# Gender-Specific Motivation and Expectations toward Computer Science

Sarah Theres Völkel
LMU Munich
München, Germany
sarah.voelkel@ifi.lmu.de

Wiktoria Wilkowska
RWTH Aachen University
Aachen, Germany
wilkowska@comm.rwth-aachen.de

Martina Ziefle
RWTH Aachen University
Aachen, Germany
ziefle@comm.rwth-aachen.de

## ABSTRACT

This paper provides an analysis of current motives for choosing computer science as a subject of study, focusing on male and female computer science students' perception about expectations and required qualifications for this professional career. A multi-method approach (qualitative and quantitative research) was applied in two studies in Germany to, firstly, explore which motivations dodge behind the decisions to study this complex discipline, and secondly, to examine if motives and the required skills are gender-specific or not. The results of the presented studies confirm that women and men are guided by different motives and expectations regarding the subject of computer science and in some cases evaluate their strengths and abilities in different ways.

## CCS CONCEPTS

• **Social and professional topics** → **Computer science education**; **Women**; • **Human-centered computing** → Empirical studies in HCI;

## KEYWORDS

Gender Gap, Computer Science Education, Interest in Science, Technology, Engineering and Maths, STEM, Motives for Computer Science Career

**ACM Reference Format:**
Sarah Theres Völkel, Wiktoria Wilkowska, and Martina Ziefle. 2018. Gender-Specific Motivation and Expectations toward Computer Science. In *Proceedings of 4th Gender&IT conference, Heilbronn, Germany, May 2018 (GenderIT'18).* ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3196839.3196858

## 1 INTRODUCTION

There is a high demand for professional computer scientists in Germany [30]. In 2016, more than 51,000 open positions for IT specialists in Germany were reported, an increase of almost 20% within one year [9]. Due to this lack of trained personnel, the German Federal Employment Agency predicted an even higher need for computer science graduates [30]. But not only IT specialists must have IT knowledge today, professionals in nearly all fields encounter advanced dealings with computers to ensure efficient work, modern logistics, intelligent transport systems, data privacy, and IT security and thus, could benefit from basic computational thinking skills and concepts. Examples are the use of databases, awareness of security threats, programmatic use of calculating tools, or the implementation of short programs to optimize workflows [56, 60].

This need for IT experts requires filling more students with enthusiasm for computer science. However, women remain underrepresented in computer science and show less interest for this sector [3, 30]. Apart from a lack of qualified computer scientists for the economy, the underrepresentation of women has further negative consequences, not only for society, but also for women themselves. For example, women miss out on beneficial opportunities the IT industry has to offer [28]. One of these opportunities are well paid and reliable employment conditions [40]. Moreover, serious design flaws were attributed to the absence of women's perspective in the development process [28, 40, 52]. Examples include voice and video recognition software, performing worse for women's voices, airbags only designed for male drivers [43], and intelligent personal assistants such as *Apple's Siri* lacking the ability to offer advice to problems mainly women are concerned with, e.g. sexual assault [40, 44]. Women could offer more diverse perspectives on the development process and draw developers' attention to special needs of women, like physical differences (e.g. in the design of airbags) or topics (e.g. information on sexual assault).

In the following subsection, the current state of women in computer science is presented (Subsection 1.1). Afterwards possible reasons for this gender gap are described based on previous findings in the literature (Subsection 1.2). Based on this overview our research approach in this paper is introduced in Subsection 1.3.

### 1.1 Women in Computer Science

A gender gap between male and female computer scientists can be observed globally in the western world, for example in the U.S. [18, 28, 52], Germany [30], and Spain [45]. The specific proportion of women in computer science study programs and the IT workforce varies but is described to be around 20% in the United States [3, 15], 22% in Sweden, 18% in the UK [23], and 19% female computer science students and 16% women in the IT industry in Germany 2014/15 [30]. Even though the share of women was at its highest point in the 1980ies, it is particularly alarming that the number of female computer science graduates is constantly decreasing [15]. This decline is even more astonishing since the IT sector in general is still thriving [52]. While other initially male-dominated fields such as medicine and chemistry achieved a balanced gender distribution,


*GenderIT, May 14–15, 2018, Heilbronn, Germany*

ACM ISBN 978-1-4503-5346-5/18/05…$15.00
https://doi.org/10.1145/3196839.3196858

STEM (Science, Technology, Engineering, and Mathematics) still suffer from a serious imbalance [14]. A large-scale study by Lehman et al. examined about 30,000 first year students and their intentions to major in computer science or other STEM fields and found out that there are significant differences regarding the proportion of women and their profiles in computer science and other STEM fields, revealing an even more serious gender gap in computer science [40].

The attrition rate of women in computer science can be compared to a leaking pipeline: While at the beginning of their school education a balanced representation of female and male students enter the pipeline, women drop out of it at disproportionate rates at the beginning of university and especially before higher positions in academia and industry [29]. However, several researchers have argued that the disproportion of gender starts as early as high school with reasons going back to their childhood [14, 17, 29]. Despite the positive effects of pre-college computer science classes on students' interest in the subject [34], many high schools in the U.S. still do not offer these classes [33]. Furthermore at this level, female students are already significantly less interested in taking a computer science class or pursuing a related career [14, 54, 58].

Hence, by the time they enter college or university, female students' intention to major in computer science is already four times lower than their male counterparts' plans [14], resulting in the low numbers of female computer science students already discussed. Moreover, the gender gap continues after university with qualified women diverging from the sector [37]. In academia, only 21% of the researchers publishing in computer science conferences are female authors. However, while there still more papers published by only men in contrast of only women, the number of papers with at least one female author is increasing [2]. Another well-known yet nevertheless alarming finding is that women are still concentrated at lower and middle levels but under-represented at higher levels in IT industry [1, 3] and academia [20, 29].

Summing up, a critical gender gap between male and female computer scientists can be confirmed for all levels, starting at high school and going up to industry and academia. In the following subsection, the reasons for these differences will be examined.

## 1.2 Reasons for the Gender Gap

Several researchers examined the reasons for the gender gap, resulting in a large body of scientific research, which indicates significant social barriers [14]. A major influence confirmed by several researchers is women's self-perception and lack of confidence to succeed in a computer science career [14, 21, 26, 28, 34, 40]. Girls and women consistently underestimate their abilities in mathematical, technical, and science subjects, resulting in reduced interest to pursue one of these careers [14, 21, 27, 40]. Even among men and women of comparable academic achievements, women still rate their academic strengths lower than their male counterparts [51]. This lack of confidence even goes as far as that female students who major in computer science nonetheless consider their computing skills lower than men who are not computer science majors [7]. Furthermore, Lehman et al. found out that women in computer science assessed their academic ability lower than women in other STEM fields [40]. However, the expectation whether or not to prevail in a field is of substantial importance to shape the career decision [42]. Hence, increasing women's self-efficacy regarding their skills in science is particularly important to make STEM study programs more attractive for women [6, 11, 40, 61].

Women's low confidence can also be attributed to a lack of experience with computer science. Previous research has shown that male students often have more experience in computing [12]. Investigating more than 1300 first year college students, Beyer found that a positive experience in their first computer science class had a beneficial influence on students' intention to take another class [6]. The significance of early academic exposure to computer science was named one of four most influential factors determining girls' interest in computer science in a report by Google [34].

The early exposure to science and technology can be greatly shaped by social encouragement [52]. If parents or teachers believe that science careers are inadequate for women, young girls might be unconsciously directed to follow different paths [14, 50]. On the other hand, positive reinforcement by family members, teachers, or peers can encourage young girls [34].

A prominent factor, which attracted particular attention in recent research, is the influence of stereotypes [12–14, 28, 42]. Popular TV shows such as *The Big Bang Theory* have painted a picture of scientists as Caucasian or Asian socially incompetent yet naturally brilliant men [14]. In people's stereotypical beliefs, computer scientists are usually socially awkward *geeks* [48], who are only obsessed with computer science [42], prefer to sit in the front of the computer and play video games instead of socially interacting or collaborating [12, 14, 25]. Computer scientists are also believed to be brilliant geniuses, whose intellect was inborn in contrast to being learnable [41]. With the stereotypes described prominent, women in contrast to men have a feeling of dissimilarity with the description of the field, resulting in a lack of sense of belonging [11, 15]. However, the sense of belonging and identifying oneself with a field are crucial determinants of people's decision to pursue that field. Thus, if students miss this sense of belonging, it might deter them from computer science even if they are interested in the subject [4, 32, 35].

The perception of these stereotypes begins as early as elementary school when girls already expect boys to be better at math [22]. Asking about 270 U.S. students for a description of a prototypical computer scientist and their perception of similarity to this prototype, Ehrlinger et al. discovered that women gave more stereotypical-consistent descriptions of the prototypical computer scientist than men. Moreover, women rated themselves to be less similar to this prototype [28]. Particularly the impression that computer science is not a people-oriented or even unsocial field which fosters working alone instead of collaboration has a daunting effect on both men and women, but a significantly stronger influence on females [12]. As a consequence, several researchers could show that successful role models who do not fit into the stereotypical clichés have a positive longterm effect on women's interest [12, 13, 18].

Another negative consequence of these prevalent stereotypes is the denial of women's competence in computer science. After the viral social media *#iLookLikeAnEngineer* campaign, in which women working or studying in STEM fields posted pictures of themselves with the Hashtag *iLookLikeAnEngineer*, Banchefsky et al. conducted two studies, examining the relationship between people's look and the ascribed probability of being a scientist. They yielded the results that women who looked more feminine were attributed a lower likelihood of being a scientist [4]. On the contrary, men's appearance did not alter participants' opinion on whether this man is a scientist. These and other findings (e.g. [46]) reveal that there is still discrimination in STEM fields, which could lead to women's discouragement [14].

### 1.3 Questions Addressed and Logic of Empirical Procedure

The questions addressed in this paper refer to gender-specific aspects of the mastery of computer science as a professional field. The numbers presented in Section 1.1 show the alarming gender gap in computer science. In order to satisfy the need for IT experts in Germany, the sector has to be more attractive for women. A review of literature revealed that, firstly, there are still less women beginning to pursue a computer science career after graduating from school. Secondly, women, who begin a career in computer science, drop out in the early years of universities or before reaching higher in industry and academia.

According to our review an important reason seems to be that women are less exposed to computer science in their childhood and become less interested in entering a STEM study program. Thus, our first question addresses the motives of male and female students for pursuing a computer science study program. We hope that results might provide insights in how to increase motivation for studying computer science, especially among female students. On the other hand, we also want to examine if women and men significantly vary in their expectations before their studies in order to identify possibly discouraging factors.

Since another important reason for the lack of female computer scientists is women's reported lack of confidence and underestimation of abilities, we also explore computer scientists' perception of actually required skills and previous experience to manage the complex contents of the subject matter. These findings could help to foster these skills and experience already in school to improve female students' confidence.

To address these empirical questions, we pursued a two-tier approach, combining qualitative and quantitative procedures. The qualitative approach aimed at understanding possible motives for studying computer science, relevant expectations as well as potential requirements that encourage or prevent students from planning a professional career in computer science. In order to get a deeper insight into cognitive and affective factors as well as possible beliefs about the study course and individual needs, we used semi-structured interviews in which participants were free to comment on selective topics which seemed important to them (cf. Subsetion 2.1).

In the second part of the empirical process we quantified some selected aspects by using an online survey with a larger sample size. One focus of the survey was directed at participants' inclination to using technical innovations and gadgetry (as a motivational driver). Another focus aimed at understanding how the participants evaluate skills and abilities perceived as important for the successful completion of computer science as a study field and professional work (cognitive and affective factors as drivers for individual self-concepts).

## 2 QUALITATIVE RESEARCH APPROACH

To understand students' motivations for studying computer science, a qualitative research approach was chosen, which is suited to systematically scrutinize interviewees' attitudes and opinions [5]. This research design promotes comprehending even complex backgrounds or contexts which have not been considered in research yet and therefore might not emerge when using standardized research methods [24]. A semi-structured interview based on a guideline promises the advantages of a social communication situation, which gives the interviewee a more mundane and natural impression of the actually artificial situation [24]. Therefore, semi-structured interviews were conducted to get a first in-depth insight into students' motives. In a second step, these interviews can be used for forming categories [5], which can be investigated quantitatively (cf. Section 3). In the following subsections, the interview guideline and sample are presented before the findings of the survey are outlined.

### 2.1 Method

The interviews took place from July 13 to August 8, 2016 at participants' choice of place (e.g. participant's home). Participants spent about one and a half hours on the study, whereby the interviews attributed for 50 minutes on average. After concluding the interview, participants were asked to fill out a written demographic questionnaire.

The interview guideline for the semi-structured interview consisted of six units, including a (1) general evaluation of the computer science study program as well as favorite classes, (2) motivation and aims, (3) strategies for exam preparation, (4) group work, (5) dealing with failure, and (6) additional remarks. Due to the immense amount of information only the parts which are presented in the following sections are described here. First of all, students explained why they decided to study computer science and which reasons determined their choice. Apart from students' motivation, they also pointed out expectations they had before entering university. These questions primarily served to establish whether students' motives were intrinsic, e.g. because they were interested in technical subjects, or extrinsic, e.g. they expected to get a good job afterwards. These questions were based on findings that intrinsic motivation results in higher learning success [49] and a decrease in the likelihood of dropping out of the study program [36]. Since several researchers have tried to determine requirements for successfully studying computer science (e.g. [36, 59]), students were asked to name personal skills and experience qualifications they consider important for mastering computer science studies.

Evaluating the results from the interviews, all recorded interviews were transcribed in a first step. These transcripts served as the object of investigation, which were evaluated by the inductive text analysis method *Grounded Theory* according to Glaser. This approach was chosen since a literature analysis did not produce an existing framework for computer science education. Hence, a pure inductive analysis was applied to pursue an open exploratory approach, preventing that a prefabricated framework is imposed on the data and might lead to neglecting new categories [24]. In an iterative and recursive process we identified interesting statements and afterwards sorted, grouped and classified them to categories on higher and multiple levels of abstractions.

## 2.2 Sample

Sixteen students participated in the interviews with five female and eleven male participants. Seven of the interviewees were pursuing a Computer Science Bachelor's degree, three studied in a Computer Science Master program. Six participants were doing a Bachelor in Technical Communication, a two-subject degree consisting of 50% computer science on the one hand and 50% psychology and communication studies on the other hand. Four of the five female participants studied Technical Communication. The participants were 19 to 27 years old (average age: 24 years). They were in their second to ninth semester.

## 2.3 Qualitative Findings

In the following subsection the category system resulting from the interviews and the inductive and recursive categorization is presented. First of all participants' *motivations for studying computer science* are outlined. Afterwards, the results from participants' descriptions of their *expectations* in advance of beginning the study program are demonstrated. Eventually, participants' assessments of *required qualifications* for studying computer science are explained, differentiating between personal skills and critical previous experience. Although it was not explicitly asked as part of the interview guideline, some participants commented on their views of *stereotypical computer scientists*, which are presented in the last subsection. The presented categories derived from the Grounded Theory analysis, in which we clustered and classified participants' answers. To give an early impression of different gender perspectives, the tables provide the absolute frequencies of male (labeled by *nr male*) and female (labeled by *nr female*) participants, who indicated the according category. In addition, the total number of male and female participants is noted. However, it has to be stressed that due to the small sample of interviewees ($N = 16$) and the qualitative non-standardized approach these frequencies can only provide preliminary indications.

*2.3.1 Motivation for studying computer science.* As can be seen in Table 1, participants gave primarily intrinsically motivated reasons for their choice to study computer science. Thirteen participants decided to study computer science mainly due to their interest in technical and mathematical contents. For example, one participant pointed out that he has been interested in computer science for a very long time so that he expected computer science to be suitable career for him:

> "Yes, because I rather like technical stuff [...] And I found it interesting, it was fun for me and then I thought this could fit for a job later." (P9, male, translated from German)

While also the majority of male participants claimed interest to be a critical factor for their decision, all five participating women emphasized the effect of this reason.

Five participants outlined that their motivation was based on an assessment of their personal abilities. They expected to have skills, e.g. mathematical reasoning, which are useful for being successful in computer science. For example, one participant stated:

> "Math is important for studying computer science, you need this logical reasoning and I think these are things I am quite good at and that's why I decided for it." (P10, female, translated from German)

Although two participants expressed an interest in studying mathematics, they decided to study computer science because they favored its variety and practical application. Two participants explained that they appreciated the kind of learning in computer science. It is conspicuous that only women reported this reason.

On the other hand, three extrinsically motivated reasons influenced participants' decision. However, only two participants mentioned solely extrinsic reasons whereas the majority stated intrinsic as well as extrinsic reasons. Extrinsically motivated reasons included good prospects of getting a job and an influence by friends and family, who favored the study program. Yet, for two participants (both male) the lack of restriction of admission as study's entrance at the university played a role in their decision due to poor A-level results.

**Table 1: Participants' intrinsic and extrinsic motivation for studying computer science, absolute frequencies of male (*nr male*) and female (*nr female*) participants, who indicated the according category.**

| Category | nr male $n_{male} = 11$ | nr female $n_{female} = 5$ |
|---|---|---|
| **Intrinsic motives** | | |
| Interest in computer science | 8 | 5 |
| Personal abilities | 4 | 1 |
| More applied than mathematics | 1 | 1 |
| Kind of learning | 0 | 2 |
| **Extrinsic motives** | | |
| Good prospects of getting a job | 2 | 2 |
| Influence by friends and family | 1 | 1 |
| No restriction on admission | 2 | 0 |

**Table 2: Participants' expectations before entering university, absolute frequencies of male (*nr male*) and female (*nr female*) participants, who indicated the according category.**

| Category | nr male $n_{male} = 11$ | nr female $n_{female} = 5$ |
|---|---|---|
| Study program is demanding | 5 | 2 |
| More practical skills | 3 | 1 |
| Being prepared to find a good job after graduating | 2 | 2 |
| No expectations in advance | 4 | 0 |
| More programming skills | 1 | 2 |
| Developing better knowledge about computers | 0 | 2 |

**Table 3: Skills for successfully studying computer science according to participants, absolute frequencies of male (*nr male*) and female (*nr female*) participants, who indicated the according category.**

| Category | nr male $n_{male} = 11$ | nr female $n_{female} = 5$ |
|---|---|---|
| Interest in computer science | 3 | 4 |
| Endurance | 5 | 2 |
| Motivation | 6 | 0 |
| Willingness to deal with complex contents | 3 | 2 |
| Abstract, logical reasoning and mathematical skills | 3 | 2 |
| Discipline | 3 | 1 |
| Teamwork/Team spirit | 3 | 0 |
| Patience | 0 | 1 |

*2.3.2 Expectations before studying.* First semester students usually have several expectations before entering university. In the interviews, participants were asked to remember their expectations before they began their study program. An overview of their expectations can be found in Table 2. Seven participants expected the study program to be demanding. For example, participant 10 explained that she was aware of the level of difficulty:

> "I said if I go to RWTH University and study computer science, I don't have the aim to be the best any more. I knew that it's going to be demanding." (P10, female, translated from German)

However, participants anticipated to gain more practical skills, especially regarding programming skills and knowledge about computers. This expectation was particularly reported by female participants.

> "We only learned to code in the first semester but I expected to improve my programming skills." (P4, female, translated from German)

Both male and female participants claimed that they assumed at the beginning of their studies that a degree in computer science improves their prospects of finding a good job after graduating. In contrast, four participants explained that they did not examine the contents of the study program in advance so that they did not have any specific expectations. It is striking that only male participants stated a lack of expectations.

*2.3.3 Required Qualifications.* When participants were asked about required qualifications for studying computer science, they predominantly named personal skills (cf. Table 3) instead of necessary experience (cf. Table 4). Interest in computer science subjects, especially in mathematical and theoretical concepts, as well as endurance to see the studies through, particularly during the demanding first semesters were mentioned most often. Therefore, students also have to be able to motivate themselves. Interestingly, four of five female participants stressed the importance of interest in computer science topics in contrast to only three of eleven male participants. Six of eleven male participants put emphasis on motivation whereas this skill was not mentioned by any female participants at all.

**Table 4: Required or beneficial experience for studying computer science according to participants, absolute frequencies of male (*nr male*) and female (*nr female*) participants, who indicated the according category.**

| Category | nr male $n_{male} = 11$ | nr female $n_{female} = 5$ |
|---|---|---|
| **Necessary qualifications** | | |
| Previous computer science knowledge is necessary | 1 | 0 |
| **Beneficial qualifications** | | |
| Advanced mathematics class at school is beneficial | 6 | 2 |
| Computer science experience is beneficial | 6 | 1 |
| **Unnecessary qualifications** | | |
| Advanced mathematics class at school is not necessary | 3 | 3 |
| Programming skills are not necessary | 2 | 3 |

Furthermore, five participants claimed that students have to be willing to deal with concepts despite difficulties and setbacks until they finally understand them. Moreover, five participants recommended that first year students should have mathematical and logical reasoning skills as well as the ability to think in the abstract. Further mentioned skills included the ability to work in teams, discipline, patience, and independent working. While most of the skills did not indicate a different perception between male and female participants, it is conspicuous that only male participants pointed out the importance of team spirit in collaborative work environments. The requirement for these skills is summed up in a quote by a participant, who explained that students should not feel discouraged or give up but struggle their way through their studies:

> "You mustn't get discouraged, so you somehow have to stay tuned and don't give up directly, you have to go through some stuff and struggle your way through. Yes, you have to want it, you have to enjoy it, you have to be interested in what you do because I think otherwise you can't do it." (P10, female, translated from German)

Regarding required previous experience for studying computer science, for example specific classes or knowledge, participants were in agreement that previous experience can be beneficial but is not necessary (cf. Table 4). Only one participant was convinced that previous knowledge about computer science was important. In contrast, eight participants pointed out that advanced mathematical classes are beneficial but not necessary to succeed. Seven participants agreed with this view concerning computer science experience, as explained by one participant:

> "I don't really think it [experience] is important. Being able to code might be useful because you can easily apply it but I don't think it's a requirement." (P12, male, translated from German)

On the other hand, six participants stressed that advanced mathematical classes at school are not necessary at all and five participants claimed the same for programming skills. Interestingly, male participants predominantly described previous knowledge and experience as beneficial while most female participants indicated that they do not think that previous knowledge is important.

Although the perception of stereotypical computer scientists was originally not part of the interview guideline, it became a matter of discussion in some interviews. Hence, it has to be emphasized that these categories cannot be seen as *complete* since the majority of participants did not comment on this issue. However, the findings give first interesting indications which are considered in the questionnaire (cf. Section 3). Three participants (two female) depicted a computer scientist as someone who spends a lot of time with his computer. Furthermore, two female interviewees expected a computer scientists to have a profound knowledge of computers and programming skills. Another male participant added that a stereotypical computer scientist is not socially competent. An example description was given by participant 7:

> "There are these stereotypes of computer scientists, who are not that socially competent, play a lot of computer games [...] and sit a lot in front of their PCs without many social contacts." (P7, male, translated from German)

Summing up, the interviews revealed that computer science students have predominantly intrinsic motives for entering the study program. Interest in computer science was named by almost all participants. Moreover, we found that participants hold different expectations before entering the study program, especially learning practical or programming skills. In total, eight skills for successfully studying computer science were named, including interest in computer science, endurance, and motivation. On the other hand, participants stated that previous experience, for example with computer science or advanced mathematics, is not necessary for mastering the study program. The qualitative findings provide preliminary indications that there are differences between male and female computer science students regarding their motives, expectations, and the importance of skills. This assumption is evaluated in a quantitative online questionnaire, which is presented in the following section.

## 3 QUANTITATIVE RESEARCH APPROACH

In the next step of the empirical approach a quantitative questionnaire was designed to, firstly, expand and supplement the already existing empirical data basis, and secondly, to validate the most interesting findings in a quantitative way. In this publication, only an extract from the quantitative data is presented which complements the previously described qualitative data, focusing on students' assessments of their skills and their description of prototypical computer scientists. The question concerning characteristics of prototypical computer scientists was included since some participants introduced the topic of stereotypes in the interviews and recent research pointed to their importance (cf. Section 1). The target group were students and alumni of computer science at different educational levels and with various major fields (e.g., computer science, media informatics, technical informatics etc.).

### 3.1 Method

Apart from demographic data, participants answered questions about the duration of their study (*In which semester are you currently studying?*), studying behavior and success (e.g., *How often have you failed in computer science exams during your studies (so far)?*) in the first part of the survey. Furthermore, participants stated their perceptions regarding the ease of studying computer science (*How easy / How difficult is it for you to study computer science?*). These questions were addressed due to participants' descriptions of their expectations of a very demanding computer science study program.

Due to the prevailing intrinsic motives of interest in computer science and perceived personal abilities, the next section focused on requirements for successful learning in computer science: Here, self-assessment of personal abilities (e.g., reasoning power) and skills (e.g., social competence) were inquired. The presented skills and abilities in the questionnaire were based on the previously presented statements in the interviews regarding required personal skills as well as previous experience and knowledge. Moreover, participants' behavior and attitude towards technical innovations were examined (cf. Figure 1). Eventually, participants were asked to briefly describe their mental image of a prototypical computer scientist and to assess how this image corresponds with the actual image of themselves.

The second part of the quantitative method dealt with two scenarios regarding collaborative work in computer science with and without a learning tool. Hence, the focus of this part of the survey lied on the learning tool, which has to be regarded separately and was only the first step in a running study. Thus, according to the incompleteness of the scientific data and a slightly deviant topic, the results of the second part will be not included in the presented analyses but will be subject of future research.

The student participants who took part in the quantitative study were mainly reached at German universities (RWTH Aachen University, LMU Munich, TU Berlin). It took about 20 minutes to complete the questionnaire and the data collection of the survey lasted for about four weeks in 2016 and two weeks in 2017.

### 3.2 Sample

Overall $N = 205$ respondents were analyzed in the quantitative study. The vast majority of the participants (81%) was currently studying, thereof 61% pursued a Bachelor's degree and 39% a Master's degree. The remaining 19% of the respondents were – freshly and already earlier graduated – alumni. The age of the participants ranged from 18 to 63 years ($M = 24.9$; $SD = 6.4$) with a median value of 23 years.

The participation of women and men in the sample reflects a generic distribution of gender in computer science: 21% women ($n = 43$) and 76% men ($n = 156$) took part in the quantitative study (3% of the sample did not specify their gender). More than half of the respondents (56%) reported to have failed an exam at least once in the course of their studies. Even so, a large part of the sample was

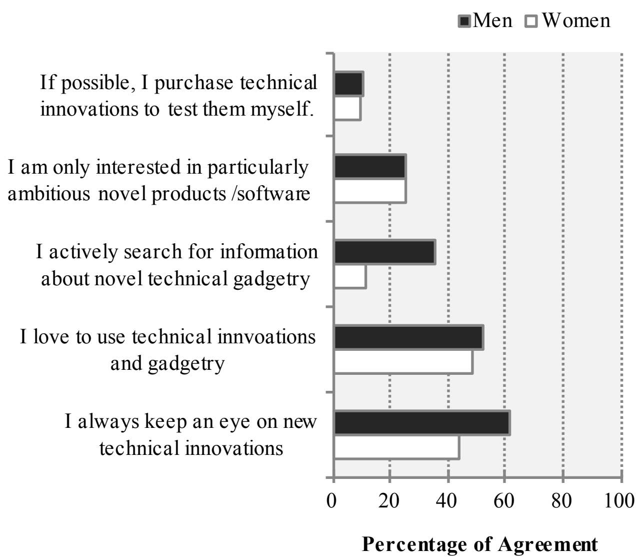


**Figure 1: Items and descriptive outcomes (means) of the attitudes toward technical innovations in both genders.**

just at the beginning of their studies so that, according to the considerable failure rate, the probability of further fails is not negligible. Apart from this objective measure of difficulty, the questionnaire additionally included a question about subjectively perceived difficulty of the study of computer science (answers ranged from 1 = *very difficult* to 6 = *very easy*). Most of the ratings covered the middle categories [*(rather) difficult* 47% and *(rather) easy* 50%] while 2% of the entire sample described their field of study as *very difficult*; as opposed to this, only one person perceived it as *very easy*. In the assessment of both aspects, academic performance [$t(193) = -1.03$, n.s.] and perception of the easiness/difficulty of the course of studies [$t(190) = -1.3$, n.s.], females and males did not differ significantly.

In addition, participants' behavior and attitudes towards technical innovations was assessed using statements as presented in Figure 1. A multiple answers format was given so that each participant could mark all items applicable. As can be seen in the figure, most of the statements were selected more often by male respondents than by female respondents. However, the only significant difference between both genders resulted for the statement: *I actively search for information and reports about novel technical gadgetry.* Here, 35% of males, but barely 12% of females reported to engage in this behavior [$\chi^2(1) = 7.97, p = .005$]. Apparently, men stronger than women try to keep their theoretical background knowledge regarding technical innovations up to date.

## 3.3 Quantitative Findings

The results of the reported quantitative outcomes are presented as follows: For a descriptive analysis, means ($M$) and standard deviations ($SD$) were calculated. For the inferential statistical analysis of differences between the gender groups, an independent samples $t$-test was used. The level of statistical significance ($p$) was set at the conventional 5%.

**Table 5: Significant gender differences in abilities necessary in computer science (f=females; m=males).**

| Ability | t-test | $M_f$ (SD) | $M_m$ (SD) |
|---|---|---|---|
| Abstract reasoning | $t(174)$=-3.3, $p \leq 0.001$ | 4.3 (1.0) | 4.8 (0.7) |
| Mathematic skills | $t(173)$= 2.2, $p$=0.029 | 4.3 (0.9) | 3.9 (0.9) |
| Social competence | $t(173)$= 2.3, $p$=0.024 | 4.9 (1.2) | 4.4 (1.2) |
| Interest in CS | $t(173)$=-4.7,$p \leq 0.001$ | 4.7 (0.8) | 5.3 (0.7) |
| Programming | $t(174)$=-7.3,$p \leq 0.001$ | 3.0 (1.4) | 4.6 (1.1) |

Based on the outcomes of the qualitative study, participants assessed their own skills, which are perceived as necessary for successfully studying and mastering the complex subject matter of computer science. The aim was to validate the findings within a larger number of respondents and to examine whether women and men assess their competencies in cognitive, social and communicative skills, persistence, interest in computer science as well as programming abilities in different ways. Figure 2 depicts the particular skills and abilities in more detail, showing the mean values for women and men separately.

Independent-samples $t$-tests were calculated to examine if there are considerable gender differences in self-assessed abilities. The significant results of the statistical analyses and the descriptive values for both gender groups are summarized in Table 5.

The outcomes confirm significant differences between men and women's perceptions regarding some of the respondents' abilities. While female participants attributed themselves on average higher competencies in the social area and – contrary to the common stereotypes – mathematical skills, males considered themselves significantly superior in programming, abstract reasoning and the general interest in computer science. Regarding the other skills and traits which were considered requirements for mastering computer science, men and women did not differ significantly from each other. In general, both genders reached on average quite high mean values regarding skills and behavior characteristics referred to as relevant for the discipline of computer science, evaluating their know-how and persistence mostly as good and very good.

Participants were asked in the questionnaire to give a textual description of a prototypical computer scientist. Afterwards, the respondents assessed to what extent they match this characterization. The textual descriptions have not been evaluated in detail, yet. However, the findings demonstrated that there are significant differences between male and female participants' assessments of correspondence to the stereotype [$t(144) = -2.7, p = .008$]. Men described their agreement in accordance with their description of a prototypical computer scientist ($M_m = 3.8, SD_m = 1.5$) higher than women ($M_f = 3.0, SD_m = 1.4$), who stated on average that the description does rather not apply. The difference is depicted in Figure 3. Nonetheless, it should be noticed that male participants were also cautious concerning their agreement with the prototypical characterization.

## 4 LIMITATIONS

In Sections 2 and 3, the research design and its appropriateness for the aims of this thesis were presented. Nonetheless, these methods

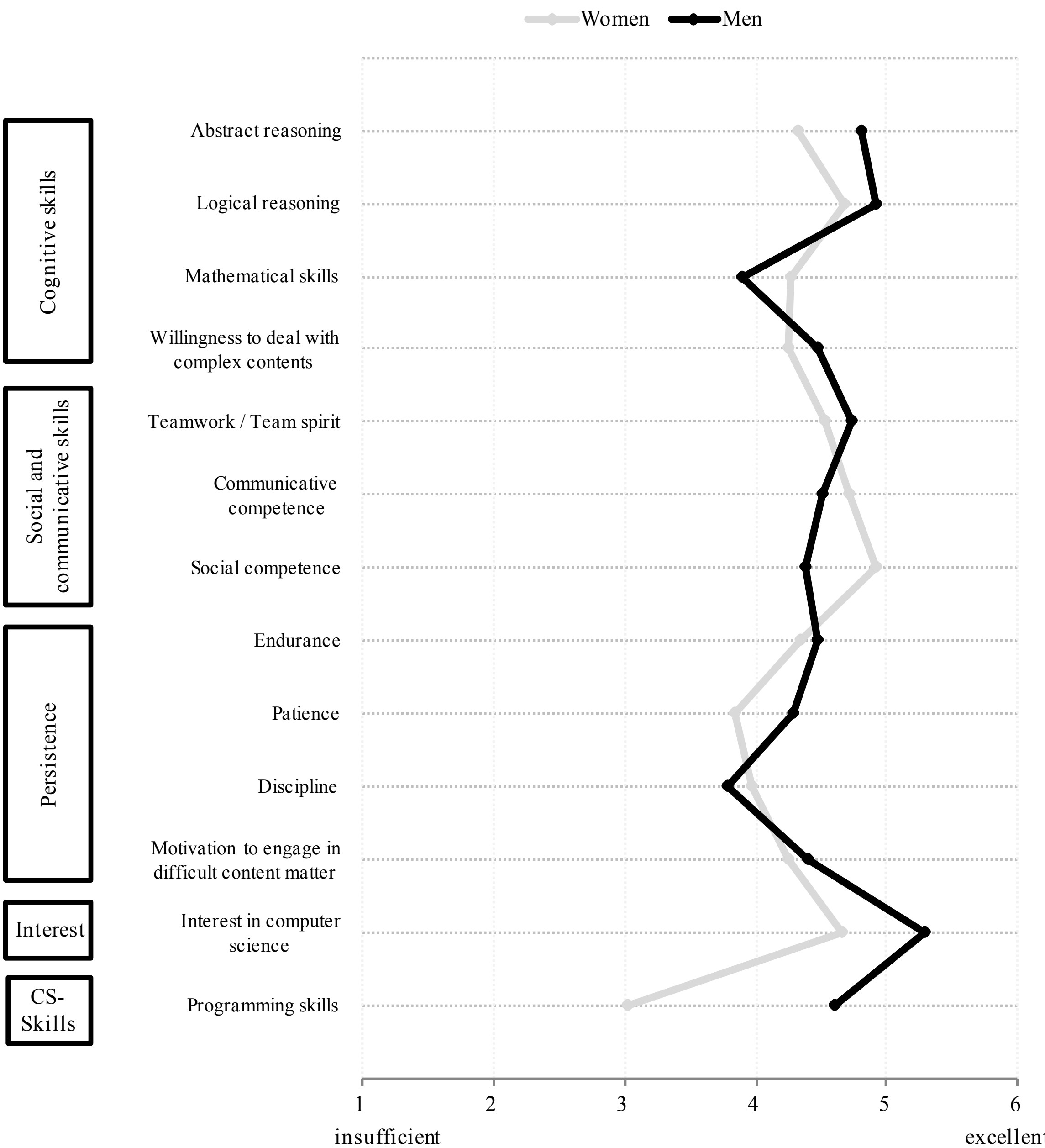


**Figure 2: Gendered self-assessment of abilities perceived as necessary for success in computer science (CS).**

are subject to limitations, which have to be considered for adequate interpretations. Although qualitative interviews offer the advantage of high validity and depth, the reliability and controllability are limited [5]. Hence, an influence by the interviewer and social desirability cannot be excluded. However, since participants revealed many personal details and even admitted to failures, a positive atmosphere in the interviews can be assumed.

Although the sample of the online survey was significantly bigger than the sample of the qualitative interviews, its representativeness cannot be guaranteed. The group of female participants, yet representative of the overall computer science population, was small. Another aspect which has not been considered yet is the influence of study program or semester on the evaluation. For example, study programs with a specific focus, e.g. Media Informatics, could differ regarding specific skills like programming abilities. In addition, only subjective self reports were examined. Consequently,

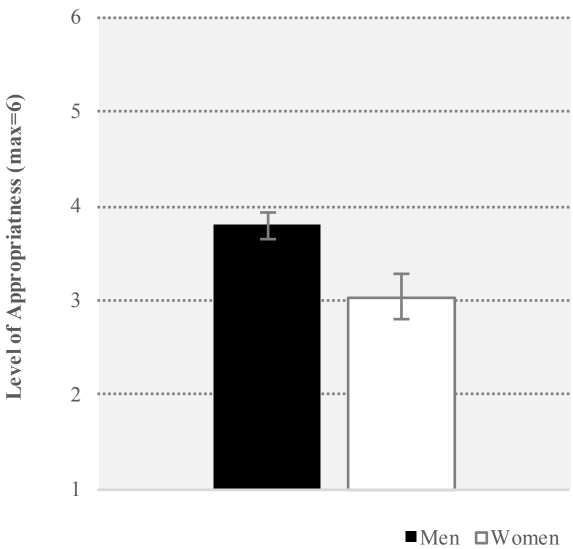


**Figure 3: The effect of gender on perceived appropriateness of a computer scientist's prototypical image with the self-image.**

student's objective abilities could not be compared. However, since literature stressed the importance of *perceived* abilities [14], this study focused on self reports. It could be interesting to compare subjective and objective means of skills in future studies. Further implications of the results as well as suggestions for future work are presented in the following section.

## 5 DISCUSSION AND FUTURE WORK

This study aimed at collecting motives for studying computer science, expectations towards the study program as well as underlying skills and abilities, which are assumed to be necessary to master the study course in computer science. The results of the presented studies confirm that women and men are guided by different motives and expectations regarding the subject of computer science.

The most crucial motive determining participants' choice to pursue a computer science career was interest in the contents. The majority of participants in the interviews also stated that this interest is an important requirement for succeeding in computer science. Especially women focused on this requirement while male participants emphasized the importance of motivation to see the tough studies through. It appears that for female participants the clear interest in computer science is sufficient as an incentive. Margolis and Fisher explained that female students often drop out of the study program due to a lack of interest and confidence [43]. Moreover, male computer science students have often developed an interest very early as children, while women encounter computer science in high school or later [43]. Hence, women could regard interest the most crucial factor, which has to be fulfilled while other requirements are less important in comparison. On the other hand, since the terms of motivation and interest were not clearly defined in the studies, future research should also investigate whether men and women understand these terms differently.

Thus, it is not surprising that the quantitative results revealed that both male and female respondents assessed their interest in computer science rather high to very high. However, despite female participants' emphasis on the necessity of interest in computer science, women still rate their interest significantly lower than men. This difference could be attributed to women's beliefs that a prototypical computer scientist has a large expertise in programming and technology [14]. When comparing themselves with this prototypical image, they might downgrade their own interest [43]. Furthermore, the findings from the questionnaire also indicate that women are less interested in innovative technologies than men, implying that women are less engaged with computer science topics in their leisure time.

The second most prominent motive for pursuing a computer science study program was an assessment of students' abilities. Participants in the interviews claimed that they were convinced of having skills that might be useful for a computer science career, e.g. mathematical reasoning skills or programming experience. These results confirm previous findings, stressing the importance of self-perceived abilities considered important for mastering the field [42][40]. Looking at the profiles of both genders, it is evident that the trends are rather similar: Both, female and male computer scientists attribute (quite) high levels of abilities and skills necessary to master the subject matter. In their perceptions of essential characteristics like work persistence, discipline, motivation as well as team spirit they do not differ significantly, testifying a high sense of responsibility and disposition to bear the brunt.

Although there are high accordances between men and women's assessments of skills and abilities, there are some intriguing differences. Female respondents averagely ascribed themselves higher social and communicative competencies, which is in accordance with previous findings (e.g. [36]). Concerning team work and spirit, no significant differences could be found. However, it is interesting that female interviewees did not mention team spirit as a required skill for mastering computer science studies although these programs usually include collaborative projects. Since previous research showed that a collaborative environment, which is often not associated with computer science, is important for the majority of female students [12], this aspect should be investigated further.

The general high assessment of mathematical and technical skills is in accordance with previous discoveries of self-assessed strengths by computer scientists [36]. Surprisingly, in contrast to previous findings [40, 51], female respondents rated their abilities in mathematics significantly higher than male participants. Since encouraging girls in mathematics was promoted during the last years, our findings might indicate that these efforts were fruitful. On the other hand, men assessed their abstract reasoning abilities as well as their programming skills significantly more pronounced than women. These results are supported by previous research on lower self efficacy in science among women [7, 40]. While mathematical as well as programming abilities are more likely to be improved by experience and education, abstract reasoning skills are often assumed by people to be innate [55]. Previous research has revealed that girls and young women have less experience with computer science topics than boys [14], which could have influenced female participants' perception of their low programming skills. Experience with mathematical topics in school, however, is similar for women and men. Therefore, these results provide preliminary evidence that experience in an initially male-dominated skill set like mathematical abilities could increase women's self-perceived assessment.

Whereas a certain part of male respondents did not have any expectations regarding studying computer science in advance, female interviewees reported to have given their decision particular thought. Since computer science is stereotypically male-dominated, female students are more likely to put effort into the decision and decide with awareness. Hence, women have clear expectations of learning gains during their studies, including advanced technical knowledge and practical skills (e.g., programming). However, our findings suggest that these skills are not fostered yet in computer science study programs and hence might disappoint women's expectations.

Our results as well as previous research (e.g. [14, 34]) stressed the importance of perceived abilities considered necessary for the field to increase women's confidence. Nonetheless, it should be noticed that female students themselves in the interviews reported that experience in computer science or advanced mathematics classes are not necessary for mastering the study program. Female participants in the interviews often refered to themselves as example for succeeding without prior experience while male participants usually had experience in computer science before beginning their studies, once again confirming previous findin[43]. Hence, the most important factor to improve the current gender gap seems to be convincing young women to actually begin with a computer science major in the first place. Therefore, interest by exposing women to computer science on high school levels as well as appealing and practical computer science education in universities addressing women's expectations are critical according to our findings as well as previous research [13, 27, 34].

Similar implications were drawn in recent research [47]. Apart from interest, women pointed out the kind of learning as an essential intrinsic motive. Both findings corroborate recent STEM claims, published by Microsoft [47]. Their paper stresses policy and high school education as major components for attracting women to technical professions, based on an area-wide European study with more than 11,500 women. Among policy issues, it was claimed that computer science education should have a specific focus on technical didactics, integrating digital media literacy, data competency as well as programming skills in the broader curriculum. This approach would foster an early support of women in STEM fields and deepen the interest in these topics, which is perceived as essential by the female participants in our study.

Examining male and female students' motives for majoring in computer science, an important factor is the opportunity to combine it with another field of interest such as medicine or business [12] or becoming aware of the variety of applications and the potential of social impact [34]. Thus, more hands-on experience with technical topics, their social contextualization and especially their relevance to societies' well being is needed to make a lasting improvement on women's interest in computer science [47]. Examples could include the application of STEM solutions for improving medical work or increasing car safety.

One possibility to achieve this aim are more experimental forms of learning that could be used in education and training, in line with innovative and technically enriched didactics. For example, collaborative learning environments are appreciated by female students and could be fostered in computer science study programs [12]. Furthermore, playful interactions with technology could be a promising approach to expose female students early to technology in schools since these learning didactics allow a more creative engagement with abstract concepts and could thus increase women's confidence in dealing with complex and theoretical concepts instead of being detered by them [10, 53]. Therefore, future research should address new learning didactics in computer science, designed to address girls' needs.

Moreover, our results indicated that students have inadequate expectations before entering a computer science university program. For example, participants in the interviews stressed that previous experience in mathematics and computer science is not required. Hence, we suggest that future research examines how adequate expectations and requirements can be communicated to pupils. A possible approach to overcome these obstacles could be role models. The power of role models for the forming of attitudes and interests in general, but particular in science education is undisputed [19]. Understanding the potential of womens' identification with successful models that allow female students to picture themselves in STEM fields and professions could support womens' internal focus on social contexts in IT and the strong interest in the contents from another side.

Beyond these findings concerning students' motivation, expectations and cognitive abilities for the mastery of computer science, naturally, there are many more issues that might be relevant for the final inclination to study computer science. It is a well-known, deeply ingrained and pertinent prejudice that male computer scientists are *nerds*, with only low enthusiasm to share social engagements and low skills in social and communicative situations [8, 14, 39, 57]. Within the literature, there is much discussion about the geek culture in STEM education, the pertinence of stereotypes and the media as part of it [16, 38]. Our findings also suggested that female computer science students have stereotypical perceptions of a prototypical computer scientist, with which they cannot identify, confirming previous findings by Ehrlinger et al. Our future work will include to evaluate participants' qualitative textual descriptions of a prototypical computer scientist's characteristics to be able to address these stereotypes.

On the other hand, computer science students who *do* identify with the stereotypes should not be deterred from pursuing this career either. For example, several interviewees expressed praise for a professor who included *Star Wars* examples in his theoretical mathematics class. Instead of dismantling stereotypes completely, the diversity and variety of applications of computer science should be stressed.

## ACKNOWLEDGMENTS

This project was supported by the project TABULA funded by the German federal ministry of Research and Education [under the reference number 16SV7574K].

## REFERENCES


[1] Renée B. Adams and Tom Kirchmaier. 2016. Women on Boards in Finance and STEM Industries. *American Economic Review* 106, 5 (May 2016), 277–81.

[2] Swati Agarwal, Nitish Mittal, Rohan Katyal, Ashish Sureka, and Denzil Correa. 2016. Women in computer science research: What is the bibliography data telling us? *ACM SIGCAS Computers and Society* 46, 1 (2016), 7–19.

[3] Manju K Ahuja. 2002. Women in the information technology profession: A literature review, synthesis and research agenda. *European Journal of Information Systems* 11, 1 (2002), 20–34.

[4] Sarah Banchefsky, Jacob Westfall, Bernadette Park, and Charles M Judd. 2016. But you don't look like a scientist!: Women scientists with feminine appearance are deemed less likely to be scientists. *Sex Roles* 75, 3-4 (2016), 95–109.

[5] Bruce L Berg. 2004. *Qualitative Research Methods for the Social Sciences.* Pearson Education, Boston.

[6] Sylvia Beyer. 2014. Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades. *Computer Science Education* 24, 2-3 (2014), 153–192.

[7] Sylvia Beyer and Susan Haller. 2006. Gender differences and intragender differences in Computer Science students: Are female CS majors more similar to male CS majors or female nonmajors? *Journal of Women and Minorities in Science and Engineering* 12, 4 (2006), 337–365.

[8] Sylvia Beyer, Kristina Rynes, Julie Perrault, Kelly Hay, and Susan Haller. 2003. Gender differences in computer science students. *ACM SIGCSE Bulletin* 35, 1 (2003), 49–53.

[9] bitkom. 2016. 51.000 offene Stellen für IT-Spezialisten. (2016). Last access 2017/10/22, https://www.bitkom.org/Presse/Presseinformation/51000-offene-Stellen-fuer-IT-Spezialisten.html.

[10] Philipp Brauner, Thiemo Leonhardt, Martina Ziefle, and Ulrik Schroeder. 2010. The effect of tangible artifacts, gender and subjective technical competence on teaching programming to seventh graders. *Teaching Fundamentals Concepts of Informatics* 5941 (2010), 61–71.

[11] Philipp Brauner, Martina Ziefle, Ulrik Schroeder, Thiemo Leonhardt, Nadine Bergner, and Birgit Ziegler. 2018. Gender Influences On School Students? Mental Models of Computer Science: A Quantitative Rich Picture Analysis with Sixth Graders. In *GenderIT: Gender & IT, May 14–15, 2018, Heilbronn, Germany.* ACM, New York, USA.

[12] Lori Carter. 2006. Why students with an apparent aptitude for computer science don't choose to major in computer science. *ACM SIGCSE Bulletin* 38, 1 (2006), 27–31.

[13] Sapna Cheryan, Benjamin J Drury, and Marissa Vichayapai. 2013. Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychology of Women Quarterly* 37, 1 (2013), 72–79.

[14] Sapna Cheryan, Allison Master, and Andrew N. Meltzoff. 2015. Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology* 6 (2015), 49.

[15] Sapna Cheryan, Victoria C Plaut, Paul G Davies, and Claude M Steele. 2009. Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of personality and social psychology* 97, 6 (2009), 1045.

[16] Sapna Cheryan, Victoria C Plaut, Caitlin Handron, and Lauren Hudson. 2013. The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex roles* 69, 1-2 (2013), 58–71.

[17] Clemencia Cosentino de Cohen and Nicole Deterding. 2009. Widening the net: National estimates of gender disparities in engineering. *Journal of Engineering Education* 98, 3 (2009), 211–226.

[18] J McGrath Cohoon. 2001. Toward improving female retention in the computer science major. *Commun. ACM* 44, 5 (2001), 108–114.

[19] Richard K. Coll, Bev France, and Ian Taylor. 2005. The role of models/and analogies in science education: implications from research. *International Journal of Science Education* 27, 2 (2005), 183–198.

[20] European Commission. 2016. She Figures 2015. (2016). Last access 2018/02/14, https://ec.europa.eu/research/swafs/pdf/pub_gender_equality/she_figures_2015-final.pdf.

[21] Shelley J Correll. 2001. Gender and the career choice process: The role of biased self-assessments. *Amer. J. Sociology* 106, 6 (2001), 1691–1730.

[22] Dario Cvencek, Andrew N Meltzoff, and Anthony G Greenwald. 2011. Math–gender stereotypes in elementary school children. *Child development* 82, 3 (2011), 766–779.

[23] Deloitte. 2016. Women in IT jobs: it is about education, but it is also about more than just education. (2016). Last access 2018/02/14, https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology-Media-Telecommunications/gx-tmt-prediction2016-women-it-jobs.pdf.

[24] Norman K Denzin and Yvonna S Lincoln. 1994. *Handbook of qualitative research.* Sage publications, Thousand Oaks, CA, US.

[25] Amanda B Diekman, Elizabeth R Brown, Amanda M Johnston, and Emily K Clark. 2010. Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science* 21, 8 (2010), 1051–1057.

[26] Jacquelynne Eccles, Bonnie Barber, Deborah Jozefowicz, Oksana Malenchuk, and Mina Vida. 1999. Self-evaluations of competence, task values, and self-esteem. In *Beyond Appearance: A New Look at Adolescent Girls*, Norine G. Johnson, Michael C. Roberts, and Judith Worell (Eds.). APA, Washington, D.C., 53–83.

[27] Joyce Ehrlinger and David Dunning. 2003. How chronic self-views influence (and potentially mislead) estimates of performance. *Journal of personality and social psychology* 84, 1 (2003), 5.

[28] Joyce Ehrlinger, E Ashby Plant, Marissa K Hartwig, Jordan J Vossen, Corey J Columb, and Lauren E Brewer. 2017. Do Gender Differences in Perceived Prototypical Computer Scientists and Engineers Contribute to Gender Gaps in Computer Science and Engineering? *Sex Roles* 78 (2017), 1–12.

[29] Henry Etzkowitz, Carol Kemelgor, and Brian Uzzi. 2000. *The Advancement of Women in Science and Technology.* Athena Unbound, Cambridge.

[30] German Federal Employment Agency. 2016. Statistik/ Arbeitsmarktberichterstattung (2016): Der Arbeitsmarkt für IT-Fachleute in Deutschland. (2016).

[31] Barney Glaser. 2017. *Discovery of grounded theory: Strategies for qualitative research.* Routledge, London, New York.

[32] Catherine Good, Aneeta Rattan, and Carol S Dweck. 2012. Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of personality and social psychology* 102, 4 (2012), 700.

[33] Google and Gallup. 2015. Searching for computer science: Access and barriers in U.S. K-12 education. (2015). Retrieved from http://g.co/cseduresearch.

[34] Google CS Ed Research group et al. 2014. *Women who choose computer science – what really matters: The critical role of encouragement and exposure.* Technical Report. Google. Retrieved from http://static.googleusercontent.com/media.

[35] Bettina Hannover and Ursula Kessels. 2004. Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science. *Learning and instruction* 14, 1 (2004), 51–67.

[36] Christoph Heine, Jürgen Egeln, Christian Kerst, Elisabeth Müller, and Sang-Min Park. 2006. *Bestimmungsgründe für die Wahl von ingenieur- und naturwissenschaftlichen Studiengängen: Ausgewählte Ergebnisse einer Schwerpunktstudie im Rahmen der Berichterstattung zur technologischen Leistungsfähigkeit.* ZEW Dokumentationen 06-02. ZEW - Zentrum für Europäische Wirtschaftsforschung / Center for European Economic Research.

[37] Sylvia Ann Hewlett, Carolyn Buck Luce, Lisa J Servon, Laura Sherbin, Peggy Shiller, Eytan Sosnovich, and Karen Sumberg. 2008. The Athena factor: Reversing the brain drain in science, engineering, and technology. *Harvard Business Review Research Report* 10094 (2008), 1–100.

[38] Lori Kendall. 1999. "The nerd within": Mass media and the negotiation of identity among computer-using men. *The Journal of Men's Studies* 7, 3 (1999), 353–369.

[39] Lori Kendall. 2011. White and nerdy: Computers, race, and the nerd stereotype. *The Journal of Popular Culture* 44, 3 (2011), 505–524.

[40] Kathleen J Lehman, Linda J Sax, and Hilary B Zimmerman. 2016. Women planning to major in computer science: Who are they and what makes them unique? *Computer Science Education* 26, 4 (2016), 277–298.

[41] Sarah-Jane Leslie, Andrei Cimpian, Meredith Meyer, and Edward Freeland. 2015. Expectations of brilliance underlie gender distributions across academic disciplines. *Science* 347, 6219 (2015), 262–265.

[42] Colleen M Lewis, Ruth E Anderson, and Ken Yasuhara. 2016. I Don't Code All Day: Fitting in Computer Science When the Stereotypes Don't Fit. In *Proceedings of the 2016 ACM Conference on International Computing Education Research.* ACM, Melbourne, 23–32.

[43] Jane Margolis and Allan Fisher. 2002. *Unlocking the clubhouse: Women in computing.* MIT press, Massachusetts.

[44] Adam S Miner, Arnold Milstein, Stephen Schueller, Roshini Hegde, Christina Mangurian, and Eleni Linos. 2016. Smartphone-based conversational agents and responses to questions about mental health, interpersonal violence, and physical health. *JAMA internal medicine* 176, 5 (2016), 619–625.

[45] Lourdes Moreno, Yolanda González, Paloma Martínez, et al. 2014. Women in computer science: Survey on the perception of the women's participation in STEM studies. In *Proceedings of the XV International Conference on Human Computer Interaction.* ACM, Puerto de la Cruz, 82.

[46] Corinne A Moss-Racusin, John F Dovidio, Victoria L Brescoll, Mark J Graham, and Jo Handelsman. 2012. Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences* 109, 41 (2012), 16474–16479.

[47] Kathleen Noonan and Sylvie J. Laffarge. 2017. Why European girls aren't studying STEM. (2017). Last access 2018/02/14, https://ncmedia.azureedge.net/ncmedia/2017/03/ms_stern_whitepaper.pdf.

[48] Els Rommes, Geertjan Overbeek, Ron Scholte, Rutger Engels, and Raymond De Kemp. 2007. 'I'm not Interested in Computers': Gender-based occupational choices of adolescents. *Information, Community and Society* 10, 3 (2007), 299–319.

[49] Richard M Ryan and Edward L Deci. 2000. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology* 25, 1 (2000), 54–67.

[50] Myra Sadker and David Sadker. 2010. *Failing at fairness: How America's schools cheat girls.* Simon and Schuster, New York.

[51] Linda J Sax. 2008. *The gender gap in college: Maximizing the developmental potential of women and men.* Jossey-Bass, San Francisco.
[52] Linda J Sax, Kathleen J Lehman, Jerry A Jacobs, M Allison Kanny, Gloria Lim, Laura Monje-Paulson, and Hilary B Zimmerman. 2017. Anatomy of an enduring gender gap: The evolution of women's participation in computer science. *The Journal of Higher Education* 88, 2 (2017), 258–293.
[53] Andreas Schäfer, Jan Holz, Thiemo Leonhardt, Ulrik Schroeder, Philipp Brauner, and Martina Ziefle. 2013. From boring to scoring–a collaborative serious game for learning and practicing mathematical logic for computer science education. *Computer Science Education* 23, 2 (2013), 87–111.
[54] Phyllis Schumacher and Janet Morahan-Martin. 2001. Gender, Internet and computer attitudes and experiences. *Computers in human behavior* 17, 1 (2001), 95–110.
[55] Judith W Segal. 2014. *Thinking and learning skills: Volume 1: relating instruction to research.* Routledge, New York.
[56] Mega Smith. 2016. Computer Science For All. (2016). Last access 2016/10/25, https://www.whitehouse.gov/blog/2016/01/30/computer-science-all.
[57] Roli Varma. 2007. Women in computing: The role of geek culture. *Science as culture* 16, 4 (2007), 359–376.
[58] Erica S Weisgram and Rebecca S Bigler. 2006. Girls and science careers: The role of altruistic values and attitudes about scientific tasks. *Journal of Applied Developmental Psychology* 27, 4 (2006), 326–348.
[59] Allan Wigfield and Jacquelynne S Eccles. 2000. Expectancy–value theory of achievement motivation. *Contemporary educational psychology* 25, 1 (2000), 68–81.
[60] Martina Ziefle, Simon Himmel, and Wiktoria Wilkowska. 2011. When your living space knows what you do: Acceptance of medical home monitoring by different technologies. In *Symposium of the Austrian HCI and Usability Engineering Group*. Springer, Berlin, Heidelberg, 607–624.
[61] Martina Ziefle and Eva-Maria Jakobs. 2010. *Wege zur Technikfaszination: Sozialisationsverläufe und Interventionszeitpunkte.* Springer, Berlin, Heidelberg.