Gender and Programming: A Case Study

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***Abstract*—Our study highlights the effects of gender-related learning styles on a computer programming course at introductory level of engineering education. It was triggered by the observation of statistically relevant under-achievements among female students over the years. We try to identify concrete differences in motivation/learning styles between genders and prove that lack of previous relevant computer experience is not the only factor to blame. The paper analyzes the situation at a LTH course from the point of view of the conflicts outlined in the literature.**

Data from "before-starting" questionnaires and follow ups for subsequent evaluations expose significant gender differences. Analysis of the course materials and interviews with students reveals problems of constructive alignment and discouragements to the motivation of novice programmers. We investigated several pedagogical methods to adapt teaching and evaluation in order to increase all students' competence and at the same time reduce the gap between genders. Our key recommendation is to make the separation between the teaching of algorithms and the teaching of the specific language syntax clearer. It is our belief that good teaching of engineering subjects will enhance learning for *all* students.

***Index Terms*—Gender, programming, learning styles.**

I. INTRODUCTION

THERE is a common intuition among teachers about female students encountering higher difficulties than their male colleagues in the first programming courses. Still there are few teachers who actually think there is anything they can do to change this situation. The problem they face is whether one can identify concrete differences in motivation and learning styles between genders or if the poor results are just a consequence of lack of previous relevant computer experience, which might be more common to women. In any case, the question that remains is: Can we use this knowledge to better adapt teaching and evaluation in order to increase all students competence and at the same time reduce the gap between genders?

II. OBJECTIVES AND METHOD

The purpose of this project is to determine those aspects of computer programming for which gender might influence motivation and learning outcomes. We study how they apply to a current introductory programming course at LTH and propose guidelines to improve this course to better meet gender differences.

The research includes two distinct approaches. We start with review of existing literature on the topic. This gives us the appropriate base on common gender differences that we can observe on programming courses. Later we describe the situation at LTH and try to analyze it from the point of view of the problems outlined in literature. For this part, we gathered data on course results and we also interviewed both teachers and students involved in the courses.

This report was written as course project for Learning and Teaching in Higher Education: an introduction

III. HISTORICAL DIFFERENCES OF GENDER

Throughout history, there has always been a notable difference between men's and women's responsibilities which has been reflected in the academic world, especially in the technical faculties. For instance, women were not allowed to apply to KTH[1] on the same formal conditions as men until 1921.

A. Gender differences in self-confidence

Experimental curiosity is essential for practically each and every subject that is computer-related. Efficient learning concerning computer science in general is always connected with some kind of trial and error. A significant difference between men and women that relates to trial and error is self-confidence. A student has to have faith in his/her abilities to dare trying out a self-made solution. In Hanström [8], it is reported that women are classified as conscientious and accurate, but less self-confident, while men have got more self-confidence and are regarded as more purposeful and aware of their careers. In an investigation performed by Hägerström [9] on a mixed class it was shown how women express that they "did not understand and did not have the knowledge", as opposed to men with equal knowledge. The self-confidence, or the lack of it, is also present in group assignments. As the man propagates and struggles to advocate his idea, the woman tries to mediate and come up with isolated contributions. In a heterogeneous group women tend to take on a somewhat passive role.

B. Women's motivation to technology studies

An important part of pedagogics, concerning both men and women, is motivation. Studies, as for instance Jansson [10], show that women, to a further extent than men, require links to reality. Harding emphasizes that women need social and

[1] Royal Institute of Technology

humanistic perspective to be motivated to study a specific subject [11]. According to Cockburn [7] programming is an own subculture, both regarding language and jargon. This subculture is created by men and for men.

C. Difficulties with the integration

In [9], difficulties of attracting women's interest to a subject area built by men are observed. Both languages and course plans are often based on what men consider convenient. Trying to equalize this environment a posteriori is therefore difficult. One such example is that due to the majority of male students, mostly men will graduate. A natural result is that lecturers and teaching assistants are mainly men. According to the opinion of Romano [5], there exists a lot of problems with male teaching assistants as some of them consider female students as potential dates. He is furthermore reporting that a male teaching assistant in general will treat male and female students differently. The special treatment of women is not necessarily positive.

IV. BACKGROUND

The department of Computer Science is responsible for the first programming course in most of engineering education programs at LTH. These courses account for around 700 students every year, divided according to their majors. The courses consist of 12 to 15 2-hours lectures, paper exercises and compulsory laboratory assignments. Assessment occurs in the form of those individual home assignments —a larger working computer program— and a final written exam. In the course we study, the teacher has established "before-starting" questionnaires to appraise students' previous knowledge. This poll has proven to be a valuable tool for dividing students into level groups for the exercises sessions.

One common aspect to almost all engineering studies at this university is a severe predominance of male population. In the overall introductory programming courses women represent 25% of the total number of students, but distribution is certainly uneven, dropping below 10% for specific computer oriented degrees as it happens in our case study course [2]. Not surprisingly, female teachers are underrepresented as well. It is for this reason that women associations are of special importance at these institutions. They provide a network of female junior and senior students and in some cases they even participate in programming instruction.

V. DESCRIPTION OF THE TEACHING SITUATION

The fuzzy problem of women performing below expectation in initial programming courses must be concretised before seeking any reasonable solution to it. On one hand we have teachers' vague observations on class learning differences. On the other hand, as education becomes more student oriented, we should practice what we preach and ask the students for their views on the matter. We have been honoured to interview Linda Andersson, fourth year student of Computer Science and chairwomen for Dchip[2] board, about her opinions on the matter.

From the teachers' point of view, a normal explanation to this education problem is often given on student's characteristics. It is called *blame-the-student* theory (see [4]), based on student's deficit. Indeed there is much evidence in the literature that for females, lack of early computing experience puts this group at a distinct disadvantage [3]. This is also apparent from the "before-starting" questionnaire, where proportionally more women than men state *no previous programming experience.*

Remarkably, the fact is that among those with the lowest previous knowledge, men still achieve better results than women in later exams. Performance evens up for more skilled programmers. So if people with no previous programming experience do develop differently —in our case: women seem to be learning less— we can suspect that there are some other underlying discrepancies, besides just their "previous knowledge". Women may be slated for lacking general skills to work with computers. But this simplification has no support in the literature and would definitely not help to solve the problem. So we must go further and try to identify specific learning distinctions that we can meet in our teaching.

A. Alignment problem

We found that the course might be sending the wrong signals to the students about what is expected from them. Some women complain that they seem to be expending a lot of time with the course but that at the end they were still not prepared to answer the questions in the exam.

According to the constructive alignment theory [4], course objectives, teaching methods and assessment must be at the same level. In this case we find that the objectives stated in the official course description[3] are appropriately assessed in the exam. However, it is in the teaching/learning methods where the mismatch occurs. The focus shifts to learn a language (Java) and produce working programs. Most learning activity is directed toward *implementing* programs on the computer. This derives from the fact that both computer intensive activities are compulsory to pass the course, whereas paper exercises as the ones appearing on the exams are voluntary. As a consequence, much time and effort are consumed on mastering the programming language, the compilator and the operating system. This may be a larger problem for the female students as they are more prone to focus on details [8].

B. Self-confidence problem

Is women's self-confidence in any way different from men's? As one professor has noted, "[Self-confidence and the

[2] Dchip is a women association for computer science students at LTH http://www.efd.lth.se/proj/d-chip/

[3] To provide knowledge and methods for analysis of problems in different areas, particularly with the aid of a computer. To give an introduction to object-oriented programming and important concepts such as, objects, classes and inheritance. In addition, to give knowledge in fundamental programming and data structures and skills in the Java programming language.

need for encouragement and advice] is the primary area in which male and female differ quite a bit . . . I had women students who where very bright and who didn't perceive themselves as such, whereas I had men students who were of moderate capabilities and convinced that their brilliance was going unrecognized" [5]. This was also mention by Linda Andersson as one of the characteristics she could observe when holding programming sessions for beginners. She also indicated that women were more willing to ask for help and that they were more concerned over small errors. This makes them uncomfortable with the Trial and Error approach, commonly used in programming.

Self-confidence is a key issue in motivation. As McCombs [6] pointed out "[To be optimally motivated] students must believe that they possess the skills and competencies to successfully accomplish these learning goals". The department is definitely not making things better when in the course description it is stated that "*No previous knowledge is required, but those who have not program before must be prepared to work hard*". This really conveys the message that one is actually expected to know some programming. And if you do not, and have a question, then it is probably because you have not worked enough.

C. Links to reality

We observed that the exercises proposed are often expressed in terms of algorithmic solutions, with no connection to real problems. This is a problem both for motivation and comprehension. It is reported that women to a further extent prefer those problems where there is a clear utility [10]. It is the difference between just giving the exercise of adding 20 arbitrary numbers, and giving the same exercise with an example of why one would need to add 20 numbers, such as computing the average score of an exam.

VI. PROPOSED GUIDELINES FOR DEVELOPMENT

Our main advice is to make the separation between the teaching of algorithms and the teaching of syntax clearer. The student now may not be able to tell whether a non-desirable output from the program is due to a syntax error or due to an error in the algorithm. As it is proved in [1], pen and paper flow chart programming, is an advantageous way to teach and assess algorithmic knowledge. It will also give rise to the need for the implementation to be in a formalized language, which can be taught later.

Another suggestion is to extend the use of assessment of the students' previous knowledge at the start of the course. This evaluation should be the base of the teaching, and also form the basis for grouping people into workgroups.

Women-only exercise groups should also be considered, as recommended in [1]. This has been shown to improve self-confidence since it makes it easier for women to make themselves heard.

VII. CONCLUSION

Our study of the literature showed that the problem is well known and that there are a number of practical approaches to improve the teaching of programming that will facilitate the learning for women. The common experience is that these changes will also improve the performance of the men in the course. It becomes clear after the study that improvements can be made in computer programming education at LTH in order to increase learning and even up the gender gap. Some of these improvements are likely to be applicable also in other engineering subjects. It is our belief that good teaching of engineering subjects will enhance learning for all students. Succeeding on this task is probably an excellent way to attract and retain more women to technical education.

ACKNOWLEDGMENT

The authors would like to thank Per Holm, assistant professor at LTH's Computer Science Department for the data provided on the programming courses. We also want to thank Linda Andersson, fourth year student of Computer Science and chairwomen for Dchip board for her time and interesting comments on this study.

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RECOMMENDED READING

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