Technology is Female: How Girls Can Be Motivated to Learn Programming and Take up Technical Studies through Adaptations of the Curriculum, Changes in Didactics, and Optimized Interface Design

Lisa Zimmermann, Gerhard Sprung

FH JOANNEUM – Degree Program Information Management, Alte Poststr. 149, 8020 Graz, AUSTRIA

Index Terms: Female Interface Design, Didactics, Motivation.

Many technically oriented degree programs in Austria such as the degree program Information Management have had and have problems to motivate females to take up technical studies. This paper looks into the reasons why females seem to be reluctant to study computer science (such as upbringing and socialization) and shows a best practice example of the degree program Information Management that managed to increase its enrolment of female students from 13% in the winter semester 2003 to 33% in the winter semester 2007. The best-practice example is based on the research of Margolis/Fisher [1] who show how the Carnegie Mellon University managed to significantly increase female enrolments in computer science within five years.

After looking into the reasons that prevent women from taking up technical studies [2], the project TouchIT that was conducted at the degree program information management is described briefly.

Within this project changes in the curriculum, the program's advertising strategy [3], but also in the didactic approaches were made to meet the needs of female students in the field of technology. Great emphasis was laid on finding out design preferences of females as far as user interfaces are concerned [4]. These preferences will also be described in this paper along with different expectations towards computing of girls and women according to Margolis/Fisher [1].

This paper furthermore describes which aspects are important when it comes to teaching programming and how programming can be made a fun experience for both – male and female students by the use of robots and/or alternative interfaces.

The conclusion of this paper will be that both, males and females can learn technical content; however, they are more likely to succeed if that content is taught and presented in a way that is appealing and motivating to both sexes.

INTRODUCTION

The degree program Information Management at the FH JOANNEUM has been in existence since 1998 and started as a small program with only 34 students (6 female/17.6%). Out of these 34 students 27 graduated in 2002 (5 female). In the following years more students were admitted (1999 – 45 students, 19 % female, 2000 – 75 students, 25% female) but then the amount of female applicants decreased until 2003 when only 13% of female students started to study Information Management. At that time the department and the teaching staff of the degree program started to research the reasons why technical studies did not seem to be attractive options for females. In a first survey in May 2006 we conducted qualitative interviews with 18 female students in our department, who were already in higher semesters, and asked them about their motivation to study in this program. Most of them mentioned that they were interested in technology in the combination with business and that they liked to work with computers and new technologies. The problem seemed to start earlier. Asking a not representative sample of female pupils at middle schools we found out that many were discouraged by their teachers and parents to choose a technical program, because according to them it was "very difficult" and "very time-consuming".

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

Margolis/Fisher described how the Carnegie Mellon University managed to increase its number of female students at the School of Computer Science from 7% to 42% [1, p. 137] within five years. As the situation seemed very similar, we started to develop similar measures such as:

- making women and female students visible in all our public relation material (e.g. information folders) and at different events (e.g. Open House Day)
- changing the descriptions and titles of some technical courses to focus on results and not on technology
- training our instructors on gender-fair teaching
- starting co-operations with schools to conduct workshops in order to get across that "technology is fun"
- showing successful women in IT
- conducting the 2-year-project TouchIT

In the project TouchIT, which was conducted with different high schools in Graz, pupils could participate in workshops such as "how to motivate females to study in the field of technology", programming with Lego-robots and the graphical programming interface Lego-Mindstorms and NQC (not quite C). We also implemented a lab – called TouchIT-Lab - with installations that were developed at the degree program, mainly showing alternative user interfaces (tangible user interfaces, robots, collaborative applications) and games that could only be played if people worked together. The lab that was officially opened in June 2006 became a huge success and has helped males and females alike to make technology more tangible and to take away possible fears from the subject area. At the same time students and staff of the degree program became more aware of different needs and approaches to technology in females. Research in the field of gender and programming was intensified.

The staff of the degree program participated in a workshop on gender-fair teaching which was partly awareness-training to become aware of biases in teaching behavior. Linley Erin Hall describes that teachers in science and math subjects in general expect less from female students and tend to focus their attention on male students who are also usually quicker to put their hands up (whether they know the answer or not) [5, p. 30f]. The authors also experienced that the work and/or contributions of female students are sometimes belittled whereas the same work or contributions made by male students are praised. It is very important for instructors to be aware of their own teaching behavior and to offer males and females similar amounts of praise and criticism [5, p. 30]. When it comes to teaching programming and to get people interested in the subject, instructors have to take into account that females have different needs than males.

Taking the example of introducing the principle of a pump in physics at school we know from experience that if we focus purely on the scientific aspects, the topic won't be very appealing to either males or females. When this principle is explained taking a crude oil pump as an example more males than females will be interested. However, taking the human heart as an example, the topic becomes relevant for both females and males. Females need more examples that demonstrate an application they know or they are personally involved in [13]. When our degree program started to focus on describing projects such as the MediaWheelie – a wheelchair that was equipped with software and applications to help a child with special needs – the enrolment of female AND male students increased. Females and also males need to see why learning programming can be relevant in their future lives and what they can actually do with the acquired skills (computing with a purpose). Daniela Grabe describes in her degree dissertation that topics and tasks that are not motivating or are not related to reality can lead to a higher drop-out rate of females in technical studies [6, p. 14]. She recommends that students with little or no previous knowledge need to get the possibility to catch up through tutorials and a more detailed description of the given tasks [6, p. 34f]. In our program we started in February 2008 to teach programming using Lego-robots taking into account the suggestions Daniela Grabe made in her degree dissertation. The already achieved results will be discussed in the following.

RESEARCH QUESTIONS

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

In our research we tried to find out what female students need and expect when they learn programming. We also wanted to find out whether the already implemented changes in curriculum, design, and corporate wording as well as our projects offering programming courses using the Roberta-principle and our TouchIT-lab which is used for guided tours for high-school pupils showed relevant results.

Furthermore, we tried to find out which changes should be considered to improve the situation for girls and female students in a technical program.

We also wanted to know which programming languages, interfaces and aims are apt to help female students to have fun and success in IT.

In addition to that we tried to find out whether it was necessary to adapt user interfaces to meet the needs of female students and we wanted to know if it was possible to use better examples and content when teaching programming to help female students to develop interest, self-esteem, confidence, and also a sense of usefulness.

METHODOLOGY & RESULTS

Our recent research concerning user interfaces showed that there is a possibility to improve GUIs and design patterns to help women to feel better about the software. We adapted user interfaces to the special needs of women according to prior research of Moss [10], Margolis [1] and others. In her degree dissertation Manuela Prassl took a look at interface criteria and application models that show the flow and structure of information, navigation, text, images, symbols, audio interaction and color assignments according to their differences between males and females. In a usability test with 40 people she found out that women have different preferences as far as color and structure of information are concerned. Males need a hierarchical structure (figure number 1) whereas females prefer a more dynamic structure (figure number 2):

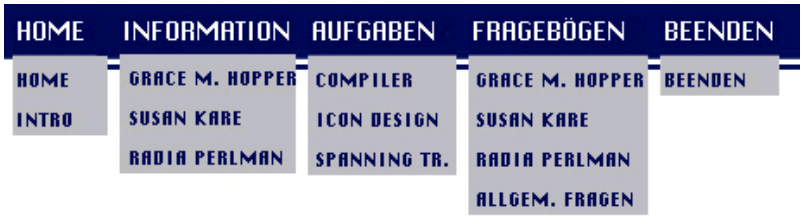

Figure 1: optimized male interface [7, p. 40]

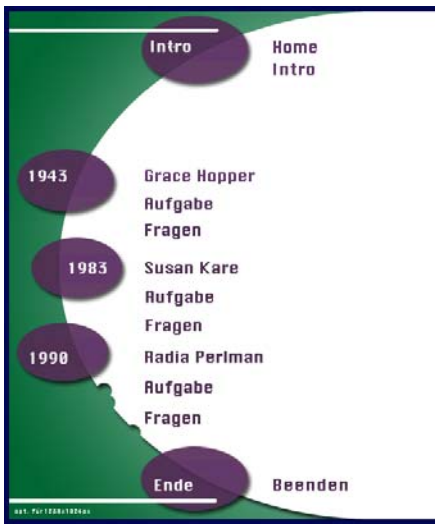

Figure 2: optimized female interface [7, p. 41]

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

In the specially adapted interfaces males and females were more successful and quicker fulfilling the given tasks than in the control groups. It was very interesting to see that in the male control group the difference was not significant (males using female optimized interface) whereas the difference in the female control group (females using male interface) was significant with nine out of ten female users having problems with the navigation [7, p. 74f]. This result alone allows the conclusion that questioning interface design is worth the effort if females shall be motivated.

In a second research project we tried to compare an adapted graphical user interface to Lego Mindstorms for its suitability for introducing the fundamental principles of imperative programming. Lisa Pump based her degree dissertation on the results of Manuela Prassl and developed a very simplified programming interface for girls. In several usability-tests with 10 to 14 year old boys and girls she could show the influence of design, color, goals, and connection to real life can improve the motivation of girls [see 8, p. 92].

Most of the preceding international research shows similar results concerning the needs and problems of girls and women when dealing with programming and IT. We can fix some points which are relevant for our research and our approach to help younger girls to find a way into the male dominated world of computing.

There are differences between men and women in self-confidence and self-efficacy [14], [15], [16]. Women tend to underestimate their own abilities and have lower confidence in their abilities. They do not play as much with the computer and do not tinker around.

Women have different working styles and need teams and collaboration [1], [19] and they have less experience with computers [17] which causes a feeling of inferiority. Rowell [18] showed interesting differences in the usage of IT: Women use the computer more for entertainment purposes (which includes communication) than men whereas men like to install things on their computers. Similar results can be found in Fallows [12].

To find out and prove if and/or the female students of our degree program have similar problems and needs as the American students who most of the research in this area is focused on, we conducted a survey. We wanted to find out if the above described measures that were taken at the degree program were successful, whether students felt there were special needs to be met for females when they learn programming, and whether there was a difference between their attitudes towards their skills and the grades they received.

In April 2008 the authors questioned all of the 162 presently enrolled students of the degree program Information Management using an online survey. Altogether 113 students from all four classes responded to the survey and 34 female and 79 male students completed it. The four classes were distributed more or less evenly (23% from class 2004 and class 2005, 27.5% from class 2006, and 26.5% from class 2007 which is the first class that started using robots in the course "Programming 1").

A few results that were not surprising but proved what can be found in literature [13] were that females gravely underestimated their programming knowledge and had a complete wrong perception of their skills whereas the male estimation of their skills reflected their grades. The question: "How good are you at programming (scale: very good, good, medium, bad, very bad, 1-5)?" was answered by females significantly lower than by men (mean values 3.27/2.5).

When we asked the students later in the survey about the grade they got in their Programming course (scale ranging from very good, good, sufficient to poor 1-4) females showed a mean value of 2.52 compared to 1.9 by men.

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

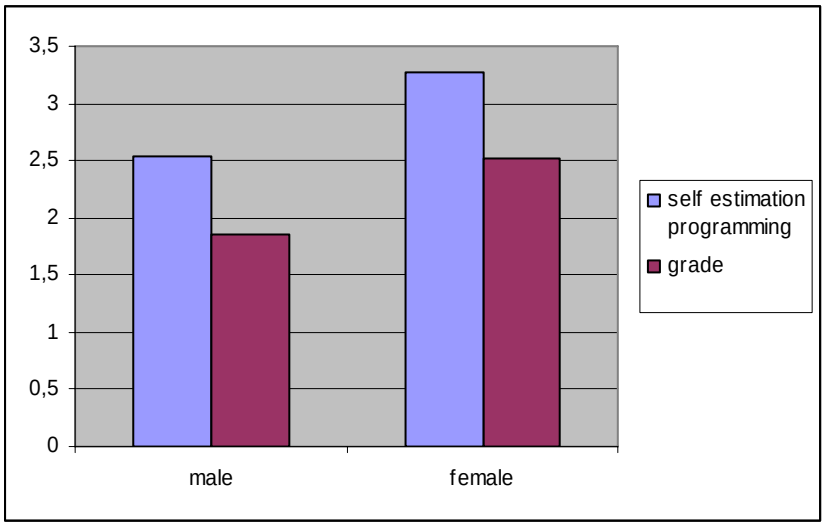

Figure 3: Programming skills self-estimation and grade

The question on whether males or females have different needs when it comes to programming was answered in the following ways:

81% of participating females stated that females have different needs when it comes to learning programming whereas only 55% of participating males were of that opinion.

65% of the male participants think it is not necessary to specially consider the needs of females in programming whereas only 45% of the women share this opinion.

Another result was that 66% of students (67.7% females and 66% males) are satisfied with equal treatment of males and females at the degree program and only 13,3% (13% females and 13,5% males) are not satisfied.

We further asked students about whether they had any role models that influenced their choice to study Information Management and whether these role models were male or female. All 14 students (13 male, 1 female) that had such a role model remarked that their role model was male. Not a single person had a female role model. This shows again how important it is to make women in technology visible.

The 30 students in their second semester that answered the question how they liked programming with Lego robots (scale: not at all, not a lot, okay, a lot, very much) mostly liked it (21 students); 8 students found it okay and only one student did not like it. (mean: male: 2.37, female: 1.82).

This reflects the results of a study done on Roberta-courses where 94% of 499 participants thought these courses were fun [9, p. 68]. Zorn et al also indicate that:

"The technology being used, whether as hardware or software, must be transparent and ought to enable children to develop and experiment with their own solutions." [9, p. 182]

In order to increase motivation and self-esteem students should be able to experiment with something they already know so that they can build on that and be open for the things they need to learn. According to Zorn [9], Margolis/Fisher [1], and Besana [19] females also need female peer-groups such as a girls-club for programming where they are visible and have role models to identify with and where their skills and contributions are valued.

Margolis/Fisher furthermore describe that females enjoy computing when it is computing for a purpose [see 1] whereas males according to Zorn et al [9, p. 162f] don't have fun in using but in knowing the computer, which is a far less people-oriented approach (similar results also in [13] and [18]).

In order to evaluate the different approaches to learning computer science (CS) we refined the question how to motivate girls to start programming. On the one hand it seems obvious that girls need different goals to be motivated, on the other hand the demands of employers and schools/university have changed in the last few years. Students, no matter if male or female, have to understand the principles of imperative programming languages, the idea of objects and OOP, optionally/ideally the principles of event-driven programming (Petri-nets, finite state machines).

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

In our survey we found out that our female students have less experience with computers at the time of enrolment, as we expected according to earlier research [20], [13], and [17]. They also need different goals to get involved. 25% of female students wanted other examples whereas only 13% of the males thought so. 35% of female students told us that they needed more motivation, only 18.6% of questioned males shared that view. Boys are happy when they are facing problems to solve; they create software for the sake of doing it [13] and [18]. Girls have less interest in such challenges and are looking for the impact of their work in real life. Similar to Kelleher [11] we tried to work out several types of approaches to evaluate them concerning the needs of girls and industry. Kelleher divided the approaches into two groups, where one group of applications helps to understand the programming algorithms and structural needs of a computer language. The other group deals with different goals, where learning the programming language is a "spin-off".

First we look at the underlying programming paradigm; secondly we try to estimate the amount of "girl-friendly" aspects: To motivate girls to get involved, we need to provide them with a possibility to express themselves, to communicate, to collaborate in teams, and to rebuild and model social phenomena.

1.1 Programming paradigms

To decide which methods are best to teach the basics of computer science to undergraduate girls we first have to distinct between the possible paradigms of programming. Most of the teaching concepts try to explain the traditional imperative programming paradigm. The most important structures of computing like conditions, functions and loops, which, of course, build the basis of most computer languages are shown in various ways.

Although there are still other useful approaches to consider, like event-driven software and declarative programming, modern software is almost solely built of objects, following the OOP-paradigm. Therefore a new way to learn and teach programming should introduce OOP as early as possible [21] and [22]. The most important features to be taught are objects, methods, inheritance, encapsulation, and event-driven programming.

1.2 Comparison of other possible approaches

Is it possible to use better examples and content when teaching programming to help female students to develop interest, self-esteem, confidence, and a sense of usefulness?

There are a lot of approaches to help children and novices to find an easy way to programming. Some lower the barriers by providing a simpler programming language (logo, pascal), some by showing direct feedback, graphical (logo, karel) or physical (NXT, TeRK, lilipad). Another possibility is to change the interface in a way to better meet the needs and preferences of girls, such as graphical programming languages.

Considering the problems girls specifically have in finding a way to start programming (self-esteem, missing motivation…), we found several approaches which take some of these special needs into account. We can therefore distinguish between interfaces and programming languages providing a better connection to real life (intelligent clothing, simulations), allow building teams, and exchange the results (Gamedesign gamemaker, interactive storytelling), expressing feelings and telling stories (scratch, Alice). As a last approach "squeak" should be mentioned, which is a dialect of smalltalk, which is not easy to learn but fully object-oriented and powerful.

Which programming languages, interfaces and aims are apt to help female students to have fun and to be successful in IT and in learning to program?

Based on the work of Kelleher [11] we compared several approaches and intend to further evaluate them to see if they meet our needs. As described above, a strong sense for the function of objects has to be seen as necessary goal, girls have to be motivated by having the possibility to interact, collaborate, tell stories, and produce useful software. Thus, we will take a closer look at Alice 3, scratch, lilypad, and Gamemaker.

One of the drawbacks of lilypad and storytelling Alice is the missing connection to traditional programming. The Arduino interface is far from being ideal for learning programming, especially OOP. Alice 3.0 should have the possibility to switch between the graphical interface and a JAVA-IDE, that seems to be a very promising approach.

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

DISCUSSION & CONCLUSION

In our degree program we are definitely going to build on the results of our research. We will evaluate the success and drop-out rate in the course Programming 1 and continue to improve our programming courses. We will further evaluate and use new approaches to learning programming such as through interactive story-telling or using clothes (courses connecting sewing and programming) and design in projects and further research. We also intend to continue to offer taster programming courses for girls from high-schools so that they can get interested in technology from a rather early age onwards. We are committed to prefer research projects with a strong focus on usability and assistive technology that have proven to be appealing to females and males. We also try to focus on showing female role models – female scientists who were successful in the area of computer science. It would also be great and highly supported if we could motivate our female students to take the initiative and found something like a 'girls only programming club'.

Female students in our program need to be praised and appreciated for their achievements in technical subjects and we hope to be able to motivate them to present our degree program at different recruiting events and also at high schools and colleges which are specialized in less-technical areas so that pupils from these schools have a role-model to identify with. As far as the instructors in our program are concerned we must keep up the awareness for the different needs of female students in technical subjects and find creative methods to meet these needs which will certainly benefit both: male and female students.

REFERENCES

[1] Margolis, Jane/Fisher, Allan: Unlocking the Clubhouse / Women in Computing, Massachusetts Institute of Technology, The MIT Press, Cambridge 2002

[2] Collmer, Sabine: Frauen und Männer am Computer, Aspekte geschlechtsspezifischer Technikaneignung, Wiesbaden: Dt. Univ.-Verl. 1997

[3] Ritter, Martina: Bits und Bytes vom Apfel der Erkenntnis. Frauen-Technik-Männer, Münster Westfälisches Dampfboot 1999

[4] Preece, Jennifer/Rogers, Yvonne/Sharp, Helen: Interaction design beyond human-computer interaction, John Wiley & Sons, Inc. 2002

[5] Hall, Erin Linley: Who's afraid of Marie Curie? The challenges facing women in science and technology. Seal Press 2007

[6] Grabe, Daniela: How to Learn Programming by Using Robots, unpublished degree dissertation FH JOANNEUM 2007

[7] Prassl, Manuela: FemUIs – Female User Interfaces, unpublished degree dissertation FH JOANNEUM 2006

[8] Pump, Lisa: Programming interfaces for girls - Conception and evaluation of a target group oriented programming interface, unpublished degree dissertation FH JOANNEUM 2007

[9] Zorn, Isabel et al: Gender Designs IT – Construction and Deconstruction of Information Society Technology, VS Verlag fuer Sozialwissenschaften / GWV Fachverlage GmbH, Wiesbaden 2007

[10] Moss, Gloria (2006): Some men like it black, some women like it pink: consumer implications of differences in male and female website design. In: Journal of Consumer Behaviour, Jg. 5, H. 4, p. 328–341. Available online on http://dx.doi.org/10.1002/cb.184.

[11] Kelleher, Caitlin (Sept. 2006): Motivating Programming: Using Storytelling to Make Computer Programming Attractive to More Middle School Girls. Dissertation, Pittsburgh, PA, School of Computer Science.

[12] Fallows, Deborah (December 28, 2005): How Women and Men use the Internet. Women are catching up to men in most measures of online life. Men like the internet for the experiences it offers, while women like it for the human connections it promotes. Editor: Pew Internet & American Life Project. Washington DC.

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at

[13] Fisher, Allan; Margolis, Jane; Miller, Faye (1997): Undergraduate women in computer science: experience, motivation and culture. In: SIGCSE Bull., Jg. 29, H. 1, p. 106–110. Available online on http://doi.acm.org/10.1145/268085.268127.

[14] Beckwith, Laura (2005): Gender HCI issues in problem-solving software: CHI '05 extended abstracts on Human factors in computing systems. Portland, OR, USA: ACM, p. 1104–1105.

[15] Beyer, Sylvia (2003): Gender differences in computer science students. In: SIGCSE Bull., Jg. 35, H. 1, p. 49–53. Available online on http://doi.acm.org/10.1145/792548.611930.

[16] Cohoon, J. McGrath (2007): Gendered experiences of computing graduate programs: Proceedings of the 38th SIGCSE technical symposium on Computer science education. Covington, Kentucky, USA: ACM.

[17] Vilner, Tamar (2006): Once she makes it, she is there: gender differences in computer science study. In: SIGCSE Bull., Jg. 38, H. 3, p. 227–231. Available online on http://doi.acm.org/10.1145/1140123.1140185.

[18] Rowell, Ginger Holmes (2003): Computer-related gender differences. In: SIGCSE Bull., Jg. 35, H. 1, p. 54–58.

[19] Besana, GianMario (2004): Together is better: strengthening the confidence of women in computer science via a learning community. In: J. Comput. Small Coll., Jg. 19, H. 5, p. 130–139.

[20] Murphy, Laurie (2006): Women catch up: gender differences in learning programming concepts. In: SIGCSE Bull., Jg. 38, H. 1, p. 17–21. Available online on http://doi.acm.org/10.1145/1124706.1121350.

[21] Moskal, Barbara (2004): Evaluating the effectiveness of a new instructional approach: SIGCSE ’04: Proceedings of the 35th SIGCSE technical symposium on Computer science education. New York, NY, USA: ACM, p. 75–79.

[22] Cooper, Stephen; Dann, Wanda; Pausch, Randy (2003): Teaching objects-first in introductory computer science: SIGCSE ’03: Proceedings of the 34th SIGCSE technical symposium on Computer science education. New York, NY, USA: ACM, p. 191–195.

[23] Scratch: http://scratch.mit.edu/

[24] GameMaker: http://www.yoyogames.com/

[25] Civ4 Mod: http://www.2kgames.com/civ4/home.htm

[26] storytelling Alice: http://www.alice.org/kelleher/storytelling/index.html

[27] Alice: http://www.alice.org/

[28] TeRK: http://www.terk.ri.cmu.edu/index.php

[29] Squeak: http://www.squeak.org/

[30] Karel++: http://pclc.pace.edu/~bergin/karel.html

[31] Logo: http://www.cs.berkeley.edu/~bh/

[32] Phrogram (KPL): http://phrogram.com/

E-mail: lisa.zimmermann@fh-joanneum.at; gerhard.sprung@fh-joanneum.at