Gender Differences in Student Satisfaction Surveys

GENDER DIFFERENCES IN STUDENT SATISFACTION SURVEYS

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ABSTRACT

Engineering programs around the world strive to increase gender balance among their students and endeavor to encourage higher female enrollment. This paper aims to investigate and understand how current engineering students perceive their courses in terms of sufficient prior knowledge and overall general impression and if there are statistically significant differences among male and female students. The discussion on possible reasons for trends in responses will assist in taking actions to accommodate both genders.The study is carried out at the Chalmers University of Technology and focuses on courses in its Mechanical, Automation, and Industrial Design Engineering programs. This study is a continuation of previous work on variations of student satisfaction between CDIO project courses and “traditional” courses (Malmqvist et al. 2018) with the addition of an analysis of gender aspects. The present study will use the same methodology, namely a mixed methods approach and investigate both closed-form questionnaire responses and free text answers in course surveys. Quantitative methods for comparing means of survey questions and qualitative analyses of free text answers for selected courses are chosen to shed light on patterns of different gender’s perceptions. Aspects of different course characteristics such as traditional, lecture-based vs. project-based and theoretical vs. applied are considered.The results demonstrate that statistically significant differences exist in how male and female students perceive some of their courses and how involved they are in answering course surveys, with this difference being more substantial at bachelor’s level than at master’s level. Possible reasons on why those differences exist and what measures, if any, should be taken to close the gap are discussed.

KEYWORDS

Student Satisfaction, Gender Studies, Standards: 4, 5, 10, 12

INTRODUCTION

Female student underrepresentation in engineering related programs constitutes an issue for universities and policy-makers, who try to achieve a higher balance between male and female students. Marginson, Tytler, Freeman, and Roberts (2013) identify in their report the benefits of increased participation and retention of females in the STEM (science technology, engineering and, math) field with their main point being the increased economic growth and competitiveness noticed when the gender gap is decreased. Based on a UNESCO (2018) working paper, the number of female students in the engineering, manufacturing and construction field was 27% on a global average with a study by Stoet and Geary (2018) arguing that the gap of female's engagement rises in countries with high gender equality, the so-called educational-gender-equality paradox. There have been several studies focusing on understanding why those trends emerge in engineering education (Hill, Corbett, & St. Rose, 2010; Marra, Rodgers, Shen, & Bogue, 2009) and providing suggestions towards more gender-balanced engineering programs. Suggestions include for example how to make engineering more attractive to high school female students (Milgram, 2011) or to understand the different experiences between currently enrolled male and female students in engineering programs and act upon them (Hassan, Bagilhole, & Dainty, 2012).

At Chalmers, the percentage of male students in 2017 was 61% whereas the female students constituted 39% of the student body. However, when specific programs are considered there are significant fluctuations with the highest percentage of female students being observed in the Industrial Engineering Design (61%) and the lowest in the Marine Engineering (8%). Chalmers's general policy aims to smoothen those trends and increase gender balance among students across all its programs. In our context, gender balance is defined as the representation of either female or male students in any study program not falling below 40 %. To facilitate and showcase the importance of this effort all statistical information provided by the central management is gender divided. Since the overall aim is to attract an equal number of male and female students, an essential step from Chalmers' perspective is also to assure gender inclusive programs by redesigning courses or programs where gender bias is identified (Mills, Ayre, & Gill, 2010).

In our study, we take the first steps towards understanding why those trends occur by investigating how male and female students perceive their education and if there are significant differences between them in different types of courses. Our approach is to explore if and to what extent student satisfaction surveys after each course can be of assistance to identify and explain those gender trends. This paper aims to:

- Compare course evaluations to identify if there are significant differences between the responses of male and female students. The courses are categorized based on their level (Bachelor or Master), their approach (traditional, lecture-based or CDIO, project-based), and the program they belong to. The sample of courses is from Mechanical, Automation and Industrial Design Engineering programs at Chalmers.

- Provide an in-depth study of selected courses that presented significant differences in the responses of male and female students.

We first outline the research methodology applied in the paper followed by the results chapter which contains a quantitative section based on data from the course evaluation questionnaires and a qualitative section based on case studies of the selected courses. A discussion and conclusions chapter complete the paper.

RESEARCH METHODOLOGY

The study is based on courses from Chalmers' programs in mechanical (ME), automation (AE) and industrial design engineering (IDE). Chalmers offers 3-year Bachelor of Science and 2-year Master of Science programs in these disciplines, including 5-year Master of Science in Engineering programs delivered in a 3+2-year format.

The data for the study was collected from Chalmers' course evaluation system. The questionnaires in Chalmers' system are based on 11 common questions. The common questions are chosen to reflect a constructive alignment view (Biggs & Tang, 2007) on education, *i.e.,* emphasizing learning outcomes, delivery of teaching and assessment, and to support cross-university quality enhancement. Seven of the common question are quantified on a scale of 1 to 5, reflecting very poor to excellent, disagree completely to agree completely, or similar. Four of the standard questions are free text, such as "*Is there anything that should be changed for the next round of this course, and if so: How*?" The students can also comment on the quantified questions. The responsible teacher and the students can also agree on adding additional questions for a specific course. The results of the questionnaires were subsequently divided by student's biological sex, which is automatically tagged to each survey response through our student database.

In our analysis, we used Independent Samples t-tests to compare the average values of students' responses to perceived/self-assessed prior knowledge and overall impression of the course. The tests were performed to identify if there are significant differences between male and female students and within male and female groups of students when the type or level of the courses changes. Each test produces a p-value, which indicates the probability that the difference is random (Student, 1908). The standardized significance thresholds of 5%, 1%, and 0.1% were used. The aim was to identify general patterns in the data, and together with descriptive statistics graphs, to depict differences in the survey responses between male and female students. These enabled us to select a subset of courses for a more in-depth analysis, where we also considered free text data. Independent t-tests and descriptive statistics were our first statistical approaches to analyze our problem, and more elaborate methods should be used as a subsequent step.

The exact phrasing in the questionnaire for the two questions we chose to analyze was for the question on perceived/self-assessed prior knowledge "*I had enough prior knowledge to be able to follow the course*" and for students' overall impression of the course "*What is your overall impression of the course*." Prior knowledge was chosen as it can affect students' learning, satisfaction with the course as well as the teaching, while it can also be a point of action. The overall impression is a measure of the student satisfaction which is an important quality indicator of course quality, including teaching, structure, and learning, and useful feedback to the teaching staff and the department.

RESULTS

This section includes the results of the study. First, the quantitative results from the Independent t-tests are presented and discussed, followed by a more in-depth analysis of six courses where significant differences between male and female students were identified.

Quantitative results

Table 1 describes the study programs which were included in the analysis, whether they were at Bachelor or Master level, the number of courses considered from each program, and the share of female students in each program. Courses with six or fewer responses from either male or female students were excluded in order to increase data validity. In total three

Bachelor and nine Master programs were examined, and the data contained courses from the academic years 2015/2016 through 2017/2018.

Table 1. Programs at Chalmers considered in the analysis.

Code	Program	Level	Courses	Female Students (%)
TKMAS	Mechanical Engineering	BSc	30	25,6
TKDES	Industrial Design Engineering	BSc	22	59,8
TKAUT	Automation and Mechatronics	BSc	22	15,7
MPTSE	Industrial Ecology	MSc	11	73,5
MPSYS	Systems Engineering	MSc	10	14,5
MPSES	Sustainable Energy Systems	MSc	9	28,8
MPPEN	Production Development	MSc	13	18,9
MPPDE	Product Development	MSc	7	20,4
MPDES	Industrial Design Engineering	MSc	9	55,7
MPAUT	Automotive Engineering	MSc	2	5,7
MPAME	Applied Mechanics	MSc	12	15,4
MPAEM	Materials Engineering	MSc	5	20,7
		Total	152	

Table 2 includes the results for the Independent Samples t-tests regarding students' perception on course pre-knowledge and overall impression of the course when the courses were grouped into different categories, see the first column. The analysis of the Master level programs was omitted since the entries were insufficient to obtain accurate results. The N number refers to the total number of course entries for each gender for three academic years (2015/2016 to 2017/2018) which have at least six responses from both male and female students (out of 456 possible for 152 courses and three years) and fulfill the criterion in the 1st column.

Table 2. Independent t-tests for responses for academic years 2015/2016 to 2017/2018 (*p=<0.05, **p=<0.01, ***p=<0.001).

	Perception on course pre-knowledge					**Overall impression of the course**				
	Male		**Female**			**Male**		**Female**		
	Avg	***SD***	***Avg***	***SD***	**t-test p-value**	***Avg***	***SD***	***Avg***	***SD***	**t-test p-value**
All programs (N=338)	4.33	0.36	4.25	0.49	t=2.463 **p=0.014***	3.87	0.62	3.77	0.68	t=2.033 **p=0.042***
Bachelor Level (N=184)	4.35	0.36	4.19	0.53	t=3.427 **p=0.001*****	3.82	0.69	3.69	0.73	t=1.698 p=0.900
Master Level (N=154)	4.31	0.36	4.32	0.43	t=-0.33 p=0.741	3.94	0.52	3.86	0.62	t=1.141 p=0.255
CDIO courses (N=28)	4.36	0.46	4.36	0.62	t=0.034 p=0.973	3.73	0.59	3.48	0.75	t=1.418 p=0.162
Mechanical Engineering (N=84)	4.33	0.32	4.18	0.54	t=2.18 **p=0.031***	3.82	0.60	3.67	0.68	t=1.490 p=0.138
Industrial Design Engineering (N=60)	4.41	0.34	4.29	0.41	t=1.790 p=0.076	3.83	0.70	3.71	0.69	t=0.910 p=0.365
Automation and Mechatronics (N=40)	4.33	0.46	4.08	0.65	t=1.973 p=0.052	3.81	0.87	3.71	0.88	t=0.493 p=0.623

From Table 2 we observe that the female students have a slight tendency to rate the overall impression on average 0.1 points lower compared to the male students, significant at the 5% level. However, when we break down the analysis into different groups, for instance on BSc and MSc level and program level, we do no longer distinguish a significant difference. Furthermore, we observe that female students on the BSc level rate their prior knowledge 0.16 points less compared to the male students. This finding is significant at the 0.1% level. At the MSc level, we instead observe that male and female students report similar results. When we conducted similar tests for the courses within specific BSc programs, the differences on the average responses for both the questions posed were not significant except for the Mechanical engineering program where female students on average rated their prior knowledge 0.15 points less than male students.

Table 3 describes the results for the Independent Samples t-test regarding students' perception of their prior knowledge and the overall impression of the course for male and female students separately, broken down on BSc and MSc levels.

Table 3. Independent t-tests including all the courses in the study for academic years 2015/2016 to 2017/2018
(for BSc N=184 and for MSc courses N=154, (*p=<0.05, **p=<0.01, ***p=<0.001)).

	Perception on course pre-knowledge					**Overall impression of the course**				
	Bachelor		**Master**			**Bachelor**		**Master**		
	Avg	***SD***	***Avg***	***SD***	**t-test p-value**	***Avg***	***SD***	***Avg***	***SD***	**t-test p-value**
Male	4.35	0.36	4.3	0.35	t=1.327 p=0.185	3.82	0.69	3.94	0.52	t=-1.8 p=0.073
Female	4.19	0.53	4.3	0.43	t =-2.348, **p=0.019***	3.69	0.72	3.86	0.61	t=-2.3, **p=0.022***

From Table 3 we observe that for male students there is no significant difference in the prior knowledge perception or the overall impression between the BSc and the MSc levels. However, we can observe that there are significant differences in female students. Female students on MSc level rate their prior knowledge on average 0.11 points higher than they do on BSc level. They also rate their overall impression of the course on average 0.17 points higher on the MSc level compared to the BSc level. In both cases, the level of significance is at the 5% level.

Table 4 describes the results for the Independent Samples t-test regarding students' perception on their prior knowledge and overall impression of the course for male and female students separately, when they rate traditional (lecture-based courses) and CDIO (project-based) courses.

Table 4. Independent t-tests including all the courses in the study for academic years 2015/2016 to 2017/2018 (for traditional courses N=310 and for CDIO courses N=28, (*p=<0.05, **p=<0.01, ***p=<0.001)).

	Perception on course pre-knowledge					**Overall impression of the course**				
	Traditional		**CDIO**			**Traditional**		**CDIO**		
	Avg	***SD***	***Avg***	***SD***	**t-test p-value**	***Avg***	***SD***	***Avg***	***SD***	**t-test p-value**
Male	4.33	0.35	4.36	0.46	t=-0.46 p= 0.645	3.88	0.62	3.73	0.58	t=1.24 p=0.216
Female	4.24	0.48	4.3	0.62	t=-1.198 p=0.232	3.8	0.67	3.48	0.75	t=2.387, **p=0.018***

From Table 4 we notice that for male students there is no significant difference in the prior knowledge perception or the overall impression between traditional lecture-based and CDIO project-based courses. However, for female students, there is a significant difference where they rate CDIO courses on average 0.32 points lower compared to traditional courses.

Case studies

Here we discuss in more detail some selected courses in which gender aspects are believed or found to be important. The courses range from basic and intermediate (BSc) level courses in programming, basic courses in Applied Mechatronics and Logistics to advanced (MSc) level courses in Productions systems and Finite Elements. The courses considered together with certain basic facts are given in Table 5.

Table 5. Description of courses in case studies for academic years 2015/2016 to 2017/2018.

Course Name	Program	Level	Type	Applied vs. Theoretical	Mandatory vs. Elective	No of answers (Respons e rate)
Object-oriented programming in Python	Mechanical Engineering	BSc	Elements of blended learning	Applied	Elective	Male=49 (40,6%) Female=24 (58,5%)
Production systems	Production Development	MSc	Traditional with labs, seminars, study visits	Applied	Mandatory	Male=81 (54,7%) Female=25 (69,4%)
Applied mechatronics	Technical Design	BSc	Traditional with labs	Applied	Mandatory	Male=25 (51%) Female=36 (49,3%)
Logistics	Mechanical Engineering	BSc	Blended learning	Applied	Elective	Male=56 (40,6%) Female=37 (59,7%)
Programming in MATLAB	Mechanical Engineering	BSc	Elements of blended learning	Applied	Mandatory	Male=164 (44,8%) Female=75 (60,5%)
Finite element method - structures	Applied Mechanics	MSc	Traditional with computer lab	Theoretical	Elective	Male=49 (43,9%) Female=24 (54,4%)

Table 6 includes the results for the Independent Student t-tests regarding students' perception on course pre-knowledge and overall impression for the specific course between male and female students. Each course is subsequently analyzed individually.

Table 6. Results for the independent t-test for the case studies.
(*p=<0.05, **p=<0.01, ***p=<0.001)

Course Name	Perception on course pre-knowledge					Overall impression of the course				
	Male		Female			Male		Female		
	Avg	***SD***	***Avg***	***SD***	**t-test p-value**	***Avg***	***SD***	***Avg***	***SD***	**t-test p-value**
Object-oriented programming in Python	3.82	1.24	2.67	1.52	t=3.452, **p=0.001****	3.65	1.13	3.21	0.96	t=1.638 p=0.106
Production systems	4.31	0.78	4.2	1.06	t=0.564 p=0.574	3.58	1.16	2.88	1.24	t =2.595, **p=0.011***
Applied Mechatronics	4.2	1.06	3.47	1.12	t =2.558, **p=0.013***	4.16	0.73	3.83	0.93	t=1.284 p=0.143
Logistics	4.57	0.90	4.51	0.79	t=0.330 p=0.742	4.18	0.91	3.7	0.98	t =2.415, **p=0.018***
Programing in MATLAB	3.37	1.48	2.57	1.30	t=4.032, **p=0.000*****	3.69	1.05	3.32	0.97	t =2.599, **p=0.01****
Finite element method - structures	3.83	1.10	3.49	1.36	t=1.146 p=0.256	3.97	0.94	3.4	1.07	t=2.921, **p=0.004****

Courses in programming

Several studies support that the female students consider themselves to have less and sometimes also insufficient prior knowledge in programming courses compared to male students, see (Butterfield & Crews, 2003; Rubio, Romero-Zaliz, Mañoso, & de Madrid, 2015). In our study, this is confirmed strongly in both the mandatory first-year introductory level course *Programming in MATLAB* which does not require any prior knowledge in programming, and it is taught at the very beginning of the study program and the elective third-year intermediate level course *Object-oriented programming in Python*, which has basic programming skills is a prerequisite.

A possible explanation of the responses in the *MATLAB* course is that male students, in general, have a higher interest in computer science and are more experienced compared to female students by having done some prior programming. However, in the beginning, and during the course, the teachers note no differences based on gender in students' programming skills. Female students perform just as well as male students and the average grades, as well as the share of students with grade 5 (the highest grade), are the same for both genders. The failure rate on the course is about 12% for both genders which is considered rather good for a first course in an engineering program. Even though female students rate themselves to have less prior knowledge at 0.1% significance level, on average 0.8 points, they perform just as well as the male students who rated themselves to have had sufficient prior knowledge. We also note that female students give a significantly lower general impression at 1% significance level, on average 0.35, on the course compared to the male students.

Considering that female and male students have taken the same courses before with the same results, they should have about the same prior skills in programming when entering the course for programming in Python. However, in the course questionnaire female students again rated their prior knowledge lower than male students at 0.1% significance level, on average 1.58 points. From a statistical point of view, we cannot claim that male students performed better in the course despite this - although the average grade of males is slightly higher than for females, it is not significant. This confirms the overall impression which implies that prior knowledge is rated slightly higher by the male students, although it is not depicted in their results. There are some studies on gender differences in the perception of introductory courses in programming. Results are somewhat conflicting but in general male students are found to have a broader interest in computers, but it is also shown that female students have the same abilities in programming but less self-confidence (Cheryan & Plaut, 2010; Qian & Lehman, 2016). We argue that our results confirm this picture in that female students perform just as well as males but consider themselves to have considerably less prior knowledge, although teachers in the courses report no differences in prior knowledge.

Logistics course

This basic course in Logistics does not require any specific prior knowledge, which is also confirmed by both female and male students in the questionnaire, see Table 6. Regarding the impact of the course, female students perform better and have higher grades than male students. It is however interesting to note that female students, in general, give the course a lower rating on overall impression and, thus, are in general less satisfied with the course compared to male students. This rating is somewhat surprising since the subject itself is often considered to be more appealing to female students compared to more theoretical math- and physics-based courses. However, in our study based on course questionnaires at Chalmers, we do not observe this difference in female students' overall impression between theoretical and more applied courses.

The Logistics course has during the last three years transformed from being traditionally taught (lectures, exercises, and labs) to a blended learning format with online materials, short lecture film clips, quizzes, and interaction together with face-to-face classes in which lecturing has been replaced by discussing and tutoring. This can lead us to believe that female students are less satisfied with online teaching and blended learning. This trend is somewhat verified by free text comments in the course questionnaire where several female students express doubts about the value of blended learning. One female student expresses it as: *"I personally do not like this set of online lectures. I prefer regular informative lectures. I felt that I would rather prioritize my time on other than going to a discussion session when the lectures are online".* However, research shows no clear results on this. Some studies indicate no differences in students' satisfaction in terms of gender for blended learning while other studies show differences in terms of gender, see (Ekawati, Sugandi, & Kusumastuti, 2017) and references therein.

Finite Element Structures course

The course is an advanced MSc level course in finite elements. The course aims to provide a deeper knowledge and increased understanding of how to apply the finite element method (FEM) on advanced and nonlinear problems in solid and structural mechanics. The course requires prior knowledge in the mathematical background of the finite element method and its application to structural mechanics problems. Female students rate their prior knowledge somewhat lower than the male students, but the difference is not statistically significant. However, the female students perform as well as the male students in that they obtain the same average grade, the same share of grade 5 and about the same share that failed. While considering this, it is interesting to notice that the female students in average give a significantly lower value on the general impression of the course compared to the male students, see Table 6.

Production systems course

Production systems is a mandatory course given as the first course in the Master programme, and its purpose is to assure that all students have a similar level of knowledge when starting the Master programme in Production engineering. Therefore it does not have any specific requirements of prior knowledge (other than the requirements to enter the

Master programme). This is also confirmed in the questionnaire, see Table 6, where we could not find any significant difference between female and male students when answering the question about prior knowledge. It is therefore interesting to note that female students rate the course significantly lower than male students. In terms of performance, the female and male students perform almost the same. The character of this course is that it is a traditional basic course and it has several different guest lecturers. A theory is that female students may prefer more challenging courses.

Applied mechatronics course

The applied mechatronics course is a basic traditional course with lectures and labs given in the second year at the Industrial Design Engineering. In some ways, the program differs from other programs in that the required GPA to enter the program is significantly higher than for other engineering programs, and the female to male ratio is considerably higher with females constituting the majority of students. Just like in the programming courses described above, the female students rate their prior knowledge significantly lower than the male students. However, when it comes to this course, the male students perform better; male students' average grade is 4.0 while the female students' is 3.5. Though, when it comes to rating their overall impression of the course there is no significant difference; The average rating for both genders is around 4.0. One theory is that the male students, for some reason, do have better prior knowledge and that the course does not level out this difference (opposite to the programming courses, described above).

DISCUSSION AND CONCLUDING REMARKS

Our study is based on the analysis of student course satisfaction surveys from academic years 2015/2016 through 2017/2018 including 152 unique courses and, thus 456 courses in total. We also analyze six courses in more detail. Bryant, Mathios, Kang, and Bell (2006) argue that although online evaluation methods have lower response rates, the results do not seem to differ compared to paper-based methods if the sample size is not too low and therefore we included a threshold of a minimum number of responses. The respond rate of the female students in these surveys is much higher compared to the male students' respond rate (see Table 5) although in the majority of the studied programs the percentage of male students is higher (see Table 1). This is in agreement with literature where female students tend to participate in a higher degree compared to male students (Bryant et al., 2006; Thorpe, 2002). However, we could also argue that this trend could also be amplified by the fact that entering engineering program is a more conscious choice by female students since at many occasions they need to justify their choices and consequently they are more interested in the quality of their education than male students. This is somewhat supported by the fact that the drop-out rate in the first year is higher for male students than female students at Chalmers Mechanical Engineering program.

Further, we observe that female students underestimate their prior knowledge in theoretical and, in particular, in programming courses while they perform as well as male students in programming and theoretical, math- and physics-based courses (with the Applied Mechatronics being a single exception). We also observe that female students perform slightly better than male students in general system-oriented courses and CDIO courses. However, it is also noticeable that the female students give those courses a lower general impression compared to more discipline-oriented theoretical courses. For male students, we cannot observe this difference. Moreover, our results indicate that female students are less satisfied with courses using blended learning than traditionally delivered courses while we again cannot observe this difference among male students' preferences. From our study of post-course student satisfaction questionnaires, we cannot discern any critical circumstances why female students may not choose or may not remain in engineering programs. Potential circumstances that lead to this situation could be examiners who are not always equipped to manage gender diversity in their courses creating possible gender bias (as discussed by Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012), the lack of female role models and female teachers that are missed in the classroom as well as in the educational materials and gender stereotypes (see also Wang & Degol, 2017). However, what is evident in our study is a constant trend wherein almost all tests the average responses of female students are lower compared to the male students even when differences are non-significant.

Based on these results a couple of points emerged for further investigation. The first point is the perceived prior knowledge of the female students at Bachelor level and how it can become equal to the male students, especially since their performance is similar and this difference does not further exist at Master level. A first step can be that low rated courses in the pre-knowledge scale may develop a rubric to detect gender differences early in the course and provide the necessary support. The second point is the overall impression of the project-based CDIO courses. The reasons for this high difference should be investigated while considering among others the team formation and the role of the female students in their team.

From this study considering three “mechanical” programs and more than 150 courses, we conclude that female students perform as well or better compared to male students and that we need to act to convey this fact to the public to increase the female applicants to engineering programs. We also need to take measures to make current male and female students understand that there is no difference in abilities and skills between genders. However, McLoughlin (2005) argues that interventions to increase female comfort in engineering fields should avoid putting the female students on the spotlight and that should be considered in our planning. Finally, Stoet and Geary (2018) support that increased female engagement in STEM fields requires a multifaceted approach that considers a person’s competencies across different areas and presents the career value of the field compared to the others. Our results are limited to Chalmers where the surveys took place, and there might be bias since the female students considered are the ones that are already enrolled in the engineering programs. However, we argue that they can provide insights into other engineering programs that aim for gender-balanced education.

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