Different Perceptions of Computer Science

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Abstract—This research project aims to investigate, how young men and women differ regarding (1) their perceptions of Computer Science (CS) as a scientific discipline respectively as a professional field and (2) the experiences that had influenced their choice of major subject. For that purpose, we conducted a biographical study of CS freshmen at university. In total, 217 students (54 female, 163 male) participated on the survey. The qualitative analysis showed that young men and women do have different viewpoints on computer science. While the male students tend to focus on technical aspects like hardware, mathematics, or logical issues, the female students are attracted rather by creativity, communication, or job opportunities. Furthermore, we investigated the differences between several courses of study. While students of core Computer Science are emphasizing technical issues and their personal experience with computers, the students of Games Engineering, Information Systems, or Bioinformatics mainly focus on the application fields and regard CS as a tool. All these differences seem to influence the selection of the major subject of the students. They might explain the problem of low enrollment rates in Computer Science and the decreasing number of students in core Computer Science in comparison to the more interdisciplinary courses of study.

I. INTRODUCTION

It seems obvious that a student’s choice of his/her major subject might be influenced by his/her perception and beliefs of this subject. If this perception or these beliefs are not in accordance with reality, this may cause serious problems by misleading the student’s choice.

On the other hand, perceptions, beliefs or career choice are determined by their personal experiences and the influence of other persons.

To detect reasons for wrong career decisions, it seems advisable to investigate the perceptions and beliefs of potential students as well as the experiences that influenced their career choice. For this purpose, we conducted a study among freshmen of Computer Science and similar courses of study at our university.

Our research question was:

How differ male and female CS freshmen regarding
1) their perceptions of CS as a scientific discipline respectively as a professional field and
2) the experiences that had influenced their choice of major subject?

The qualitative analysis of the 217 responses detected substantial differences between young men and women as well as between students with different major subjects.

II. BACKGROUND AND RELATED WORK

A. Gender Differences in Computer Science

A lot of research has been conducted that showed the existence of gender differences in Computer Science (CS), for example in Europe or the United States [1]. Still, more boys choose computer science at school or as professional field than girls. Already in school, frequently boys are performing better in CS compared to girls [2]. Several studies explained this differences by certain stereotypes that are supposed to have a negative impact on the performance of female students, see for example [3]. For example, the role model of the typical male computer scientist is still alive [6]. On the other hand, almost no female role models for girls exist, because still the majority of computer scientists and computer science teachers are male. At home girls and boys often experience mothers that are technologically still inept, which represents a substantial obstacle to female role models in computer science [4].

When choosing their major subject, students often have a diffuse perception of CS. It seems that boys decide based on their interests on computers or programming, while girls choose due to the prospects for future professional life [5]. Boys seem to have more prior knowledge in CS. Girls, in contrast, are less self-confident in this area. They tend to attribute their successes in computer science to luck and their failures to the lack of ability [6].

However, both female and male students can reach the same level of ability in computer science [7]. It turned out that the performance of CS students does not really differ between men and women, if learning styles are taken into account [7].

B. Computer Biographies

Personal experiences were already investigated by gathering computer biographies [8]. The participants were asked to tell the story of their personal experiences with computing. Almost all participants reported that they came in contact with computers by gaming. Very often this contact was initiated by family members and friends.

Another publication of the same authors is based on the assumption that Computer Science (CS) becomes useful for students when it is connected to other disciplines [9]. They asked computer science majors to write down their computer biography and explain how they became a major in Computer Science. 79 students majoring in CS-related fields responded.
Their biographies typically start with a description of the first contact with computers. Many students described that they have had a great interest in computers and wanted to learn more. Furthermore, the students did not explicitly connect computing with usefulness and did not link computing to a context.

A similar study is described in [10]. The authors analyzed 135 computer biographies of CS majors. One of the research questions was "Do students perceive computer science as creative?" The results show that students perceive computing as a creative field. For example, they expressed a fascination and curiosity for the computer and the functionality. Furthermore, programming offers possibilities to create and design artifacts. Almost all participants mentioned critical thinking, evaluation ability, and problem solving in their texts. The first contact with computers mostly started with gaming, Internet usage, and experimenting with the computer.

Schulte and Magenheim asked 600 secondary school students for their expectations concerning CS [11]. They stated that expectations depend on prior experiences and attitudes. Furthermore, the authors suppose that male and female students still have different competence levels in this area. For example, women feel less self-confident about computers. The study was a longitudinal-analysis with students of the 11th grade. They were questioned for the first time at the very beginning of their computer science course and a second time one year later. 152 students took part in both surveys. Based on these results, the authors could create a typology of students. The first type describes students who are particularly interested in computer science, based on experiences. Boys were significantly more often assigned to this group. On the other hand, girls are more interested in usage of computers and questions of social impact.

Further, the role and impact of prior experiences was examined [12]. The study is based on the assumption that students often have misconceptions about computer science. Again, the method of computer biographies was used. The research focused on personal experiences with computers like using computers for gaming or for doing homework. All the experiences are likely to affect attitudes towards CS. During the study 44 biographies of psychology students and 89 of computer science freshmen were collected. As a result, the students could be divided into two different groups: users and designers. Both have a solid image of the CS-world and the major problem is the teaching of another image. Their world-image is deeply connected with their self-image and habits, so trying to explain what computer science "really" is would not help.

III. Methodology

To gather the computer biographies of the prospecting students, we conducted an online survey. The students had to fill in short texts according to the methodology described in [8]. The survey was conducted at the beginning of an introductory course just before the start of the regular first term. At this moment, the students have had only their previous experiences with computer science and not yet any input by their university studies.

The study contains two items. Each item is introduced by a short example text. The survey was conducted in German language. The items as well as the sample answers presented here are translated by the authors.

The first item asked the students to describe their computer science biography:

Please let the following text examples stimulate you to describe how you came to computer science (CS).

Maybe you want to write about a special experience in your childhood or at school, your motivations to choose CS, or more generally about your interest in computer science. Please describe your way towards computer science, by writing your own computer science biography.

The second item contained three questions on the personal perception of computer science as a science or profession:

- How do you understand CS as science or as a professional field?
- What are their major topics and fields of CS?
- Which working methods or activities are characteristic for a computer scientist?

Please answer these questions in the following lines as detailed as possible!

To analyze the responses, we performed a qualitative text analysis according to Mayring [13]. For that purpose we used a category system that was derived from a similar study in 2011, which comprised two dimensions: (1) Motivation and (2) Science & Profession. The categories of the first dimension is displayed in Table I, those of the second dimension in Table II. Each category is explained by a sample text from the current investigation.

To assess intercoder agreement and reliability, we recoded about 20% of all coded documents. To get an idea of the agreement, the coefficient of Brennan [14] was calculated. The common coefficients of Cohen and Krippendorff are not applicable as they require a normal distribution of the codes [15]. The first attempts resulted only in a fair agreement according to Landis [16]. For that reason, we revised the coding of the category interest and joined the categories programming and software-engineering. The outcome was an increase of the intercoder agreement. The most remaining differences were related to the decision if a text passage was relevant at all. As soon as a text passage was coded, the codes were mostly identical.

After the coding process we grouped the documents by the courses of study and gender. For each group all the codings were revisited and summarized to find the differences in the perception of computer science which are presented in the next section.

IV. Results

We collected 217 full answers to our questionnaire. 163 responses were from men and 54 from women. The partici-
Table I
OVERVIEW OF THE CATEGORIES FOR THE DIMENSION
Motivation

<table>
<thead>
<tr>
<th>category/code</th>
<th>sample coding (translated by the authors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer games</td>
<td>I have always been excited about computer games and the world of games.</td>
</tr>
<tr>
<td>Interest</td>
<td>I have always been interested in computers and new media.</td>
</tr>
<tr>
<td>Stereotypes</td>
<td>I realized that not every computer scientist is a humorless bespectacled man.</td>
</tr>
<tr>
<td>Favorite Subject</td>
<td>At school computer science was one of my favorite subjects.</td>
</tr>
<tr>
<td>Self-confidence</td>
<td>As I didn’t feel capable for such a challenging study, I didn’t want to study computer science first.</td>
</tr>
<tr>
<td>Technology</td>
<td>When I was little I had a great time playing with technology.</td>
</tr>
<tr>
<td>Interest through other subject</td>
<td>I discovered my interest for computer science in my first degree program Electrical Engineering.</td>
</tr>
<tr>
<td>Male role model</td>
<td>My dad tried early on to spark an interest in me for programming.</td>
</tr>
<tr>
<td>Female role model</td>
<td>My cousin studied Computer Science and she has often told me how much fun it is.</td>
</tr>
<tr>
<td>Previous job</td>
<td>I have completed an apprenticeship in the field of computer science before starting my studies.</td>
</tr>
</tbody>
</table>

pants attend studies in Computer Science, Games Engineering, Bioinformatics and Information Systems. The following subsections describes the computer biographies of our participants in detail, sorted by the study course.

A. Computer Science

In the program Computer Science the basic foundations of the field, such as software engineering, databases / information systems, artificial intelligence / robotics, computer graphics, computer architecture, computer networks, formal methods and algorithms, are taught.

In our study 99 students of core Computer Science participated. 18 of them were women.

Female:

My parents both work in the field of computer science. So I came into contact with computers early. During school I liked the subjects math and computer science the most. I think computer science is a broad and modern science. I see a wide professional spectrum for me in the future.

Already as a child the female CS students are interested in computers. Often this is fostered by their parents or siblings. They see a variety of professional fields and career prospects.
The main motivation are fun and interest in the subject. Furthermore, an important fact is the connection with math. In their opinion, computer scientists are more than only programmers.

Male:

After coming into contact with computers early, I found a huge interest in computer science. Besides school I learned a lot about it on my own. It is really exciting for me to see how computers and their hardware work. I think some important topics of computer science are artificial intelligence and IT-security.

Male computer science students express a great enthusiasm in the construction of computers and their hardware. Math is the base of computer science. Important fields within this science are artificial intelligence, IT-security, and technical computer science. The main motivation for them is interest in CS. So they learn about computers on their own after school.

B. Games Engineering

The program Games Engineering teaches comprehensive knowledge about game technologies. Additionally students learn a wide range of informatics and mathematics. 48 Games Engineering students (7 women) have written their computer biographies in our study.

Female:

I always liked video games and played a lot during my freetime. I also have a great interest in art and I am a very creative person. My dream is to be able to create my own virtual world.

Female students of the Games Engineering study wrote that they played a lot of video games in the past. Their main interests are creativity and art. Computer science is for them the development and programming of software and virtual realities.

Male:

I’ve been coming into contact with computers very early. Most of the time I played video games. During my time in school I had fun using HTML / CSS and programming. For me the most important parts of computer science are programming and game design.

Male students of this study course said, similar to the women, that they are interested in video games and played a lot. The most important parts of computer science are programming, games design and teamwork. They explicitly mention that they have fun in programming and that they had the first contact to computers very early in their lives. Computer science consists of math, logic and problem solving.

C. Bioinformatics

"Bioinformatics is the application of computational tools and computer technologies to model, analyze, store, retrieve, manage, present, and visualize biological data” [17]. Eleven students of Bioinformatics have participated in our study. Out of these, six students were female.

Female:

I am interested in biology and computer science. However both subjects on their own are too one-sided for me. In the combined field of Bioinformatics, I see a strong future-oriented and innovative field. I want to help people and create great things with computer science.

The main focus of computer science, for female Bioinformatics students, is programming. Furthermore they perceive CS as a kind of a miracle, because they do not understand how computers work. In the combination of computer science with one of their favorite subjects, biology, they see an innovative and future-oriented field.

Male:

The first experiences with computers I had are the ones made as a child. I think the main task for computer experts is programming. With the developed software they can make the people’s lives easier. For me Bioinformatics is a very innovative field.

Male Bioinformatics students made their first experiences with computers as a child or in the lower secondary level. In their opinion computer scientists can find jobs in many different professional fields. Particularly Bioinformatics is seen as a very innovative area. An important activity of computer scientists is programming. The students think that computer scientists improve people’s life.

D. Information Systems

Information Systems exposes students a combination of CS and business studies. The core of this study consists of design, development, introduction, usage and maintenance of business applications. 56 students (23 female) of Information Systems participated in our study.

Female:

I have always been interested in technology and asked myself how computers work. Computer scientists work together in teams and so they have to communicate a lot. The most important task of a computer scientist is the programming of software.

Female students of this specific field express that they perceive teamwork and communication as a very important part of the computer scientists’ work. From the profession’s view, the most important task is programming. Almost all women express a certain interest for technology and computers. They want to understand what is underneath.

Male:

I had the subject computer science at school. Although I didn’t like it, I think Information Systems is very future oriented. The main task of computer scientists is to program. With software they try to make our lives easier.
Male students perceive their field of study as innovative because of the combination of computer science with business studies. The main task of a computer scientist is programming and, similar to their female counterparts, they express the wish to know what is the insight of a computer. This group of students is characterized through their will to improve and automate working processes with computer science for other people. Also teamwork has a high priority for them.

V. CONCLUSION

Most of the participants mentioned that they came into contact with computers very early in their life. But when they have to describe Computer Science (CS), it seems that they do not know what it’s nature really is. Surprisingly, some students regard computer science as a black box. They do not know how computers work (e.g. “To create something from nothing”). This is similar to an observation made by Greening [18]. He found that almost all participants of his study owned and used a computer at home, but “the majority of students (over 58%) were unable to approximate a definition of computer science”.

Furthermore, the students had been influenced by other people to use computers. These people were mostly male, like their fathers or brothers.

Our qualitative analysis showed that young men and women do have different perceptions of computer science. While male students focus on technical aspects like hardware, mathematics, or logical issues, female students are attracted by creativity, communication, or job opportunities.

Furthermore, we investigated the differences between several courses of study. While students of core Computer Science are emphasizing technical issues and their personal experience with computers, the students of Games Engineering, Information Systems, or Bioinformatics mainly focus on the application fields and regard CS as a tool. Additionally, it seems that students of Bioinformatics and Information Systems have some misconceptions of computer science, except if they have already completed an apprenticeship or another course of study.

All these differences seem to influence the selection of the major subject of the students. They might explain the problem of low enrollment rates in Computer Science and the decreasing number of students in core Computer Science in comparison to the more interdisciplinary courses of study.

In future work, the detected perceptions of the students should be analyzed in a deeper way to investigate differences between male and female students. Additionally, the questioning of school students in different levels (for example primary and secondary schools) could provide advice how to deal with gender aspects in computer science.

REFERENCES