and 77 (29%) applied engineering students, 173 (64%) male and 98 (36%) female. The BSc engineering program is a 3-year or 6 semester's program and applied engineering is a 3.5 years or 7-semester program. Most of the participants, or 213 (78%), were in semester 1-6, 34 (13%) had spent more than 6 semesters on their study and 24 (9%) were master students. The participants' average age was 24.7 years, ranging between 19 and 44 years.

Measures
The online survey, consisting of eleven questions, was designed for the purpose of the study. Four background questions identifying the participant's gender, age, line of study and semester and seven questions concerning the participant's experience with computers and choice of line of study. The seven questions were the following:

- Two questions about the participants computer use in elementary and upper secondary school: "How did you primarily use computers in primary school?" and "How did you use computers in upper secondary school?". Each question had five answering possibilities: "For studying", "Playing computer games", "For programming", "Working with hardware", and "Something else". The participant could select one answer.
- One question about the participants' computer skills before they entered university: "How much computer skills do you consider you had before you started your study?" This question was rated on a five point Likert scale, ranging between "Very good" and "Very little". The term computer skills was not defined in the questionnaire and the participant could select one answer.
- One question about the reasons for choosing the present line of study: "Why did you chose your line of study?". Ten answering options were given and the participant was instructed to select the three most relevant for him/her. The participant could select three answers without categorise them.
- One question about the age of the participant when he/she got interested in his/her present line of study at university: "When did you first get interested in your subject?", with the possibility of choosing four age categories, younger than 14, 15-18, 19-22 and older than 22.
- One question asked if the participant had considered choosing another line of study at university: "Did you consider to choose another subject?". This question was rated with "Yes" or "No", and If yes, then what line of study?

Procedure
The survey was put online in the system Free Online Surveys (https://freeonlinesurveys.com). A link was sent to the participant by e-mail on the 2th November 2017 and reminders on the 15th November and the 30th of November. The survey was closed on the 11th January 2018. Data analysis was carried out in Excel and the Statistical Package for the Social Sciences (SPSS).

RESULTS

Table 1 describes the participants' reasons for choosing their present line of study, i.e. engineering and applied engineering. Of the ten options given, five differed between the males and the females. More males than females chose because they considered engineering and applied engineering interesting professions and they were interested in computers. On the other hand, more females than males mentioned interest in math and science, that they did well in science in upper secondary school and that they just wanted to try.

Table 1. The participants' reason for selecting engineering and applied engineering, according to gender.

	Male	Female	
	Yes N (%)	Yes N (%)	Chi-square

Interesting profession	108 (62.4)	37 (37.8)	15.31***
Good employment outlook	84 (48.6)	47 (48.0)	0.01
Good salary	82 (47.4)	45 (45.9)	0.05
Interested in math and science	51 (29.5)	54 (55.1)	17.30 ***
Interested in computers	25 (14.5)	1 (1.0)	13.01***
Did well in science in upper secondary school	30 (17.3)	36 (36.7)	12.77***
I just wanted to try	11 (6.4)	18 (18.4)	9.44 ***
Diversified profession	40 (23.1)	20 (20.4)	0.27
It has never been anything else	11 (6.4)	4 (4.1)	0.62
I was encouraged by others	13 (7.5)	6 (6.1)	0.19

*** p<0.001

When the participants were asked if they had considered selecting another profession than engineering or applied engineering, 98 (57%) males and 63 (64%) females said yes. Twenty-seven said they had considered business, 13 males and 14 females, 23 medicine, 10 males and 13 females, 9 computer science, all males, five physics, all males and five psychology, all of them female. Nine males also mentioned geology (2), law (2), mathematic (1), sports science (1), history (1), architecture (1), chemistry (1), literature (1) and aeronautics (1). The females mentioned also mathematic (5), nursing (2), pharmacy (2), art (2), music (1), architecture (1), molecular biology (1) and nutrition (1).

Table 2 shows that most participants got interested in their field of study when they were between 15 and 22 years old. Of interest is though, that more of the males claimed they developed their interest when they were teenagers and after 22 years of age (13 and 23 per cent, respectively), than the females (6 and 13 per cent, respectively). More females than males reported that they got interested when they were between 15-22 years old, or 81% versus 64% of the males.

Table 1. Age when participants got interested in their field of study.

	Males N (%)	Females N (%)	Total N (%)
14 years and younger	23 (13)	6 (6)	29 (11)
15-18 years old	52 (30)	41 (42)	93 (34)
19-22 years old	59 (34)	38 (39)	97 (36)
22 years and older	39 (23)	13 (13)	52 (19)
	173 (64)	98 (36)	271 (100)
	Chi-square 8.725*		

*p<0.05

Table 3 shows the difference between the genders in computer use in compulsory and upper secondary education. Males reported significantly more often having used computers for playing computer games in compulsory education, but girls for studying. Only two participants reported having used computers for programming, one male and one female and only three participants, all males, claimed having worked with hardware. Table 3 shows that the pattern is the same in upper secondary schools, males playing computer games and females are using computers for studying. Only one male participant reported having used computers for programming in upper secondary education, and five participants, four males and one female, claimed having worked with hardware.

Table 3 Participants' primarily use of computers in compulsory- and upper secondary education.

	Compulsory education		Upper secondary education	
	Males N (%)	Females N (%)	Males N (%)	Females N (%)
For studying	30 (19.4)	34 (40.0)	87 (56.1)	91 (96.8)
Play computer games	125 (80.6)	51 (60.0)	68 (43.9)	3 (3.2)
Chi-square	11.965***		45.504***	

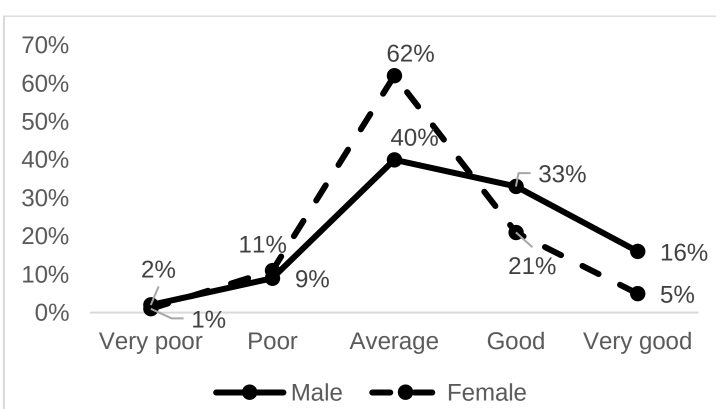
***p<.001

Twenty-eight participants, 15 males and 13 females, reported using computers in compulsory education for something else than was asked about. Ten of the male participants claimed they had not at all used computers in compulsory education, two claimed they used computers to learn keyboarding, two said they used computers to watch TV series, and one for surfing on the Internet. Four of the female participants reported no computer use in compulsory education, two claimed they used computers for social networking, two for MSN, and five claimed they used computers for making music, learning word processing and watching TV series.

Eleven participants, 8 males and 3 females, reported using computers in upper secondary school for something else than was asked about. Two males claimed they did not use computers at all, one said he hardly used computers and five reported programming, social media, watching TV series, and writing reports. The three females all claimed they used computers in upper secondary education for social media.

Figure 1 shows that 49% (83) of the males and 26% (26) of the females considered their computer skills to be good or very good when they started their current study at university. Independent samples T-test showed significant difference between the genders on this variable, males scoring 2.5 (SD=0.9) and females 2.8 (SD=0.8) (t-value 2.952, p<0.01).

Figure 1 The participants' computer skills before they started studying engineering and applied engineering at university



DISCUSSION

The main research question in the present study was: *Is there a gender difference in students' motive for choosing to study engineering?.* About half of the participants claimed that good employment opportunities and good salaries were the two main reasons, but gender differences were apparent. The male participants reported an interesting profession, but the female participants claimed it was because of their interest in mathematics and science that they choose engineering. More female participants also claimed that doing well in science in upper secondary school was a reason for they choice of study.

These findings are not in line with previous studies, where females are not considered to have much interest in STEM subjects, e.g. because of lack of interest in math and science although they are doing well in these subjects. Anyhow, Ertl, Luttenberger, & Paechter (2017) have pointed out that females in STEM subjects have overcome many barriers like negative stereotypes and might mostly be driven by their interest in math, science and computers. This implies that in order to get more females into STEM studies we need to foster their interest in those fields especially in high school (Sadler et al., 2012). With reference to the literature, we need to develop stereotypes that are more positive, change the teaching methods and the learning environment and introduce more STEM subjects earlier in schools.

Although few participants said that they choose engineering just because they wanted to try it, the gender difference is surprising, why do more females give that reason than males? Was it because they perceived engineering as a male subject or because or are they more for trying something new? This has to be studied further.

Interestingly, the findings revealed gender differences when students developed interest in their field of study, e.g. engineering or applied engineering. Most students claimed they got interested in engineering between 15 and 22 years old, especially the female participants. This wakes the question at what age it would be realistic to introduce engineering as a subject to female students and if it should be different from the male students. Although there are many other influencing factors to bear in mind when finding the right age to introduce a subject to students it is of importance to consider which is the best age and it could be useful to probe this finding further.

It is also of interest how late students get interested in their field of study and how many of them have considered other profession as business and medicine. Part of this can be described by how late students go to university in Iceland, as the normal age for finishing the matriculation exam has been 20 years of age (the study has now been shortened by a year).

Two other research questions were: *Is there a gender difference in computer use in education prior to university?* and *Is there a gender difference in self-reported computer skills among engineering students?* This study shows a marked gender different in self-reported computer use and computer skills, both in compulsory and upper secondary school education, or before the participants started their current studies. The male participants used computers mainly for playing games and the female participants for studying. In addition, the male participants reported better computer skills than the females and there was a gender difference when they claimed interested in computers to be the main reason for choosing engineering study. This is in line with the literature. How these gender differences influence students' carrier choices is not clear from this study, but as Paino & Renzulli (2013) point out, use of computers in education can impact academic performances and thus may support better technology self-efficacy among students.

CONCLUSIONS

This study indicates a gender difference in the reason for choosing to study engineering where females reported more frequently being interested in math and science and how well they did in science in upper secondary school as the main influencing factor. It also indicates that females decide older alter what subject to study at university. This could guide us in trying to attract students to engineering studies by foster female interest in STEM at an early age and introduce engineering to them.

It is important for both young men and women to realize that they do not have to conform to a certain type or personality characteristic to learn a particular subject; you do not have to be a nerd to study STEM. We have to make sure that that the schools and workplaces do not support stereotypes that scare off either gender. When it comes to other influencing factors as family, community and role models, media and culture, we come to the influence of society as whole, the cultural environment. The media and the entertaining industry plays a big role in young person's life today through smart phones and other smart equipment and there is an opportunity to change the stereotypes.

The CDIO Standard 1 (program philosophy) shows the importance of the cultural framework and environment for engineering education. The literature emphasises that the learning environment should avoid negative stereotypes of STEM subjects, which wakes the question if this topic should be added into the Standard 1. The CDIO Standards 7 and 8 (Integrated Learning Experiences and Active Learning) emphasise the importance of active teaching and learning and use of miscellaneous teaching methods. The literature points out that different teaching method may apply differently to males and females and this again wakes the question whether this topic should be added into the CDIO standards to emphasize that we need to ensure that engineering education is attractive for both genders.

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