Gender, Communication and Comfort Level in Higher Level Computer Science Education – Case Study

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Abstract - **According to research, students fare better in their studies if their comfort level is high. One of the factors in defining comfort level is how comfortable students are in presenting questions to other students and the course faculty. In this study, the students were divided into male, female and mixed groups. The communication within the groups was observed during the training sessions. In addition, the students filled in a survey after each training session, which measured the number of completed exercises and the level of experienced difficulty of the exercises. The study reveals that in the computer science classes typical gender distribution (majority male) lowers the comfort level of all students in comparison to a case with an even gender distribution. In light of this research, the study presents, that both male and female students would benefit, if more women studied computer science.**

Index Terms – Comfort level, Gender distribution, Performance, Loss of Potential Employees in IT-sector

INTRODUCTION

Female employees form a minority of employees in the field of information technology (IT). Over the past few decades the percentage of female students in computer science (CS) and related study programs has decreased even though the amount of education has steadily increased [1, 2]. This means that many gifted female students have chosen a field of study other than computer science. Another significant problem is that the few women who stay in the field discontinue their studies more often than men [1, 3, 4]. The phenomenon is also known as "the shrinking pipeline": even though young girls could be attracted by CS, the higher the level of education, the smaller is the proportion of female students [1]. This leads to a loss of potential employees in the IT sector. From a larger perspective, this results to a decelerated Gross National Product and disbenefit to the society.

The problem of diminishing percentage of female students in CS and IT is especially difficult, since despite the amount of attention paid to this problem, recent data suggests that the numbers are still falling [5]. Additionally, numerous acts of dedicated support in Finland as well as in other countries have not been able to make a significant difference: no distinguishable growth in the amount of female employees or students in the IT-sector has taken place despite the significant effort invested at the beginning of the 21st century [1, 4, 5, 6, 7, 8].

We state the problem as follows: varying factors exist that prevent women from undertaking CS studies and make the rare female CS students discontinue their studies significantly more often than their male peers [1, 3, 4]. In this study, we focus on observing the very first CS training sessions the students take in Helsinki University of Technology (HUT). This study concentrates on the beginning of studies, which is essential, since it has been noted in the previous studies that the critical period when women drop out of the natural science and engineering pipeline is before choosing a university major [9].

Our approach to examine the problem is to observe how comfortable students are during the sessions and does this affect their success in the exercises. According to previous research, students fare better in their studies if their comfort level is high. One of the factors in defining comfort level is, in fact, how comfortable students are in presenting questions to other students and the course faculty [5, 10, 11].

Feeling comfortable is more important for female than male students, because according to previous studies, the comfort level affects women much more than men: women with low comfort level performed significantly worse than in normal, i.e., comfortable, circumstances. On the other hand, female students with significantly high comfort level clearly exceeded their normal ratings. Similar results observed with male students were, however, insignificant in measure. This indicates that women profit more from positive studying experiences than men [10].

We concentrate on the verbal communication and possible differences in social interaction between female and male students during basic CS course training sessions. We focus in observing training groups with differing gender distributions. How do the students interact with each other? Is there a difference between the way female and male students interact in different kind of groups? Does it matter if the gender balance in a group is even or not? If it does, what kind of balance would the different genders most benefit from? In what kind of group would they be the most comfortable?

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BACKGROUND

Historically, computer science and engineering discipline in general has had a strong image as the men's playground. However, this is not exactly true, since female researchers and programmers have played an important role in the history of computers. To mention a few examples, in the forties women formed a majority of the first programmers during the World War II. In the fifties and sixties female researchers contributed heavily in, for example, the development of user interfaces [12].

However, from the early eighties to nineties the percentage of B.A. / B.S. degrees awarded in CS to women has consistently declined [1]. In the nineties, the same trend has continued despite the supporting acts started in several countries [1, 4, 5, 6, 7, 8]. In Scandinavian countries, women form only a very small proportion of university level CS students [4, 6]. In Finland, our specific problem is that due to our relatively small population, the loss of potential female students from the IT-sector forms a serious professional void, which is difficult to fill.

It could be argued that the problem is a straightforward consequence of the way how home computers arrived in the early eighties: computers became a very popular hobby for young boys. This led to the situation where, due to the boys' early involvement with computers, the female students enter introductory CS classes with weaker programming skills and less prior involvement with computers than their male counterparts [13]. Lack of computer related background could be a reason explaining why girls couldn't get along with computers and continued to drop these courses, considering them too difficult. However, the case is not that simple. The emergence of computers may indeed be one reason for the unbalanced situation in the CS and IT, but we do not assume it to explain the phenomenon as a whole.

According to previous studies in this area, it can be stated that the loss of women in CS is a complex and diverse problem [14]. One key factor is social pressure existing elsewhere: The society doesn't actually prevent girls from accessing computers, but it has failed to introduce CS or IT as a feasible option to them. A variety of reasons lead young girls to other fields than IT. As a result, women who would otherwise be suitable for the IT-sector will choose some other line of profession.

On the other hand, according to previous studies, some reasons why the rare women find their way into CS can be listed as follows [15]:

- The continuing presence of computers in a way that women (/ young girls) can comprehend the versatility of computer use
- Support and encouragement to the field from someone close to women (/ young girls)
- Women's (/young girls') own understanding of the different career possibilities in IT

One could argue that women would not fit or enjoy a career in fields of IT or CS. Therefore, it would be a waste of resources investing in their CS education. However, previous research reveals that if women do choose the studies in CS and survive them, they will most likely enjoy their career in the IT and like the work they do [16]. (This would implicate that women are most suitable for the IT sector. For this reason, success in getting women into this field would result in benefiting the society.)

The reasons for women to discontinue with their CS studies are various. According to previous studies most common reasons are as follows [3, 6, 7, 16]:

- Overall pressure not to study CS
- Lack of self confidence
- Feeling of being unwanted, alone, uncomfortable
- Having one's opinions under-valued
- Considering CS to be male-dominated
- Fear of combination of work and family life in IT-sector being problematic

It seems clear that some kind of supporting acts are needed. These acts should be focused in both the age period before girls make a decision that will affect their possibilities to choose CS as a discipline and during the actual CS studies. The critical time period during studies to focus in the supporting acts could be at the very beginning of the studies: the probability for women to drop out of the natural science and engineering pipeline is relatively higher before choosing a university major than after this point [9]. This indicates that the first higher level computer courses are extremely crucial to the retention of women in the field. The better the women perform in the first courses, the better chances there are that they find the field attracting and decide to major in it. Therefore, in this paper, we concentrate on the situation at the beginning of CS studies.

Previous studies [5, 10, 11] have concluded that the comfort level of the student is a decisive factor of student's success on a computer science course. Comfort level here was defined by Cantwell Wilson and Shrock (2001) as follows [11]:

> *a continuous variable [..] regarding asking and answering questions in class, in lab, and during office hours; anxiety level while working on computer assignments; perceived difficulty of the course; perceived understanding of the concepts in the course as compared with classmates; and perceived difficulty of completing the programming assignments.*

This study aims to find out if there is a difference in the comfort level among students depending on the gender ratio of the study group. This study especially targets the amount of interaction in class through empiric study of the behavior of the students.

METHODOLOGY

The research was conducted on a large annual computer course in Helsinki University of Technology, "Computer as a Tool", which teaches the use of basic computer and

telecommunication services of HUT. The course is mandatory for all the freshmen at the university, totaling approximately 1100 students yearly, and it is run as an intensive course on the first two weeks of their studies. Eventually, only 10% of all the students on the course will major in computer science. The students come from very different backgrounds with regards to previous computer experience.

The course consists of lectures and training sessions in computer classes. There are four mandatory computer exercises, each lasting 1.5 hours, where the students complete the exercises in small groups of 8-15 people. An assistant is present in the classroom, giving help and demonstrating some of the more difficult parts of the exercises.

The research was conducted through classroom observation and questionnaires. In addition to students and an assistant, an observer was present in these exercises. Questionnaires were presented to both the students and the assistants. Students were required to fill in these questionnaries as a part of the exercise.

I. Classroom Observation

Out of the approximately one hundred exercise groups, six were taken under observation. For each group, three exercises out of the total of four were followed. The gender distribution of the groups was planned to be as listed below:

- All-female group with female assistant
- All-female group with male assistant
- All-male group with female assistant
- All-male group with male assistant
- Mixed group (both genders represented) with female assistant
- Mixed group (both genders represented) with male assistant

The mixed groups were originally designed to have an even distribution of male and female students. However, due to the common migration of students, most of these group training sessions ended up with a drastically uneven gender distribution (only one or two female students, ten males). In addition, some all-male exercises had female visitors, and the other way around. Therefore, while the study lacks inclusive data (=collected from all three exercises) from groups with equal gender distribution and all-male-groups, we gathered additional information on the uneven gender balance, which is very typical in the field of CS.

Because of the migration, some exercise groups might be classified as all-female in one session and a mixed group in another. The changing status of groups can be seen in Table I. Groups 1 and 2 were intended to be all-female groups, groups 3 and 4 were intended to be all-male groups, and groups 5 and 6 were inteded to have an equal gender distribution.

When interpreting the results using qualitative methods, we gained crucial information on behavior of groups with different gender distributions. However, the lack of inclusive series of results in groups made the quantitative analysis of the data somewhat limited. For this reason parts of the quantitative results represented in the next section should be considered as indicative.

The observers were observing both the behavior of the students as well as that of the assistant. Besides making qualitative notes on the situation in the classroom, the observers kept a tally of the occurrences of assistant's verbal actions into three categories, based on the number of times:

- The assistant advises the whole class (AWC)
- The assistant advises a student (AS-F and AS-M), with "F" marking that the student being advised was a female, and "M" marking that he was male
- The assistant advises a student proactively (ASP-F and ASP-M)

Accordingly, a tally of each student's behavior was kept as shown below, based on the number of times:

- The student asks help from an assistant
- The student asks help from another student
- The student helps another student
- The assistant advises the student proactively
- The student initiates a discussion not related to the given exercise

These figures were marked on a sheet that also revealed the seating arrangement of the students in the computer room. Each student had a section as described in Figure 1. Into this section student's gender was marked as well as all verbal interaction with other students and/or assistant. The sheet consisted of students and assistance sections. Also the seating arrangements (computers close to each other and / or far apart) were marked on the surveillance form. In that way, we were able take into consideration, the possible physical obstacles for communication and evaluate their effect on the results.

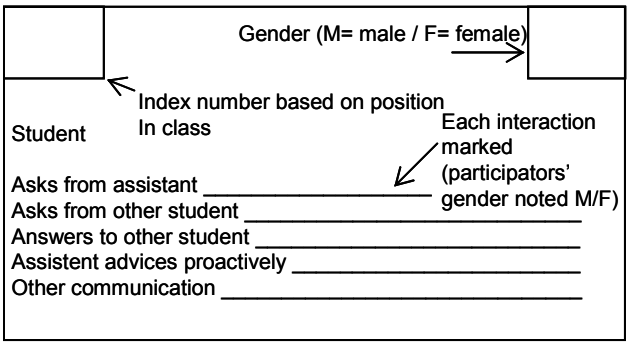

FIGURE 1
EACH STUDENT'S SECTION IN THE SURVEILLANCE FORM

TABLE I
STATUS OF THE GROUPS IN DIFFERENT SESSIONS OBSERVED

Group	1st session	2nd session	3rd session
1	Mixed (|F| > |M|)	All-Female	Mixed (|F| > |M|)
2	All-Female	Mixed (|F| > |M|)	All-Female
3	All-Male	All-Male	All-Male
4	Mixed (|M| > |F|)	All-Male	All-Male
5	Mixed (|M| > |F|)	Mixed (|M| > |F|)	Mixed (|M| > |F|)
6	Mixed (|M| > |F|)	Mixed (|M| > |F|)	Mixed (|M| > |F|)

II. Questionnaires

The assistants were asked to fill out a questionnaire comprised of questions related to their past experience of teaching single-gender groups and the differences they had noticed in the groups. The questionnaire was filled out after all the exercises were over.

The students filled out a questionnaire at the end of every exercise. The students were asked about the amount of interaction they considered they had had with the other participants, the difficulty level of the exercises, and the atmosphere of the exercise.

RESULTS

I. Observed Interaction in a Group Situation

According to the observers, the differences between groups were noteworthy: in all-female groups, the students spontaneously formed working pairs or small groups. Working together seemed to be a prevailing condition throughout the exercises. The pairs and / or small groups were based on whoever happened to sit close enough to make the co-working easy. The atmosphere in all-female training sessions were described as vivid, casual and focused.

In all-male groups, no working groups or pairs were formed. Students worked alone and did not communicate much. They rather searched for help from books and papers than from each other or the assistant. The atmosphere in all-male- training sessions was described quiet.

In mixed-gender groups, the common way of working was dependent on the distribution: if the distribution was close to even, the training sessions were described as casual and relaxed. Female students acted as initiators in most cases and they asked a lot from both other students and the assistant regardless of the gender of assistant or other student. If the gender distribution was typical for CS (a lot of male students, only 1-2 female), the female(s) only interacted with assistant and each other, and the male students only interacted with other male students. In this case, the training sessions were described as quiet.

The average number of times a single student asked a question from a classmate during one exercise is represented in Table II. Also the standard deviation is shown in Table II as well as other tables to emphasize the individual differences between students. Both uniform and individual behavior in the verbal communication can be observed according to the statistics.

TABLE II
AMOUNT OF QUESTIONS ASKED FROM CLASS MATES IN DIFFERENT GROUPS

Group	Average	Standard Deviation
All-Female	2.81	4.82
Females, Mixed (|F| > |M|)	5.13	6.20
Males, Mixed (|F| > |M|)	6.50	9.95
Females, Mixed (|M| > |F|)	5.08	4.92
Males, Mixed (|M| > |F|)	1.73	2.42
All-Male	2.04	2.96

Table II clearly shows that peer interaction was higher among females than males, and it reached its peak among females in mixed groups. As explained above, all-male groups were the most non-communicative group type. The students' behavior in male groups was the most uniform: communication level of all students was equally low. On average, males were most quiet in the mixed group with a majority of males.

It should be noted that only three mixed group exercises with a majority of females were observed as compared to the seven mixed exercises with a majority of males. Thus the figures for the males in mixed groups (majority "F") cannot be considered statistically valid. They are represented in the table as a curiosity.

The females were more inclined to ask questions from the assistant in comparison to the males, as shown in Table III. Additionally, the more females in a group, the more questions the males asked from the assistant and the other way around.

TABLE III
AMOUNT OF QUESTIONS ASKED FROM ASSISTANT IN DIFFERENT GROUPS

Group	Average	Standard Deviation
All-Female	3.33	3.06
Females, Mixed (|F| > |M|)	4.59	3.72
Males, Mixed (|F| > |M|)	2.50	2.08
Females, Mixed (|M| > |F|)	5.38	4.04
Males, Mixed (|M| > |F|)	1.97	2.27
All-Male	1.28	2.51

TABLE IV
OVERALL AMOUNT OF INTERACTION RELATED TO THE EXERCISES IN DIFFERENT GROUPS

Group	Average	Standard Deviation
All-Female	9.30	9.94
Females, Mixed (|F| > |M|)	15.63	12.89
Males, Mixed (|F| > |M|)	15.50	14.06
Females, Mixed (|M| > |F|)	14.23	7.63
Males, Mixed (|M| > |F|)	5.91	5.73
All-Male	5.47	6.56

TABLE V
AMOUNT OF CONVERSATION NOT RELATED TO THE EXERCISES IN DIFFERENT GROUPS

Group	Average	Standard Deviation
All-Female	2.07	3.50
Females, Mixed (|F| > |M|)	3.41	4.30
Males, Mixed (|F| > |M|)	4.75	5.50
Females, Mixed (|M| > |F|)	1.08	2.35
Males, Mixed (|M| > |F|)	2.26	3.91
All-Male	0.51	0.86

Overall, there was more interaction among females when there were males present in the group, as is shown in Table IV. The total exercise-related interaction between males did not differ from each other regardless of whether there were females present in the group or not. However, the males did start conversing more about things not related to the exercises when there were females present, as shown in Table V. This is opposite from the females, whose amount of non-related

conversation lessened when they were in a minority of a mixed group.

The standard deviations in this study are seemingly large due to the somewhat small size of the sample population as well as the individual differences between students. The former is especially true in the case of males in mixed groups with a female majority, and therefore figures for this group especially should be viewed with the sample size in mind.

To examine the latter explanation, let us look at the figures in Table IV on the previous page, especially the figures on females in mixed groups versus all-male groups. The females on average interacted almost thrice as much as the males, but there was also a larger difference in the amount of interaction within the female-dominant group. Table VI lists sample material from the observations for these figures. As can be seen from the table, the differences between individuals as well as groups are large.

TABLE VI
EXAMPLE MATERIAL FROM THE OBSERVATIONS FOR FEMALES IN MIXED GROUPS WITH A FEMALE MAJORITY VERSUS ALL-MALE GROUPS

Group	Number of communication events per student
Females, Group 1	18, 11, 5, 4, 4, 3, 2, 2
Females, Group 2	40, 31, 30, 25, 23, 18, 17, 16, 15, 15, 12, 11, 11, 7
Females, Group 3	42, 42, 40, 40, 17, 16, 12, 11, 5, 4, 4, 2
Males, Group 1	9, 8, 6, 3, 2, 2, 1, 1, 0, 0, 0, 0
Males, Group 2	17, 11, 9, 7, 4, 4, 3, 3, 3, 2, 2, 1, 0, 0
Males, Group 3	11, 10, 10, 9, 9, 8, 6, 5, 3, 3, 2, 1, 1, 0, 0

II. Interaction with the Assistant Based on Gender

One of the key findings in this study is that there are differences in the amount of questions students ask from an assistant depending on the gender of the assistant. In Table VII, the perceived frequency of questions asked was divided by the expected frequency of questions, giving a figure less than 100% if a student asked fewer questions than expected, and in turn a higher number if the amount of questions was higher than expected. This indicates that while the female students do not seem to prefer assistants of either gender, the male students preferred to ask questions from a male assistant. Figures for males in female groups and females in male groups are in parentheses due to their very small sample population, which makes the results untrustworthy.

TABLE VII
PERCENTAGE OF PERCEIVED OUT OF EXPECTED FREQUENCY IN QUESTIONS ASKED FROM ASSISTANT

Group	Males	Females
Assistant F, female group	(62.5%)	103.0%
Assistant F, male group	79.0%	(338,7%)
Assistant M, female group	(58.7%)	101.0%
Assistant M, male group	90.3%	(209.7%)

In the questionnaire, the students were asked to answer questions on whether they asked more questions from the assistant or from other class mates. By using Pearson's χ^2 test, it was found out that there was a clear difference between the two sexes on assistant interactions in all the groups.

The women in all-female groups were more inclined to ask questions from the assistant when the assistant was female ($p(9.56) < 0.010$, $df = 2$). The men on the other hand interacted differently depending on the group situation. In all-male groups, men preferred to ask questions from the male assistant ($p(7.32) < 0.050$), whereas in the mixed groups, the men were more inclined to ask questions from the female assistant ($p(13.1) < 0.005$).

It has to be taken in account that there were only two assistants studied in this research. Therefore, the gender of the assistant might not be as much of a decisive factor compared to the assistant's personality.

III. The Exercises Compared to the Group Setting

The students were asked in the questionnaire to site how many exercises they had completed during the classroom hours. While the men in different groups showed no indication of a difference depending on the group setting, the women were clear to perform differently according to their group.

The women in female-only groups performed more uniformly than those at mixed groups. While the women in female-only groups accomplished approximately seven exercises, the mixed group was clearly divided into persons excelling – those who were able to complete nearly all the exercises by the end of the lesson – and underachievers, who could accomplish only a few exercises.

When the male and female students were compared with each other, it was found that the men generally completed more exercises than the women. However, more than 10% of the male students completed less exercises than any of the female, in fact only one or two. This tells us that the diversity of the male students' performance was large, while the women can be regarded as being average level students. This might result from more modest interaction among the men, i.e, when a male student in an all-male group failed to accomplish a certain exercise by himself, he for some reason was not able or willing to ask help to accomplish the task at hand. Female students didn't have a similar problem. Women were always able to ask for help if needed.

When asked about the difficulty level of the exercises, women felt that the exercises were more difficult than their male associates did.

IV. The Atmosphere of the Exercises

When the assistants were asked to describe their own feelings and thoughts about the exercises, the overall view was that the female students in the exercises were more comfortable with asking help from each other or from the assistants. One of the two assistants had noticed that men in the mixed groups were more eager to ask questions than the ones in the male-only group. The other assistant had not noticed any clear difference between the behaviors of the groups and instead emphasized the individual differences of the students.

Surprisingly, based on the questionnaires there was no indication of a difference between how the female and male students experienced the atmosphere of the exercises.

CONCLUSIONS

The study clearly reveals that in computer science classes typical gender distribution (majority male) lowers the comfort level of all students and the performance of weak male students in comparison to a case with an even gender distribution. Noteworthy is that this typical unbalanced gender distribution discourages especially the male students from asking questions from the assistant and conversing with peers both on and off topic, which leads to the underachievement of the weaker students.

The situation is two-dimensioned: while female students gained the information they needed to accomplish the exercises, they, according to the previous research on the field, are the ones to suffer the most in the long run if they do not feel comfortable and accepted. [10] On the other hand, their male peers would benefit significantly from the presence of women co-workers in the field.

Female students seemed to have no problem asking questions regardless of the group type. However, female students' average performance was significantly better in the groups where gender distribution was either even or with a female majority. This leads us to assume that while the good female students have no problem performing in any kind of group, the less successful female students might have a need for either an even gender distribution or female-only training sessions to perform expectedly, taking into consideration that female students enter introductory CS classes with less prior involvement with computers than their male counterparts [12].

The study reveals a problem: males would profit from the presence of more females in a group. Efforts in accomplishing this have been met with limited success. In HUT, the percentage of females out of all the students in the computer science department is less than 10%, so if we were to form groups with an equal amount of men and women – what should we do with all the males who do not fit into the equal-gender-groups?

Since bringing sufficient number of women to study computer science will require a certain time period, we should in the mean time turn our attention to finding different ways to activate male students. One possible solution to compensate missing female presence would be to support social and co-operative forms of education. Point being, these advanced learning methods should be tailored for male students. For instance, the TiNA equality project [17] in HUT has successfully used a study group technique to improve the underachievers' success in basic mathematic and physics courses in the department of electrical engineering. In these study groups, students worked on their weekly homework together under a course assistant's presence. Preliminary results from this project are considered promising. Students have been able to improve their usual learning results significantly. (Public results are not available at this point.) Same kind of method could be used to certain CS courses as well.

In light of this research, we conclude that both male and female students and in the long run the whole society would benefit, if more women were to study computer science.

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