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EDUCATIONAL ASSESSMENT & EVALUATION | RESEARCH ARTICLE

Influence factors on students motivation in introductory programming lectures of computer science non-majors

Sabine Wolz[1], Bianca Bergande[1*] and Philipp Brune[1]

Abstract: Programming is an essential part of the curriculum of computer science non-major students. The motivation for the various elements of interdisciplinary degrees is often very low in computer science, which faces a gender gap as well. Differences between study courses and gender in confidence, attitude, student numbers, and motivation in computer science are investigated. In addition, the influences of attitude, perception, and social background are considered.
A questionnaire was designed based on an extensive research model for the purpose of this research. A survey was conducted with two cohorts of computer science non-major freshmen from two degrees in an introductory programming class at a university of applied sciences. The outcomes are compared against each other. First, an explorative factor analysis was performed. Afterwards, SmartPLS was used to test the developed model. The overall motivation of the participants is moderate and mostly influenced by their ability and effort beliefs. These constructs are different for men and women, but not for the degree programs, and have different impacts on motivation. In general, motivation is influenced by ability and effort beliefs, which in turn are mostly affected by perception and social background. While women show lower ability and higher effort beliefs, the males in the samples have opposite outcomes and thus a higher motivation in introductory programming classes.

Subjects: Engineering Education; Gender Studies - Soc Sci; Educational Research

Keywords: computer science education; motivation; gender gap; PLS-SEM

1. Introduction

This work explores the motivation of computer science non-major students to visit introductory programming lectures with a focus on gender differences. To tackle the rising labour market demand of computational skills many interdisciplinary degrees have been established. They include parts of the

PUBLIC INTEREST STATEMENT

Computer science is an important subject in higher education and has become part of many study courses. Unfortunately, the students often lack interest in the content. In this paper, several influence factors have been tested on a group of first-semester students. We wanted to know, how students perceive computer science topics, how much meaning computer science content has on their career aspirations and if they enjoy the classes in comparison to the rest of their curriculum. Therefore, a questionnaire was developed. In addition, study courses and gender have been compared. Male students have more interest in computer science topics, feel more confident mastering computer science courses and are more likely to aspire for a career in computing than female students. Also, more male students study computer science non-majors with a focus on engineering while female students prefer a focus on economics. These preferences likely stem from the perception of computer science in general and are influenced by the social background of the student.

computer science curriculum such as programming or software engineering. Students of these interdisciplinary studies are called computer science non-majors, as their courses partly overlap with the information and communication technology curriculum of computer science majors. This group of students mostly do not want to become programming experts as the overlap is often supplementary (O'Donnell et al., 2015). Thus, the challenge for lecturers is that they are often facing an unmotivated student group. Furthermore, it is more difficult for non-majors to learn programming languages mainly because these languages feature specific semantic computer science and syntactical rules. As a result, their impression of the computing field is mostly negative, which often correlates with their negative experiences in class (Courte & Bishop-Clark, 2009). This represents a major problem as it hinders computer science non-majors to develop the intended interest in the computing field. It also adds to another issue, which has been part of computer science education research in the past decades: the gender gap in computer science. Women and men seem to have different expectations of computer science and their own abilities, the value it has to them and how much they will enjoy the tasks surrounding computer science like programming (Gressmann et al., 2019). Gressman et al. conducted a study on the intrinsic motivation of two different computer science non-major degrees about the use of two educational robots for programming beginners. They found that the humanoid robot was more popular with the female participants and students of the degree, which focussed on economics and communication, while the vehicle-shaped robot showed stronger effects in motivation on the male participants and students of the degree with an engineering focus (2019). This showed that gender and degree are open derivates for motivation research in this field. While intrinsic motivation has been studied in this group, questions about external influence factors have not yet been explored in depth.

External influence factors, such as expectancies, prior knowledge, and attitudes of computer science non-major students in introductory programming lectures, and how they are related to students' motivation have not been satisfactorily researched so far. A promising approach, which focusses on the gendered differences in external factors on learners in STEM has been established by Wigfield and Eccles. The expectance value theory—or EVM—by Eccles matches research about motivational factors in computer science at universities (Wigfield & Eccles, 2000). They greatly influence students' motivation but have not yet been tested on computer science non-majors at German universities in a setting, which compares the genders and two different computer science non-major degrees at the same time.

Therefore, this work aims to answer the following research question: "How do value and expectancy beliefs influence the motivation of women and men in computer science non-major introductory programming classes?"

This study examines extrinsic influence factors on the motivation of male and female computer science undergraduates in depth by introducing a questionnaire, which builds on a comprehensive theoretical model that is developed especially for the purpose of this research. The research design as well as the extensive model examined are a unique contribution to the research in this field and adds value to ongoing investigations in computer science education research. First, this article establishes the theoretical und empirical evidence, followed by the methodological implementation, data collection, and analysis in section 2. In section 3, the results of the initial survey are discussed, and section 4 introduces the second data collection, as well as a comparison to the outcomes of the first survey. Sections 5 and 6 discuss and sum up the outcomes and examine perspectives for future research.

2. Related work

The EV Model by Jaqueline Eccles and Allan Wigfield was developed in the mid-1970s (Eccles, 2007) and provides the main theoretical basis for the research question in this work. Eccles' objective was to find psychological and social factors causing gender differences in educational and vocational choices with a particular focus on science, technology, engineering, and mathematics, the STEM subjects (Eccles, 2007). The research focus was on motivation differences of boys and girls in math.

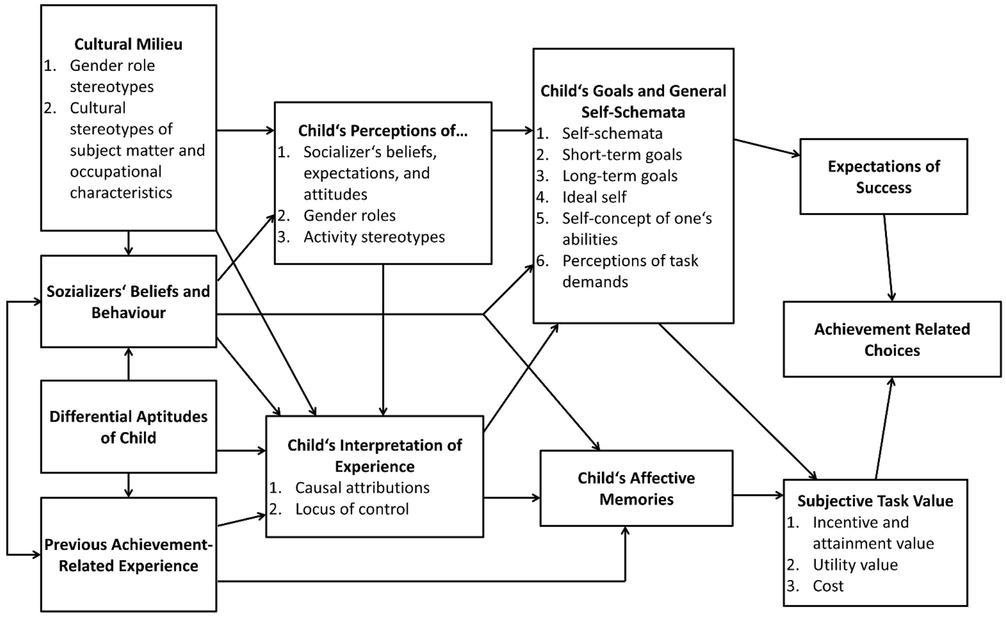


Figure 1. Expectancy-value model of achievement motivation based on (**Wigfield & Eccles, 2000**, p. 69). Licensee: **Neu-Ulm University of Applied Sciences,** Order Date: **Mar 22, 2022,** Order Number: **5274130122570**

The psychological and social factors that lead to the gender differences in educational choices were examined. Figure 1 illustrates the EV model developed by Eccles and her colleagues.

Gender differences are primarily influenced by utility value, attainment value, and cost (Eccles, 2007). The achievement-related choices are directly influenced by the expectations of success and the value an individual gives a certain task. The subjective task value depends on the student enjoying the task, fulfilling their goals, or the level of encouragement from peers or family (Eccles, 2007). Value can be classified into four categories: incentive, attainment, utility, and cost (Wigfield & Eccles, 1992). Incentive value encompasses the enjoyment one experiences from engaging in a certain activity. Attainment value is the way one values a task with respect to his or her sense of his or her own identity and self-concept. It reflects how important it is for someone to perform a certain task or activity. Cost describes how the decision to engage in one activity limits the possibility to engage in other activities. The perceived cost depends on the value the task is given. The last achievement value in this context is the utility value or usefulness. The utility is higher if a benefit is seen in completing a task. Utility is an extrinsic factor, as the value of a task derives from reaching a certain goal (Eccles & Wigfield, 1995). The expectancies for success are domain-specific beliefs in one's personal efficacy to master a task (Eccles, 2007). In general, the cultural background influences expectancy and values and the role models presented within it. Expectancy and values influence performance, persistence, and task choice. However, expectancy beliefs are stronger predictors of future achievement whereas value beliefs are stronger predictors of future academic choices (Wigfield & Eccles, 2000). Students tend to select subjects and study programs they believe they can master and value (Eccles, 2007).

The academic and career aspirations of the learner can motivate or demotivate learning certain things and shows different patterns for men and women. For example, Marín et al. discovered that the strongest motivating factor for women in education is their future job opportunities due to influences from family and teachers (Marín et al., 2008). On the other hand, they are demotivated by their belief that many skills and a lot of experience are necessary to be successful. For men, the motivators are their knowledge about being good at the task and interest in it whereas the perception of too much required effort to succeed is demotivating (Marín et al., 2008). The perceived necessity of the taught material is also a huge motivator. Furthermore, the cost value has been found to be different for males and females in high school. This often correlates with the fear of rejection if engaging in a subject, which does not match the stereotypes regarding gender roles, which can be a hindrance if a certain subject is perceived as particularly feminine or masculine (Vekiri, 2013).

2.1. Research context

The interdisciplinary curricula in this study are Information Management Automotive (IMA) and Information Management Corporate Communication (IMCC). Both degrees have a similar structure consisting of three parts: economics, information sciences, and a specialization. IMCC's specialization is business communications and IMA's is the automotive market. The first one is more popular with women, the second with men (Gressmann et al., 2019). Samples are taken from the first-term lecture "programming technique" (ProTech), which is taught in both degrees with similar contents and secures the comparability of the results. Earlier studies showed that this group mostly views the course as a complicated supplement and has little interest in this field (Janke et al., 2013). Therefore, the freshmen of these degrees are the sample for this study to examine the reasons for their attitudes.

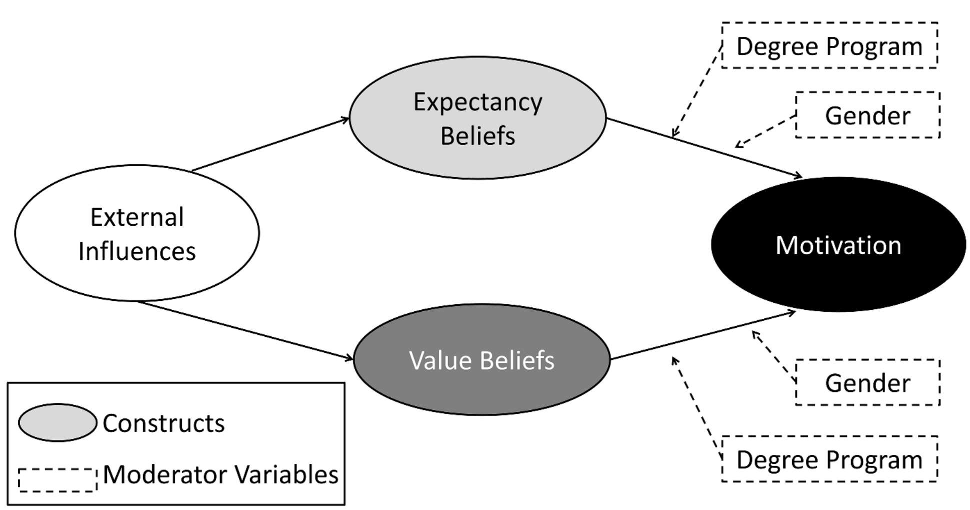
Several motivation factors are considered based on the research discussed in the literature review in Section 2. In general, more men study IMA and more women study IMCC, so that this adds to the assumed gender gap in motivation discussed earlier. Therefore, motivation in these two degree programs and between the genders will be compared. The different factors, which influence motivation are combined in the model illustrated in Figure 2. A survey is carried out to test the proposed assumptions and the developed research model.

2.2. Final research model and hypotheses

The model illustrated in Figure 2 includes external influences on the expectancy and value beliefs of students, divided into the attitude towards studying, perception of the degree content and social background of the participants. These factors are in line with the findings of Eccles and help to operationalise the theoretical and empirical assumptions into a valid instrument. While motivation is influenced by expectancy and value beliefs, these two constructs are influenced by additional external influences, which are categorized as attitude towards studying, perception, and social background. These are defined and constructed as follows.

The attitude towards studying (at) is defined as "a feeling or opinion about something or someone, or a way of behaving that is caused by this" (Klosa, 2015). This includes the decisive reasons for

Figure 2. Illustration of the research model.



choosing a degree or a university. The impact of attitude on motivation has been proven by several researchers (Beyer et al., 2003; Esmaeili & Eydgahi, 2014; Fisher & Margolis, 2002).

In addition, perceptions (per) are taken into account, as their influence on motivation has also been proven (Centra & Gaubatz, 2005). They are defined as ‘a belief or opinion, often held by many people and based on how things seem (Klosa, 2015). Therefore, this includes what the students expect of the lecture and especially how well the lecture meets these expectations. Furthermore, future job perspectives are considered as they coincide with the opinion about certain subjects. In addition, stereotypes about the discipline are part of the perceptions.

The third external factor is the social background (sb). The importance of social influence on ability beliefs, self-efficacy, and motivation is already discussed earlier in this paper. The reasons for taking social background into account are based on the findings of (Fisher & Margolis, 2002; Meece et al., 2006; Vekiri, 2013). These three independent factors are assumed to have an influence on students’ expectancy and value beliefs. Therefore, they influence motivation indirectly.

The construct of expectancy beliefs consists of three interrelated variables according to the model by Eccles and her colleagues (Wigfield & Eccles, 2000). The first component is ability belief (ab), which is the degree to which individuals consider themselves capable of fulfilling or learning how to fulfill a certain task (Wigfield, 1994). The assumption is that strong ability beliefs have a positive impact on motivation. The second component of expectancy beliefs is called effort belief (efb). The assumption is that the more effort one needs to accomplish a task, the less motivated one is. The last of the three components is the enjoyment belief (enb). The assumption is that students who enjoy studying are more motivated. The three expectancy beliefs are interrelated. Therefore, the model assumes that ability has an impact on enjoyment. People who have high efficacy are supposed to enjoy their work more. In contrast, ability is likely inversely related to effort. This means that less effort is needed if the person is more able and more effort is needed if the person is less able. In addition, more effort leads to less enjoyment.

Lastly, value beliefs (vb) as an influence on motivation are considered. They consist of four variables: incentive value, utility value, attainment value, and cost, according to (Eccles, 2007). Cost (cv), in this case, is defined as the sacrifices one must make to spend time on a particular activity (Wigfield & Eccles, 2000). In addition, motivation seems to be higher if the interest in the course material, the incentive value (iv) is high. Furthermore, the perceived usefulness, the utility value (uv), and the intention to do well, namely the attainment value (av) influence motivation. This leads to the research model illustrated in Figure 3.

Gender and degree program act as moderating variables affecting the values’ and expectancies’ influence on motivation, as has been repeatedly proven in past research (Eccles, 2007; Fisher & Margolis, 2002). This model leads to the following hypotheses:

H1 Ability beliefs influence motivation positively.

H2 Effort beliefs influence motivation negatively.

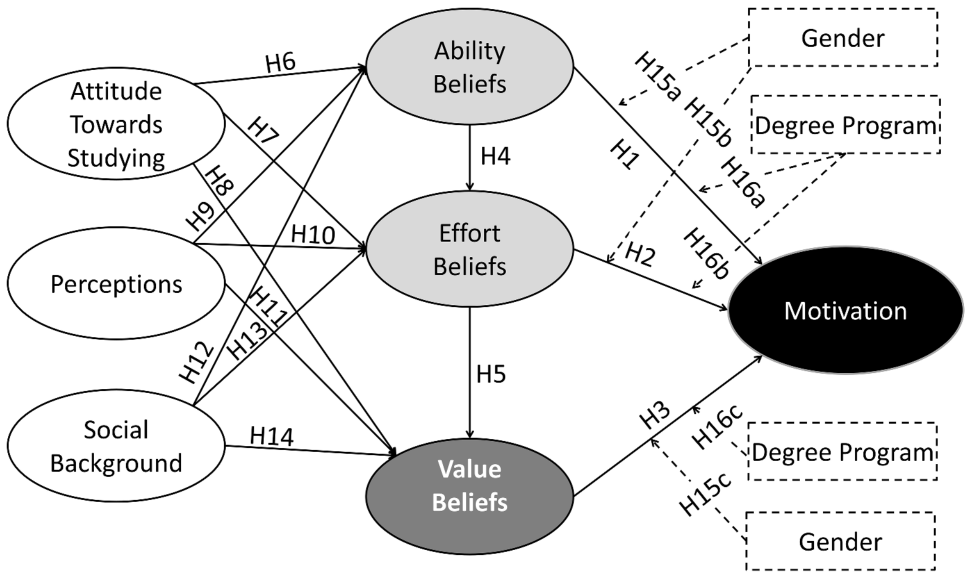
H3 Value beliefs influence motivation.

H4 Ability beliefs influence effort beliefs.

H5 Effort beliefs influence value beliefs.

H6 Attitude towards the degree influences ability beliefs.

Figure 3. Final measurement model of the survey with the corresponding hypotheses from H1 to H16a.



H7 Attitude towards the degree influences effort beliefs.

H8 Attitude towards the degree influences value beliefs

H9 Perception influences ability beliefs.

H10 Perception influences effort beliefs.

H11 Perception influences value beliefs.

H12 Social background influences ability beliefs.

H13 Social background influences effort beliefs.

H14 Social background influences value beliefs.

H15a/b/c Gender influences a) ability, b) effort and c) value beliefs

H16a/b/c Study courses influence a) ability, b) effort and c) value beliefs

2.3. Data collection

As a measurement instrument, a questionnaire was developed based on (Hair et al., 2014). The questionnaire covered all constructs of the measurement model with at least one pair of questions for each construct and is included in the appendix. To gain comparable data and a bigger sample the survey was conducted two times. In addition, the initial survey had some surprising results that had to be investigated. The data was collected in the beginning of the lecture. All participants were asked to fill out the questionnaires voluntarily and anonymously and handed them back to the researchers. They scanned the questionnaires, using the EvaSys evaluation system and imported the raw data sets into local databases.

2.4. Data analysis

The questionnaires' reliability and the measurement and structural model were tested. For the evaluation of the model the partial least squares (PLS) method was used, as it is a popular method for investigating causal models and is often used for the development of theories in exploratory research (Hair et al., 2014).

An explorative factor analysis (EFA) was performed in SPSS 23 for the 1st survey and SPSS 24 for the 2nd survey. The factors were extracted and the EFA was performed as a principal components analysis.

The analysis was continued by using SmartPLS 2.0 (Ringle et al., 2005) following the guidelines of (Chin, 2010). The first stage estimates the latent constructs' scores. The next step calculates the final estimate of the outer weights and loadings and the path coefficients of the inner model (Hair et al., 2011). The PLS algorithm calculation results of the final measurement model are illustrated in Figure 4.

Before the results were analyzed, the convergence of the algorithm was verified. Next, the indicator reliability was verified. Since the model is reflective, the outer loadings of the construct are considered; formative measurements would consider outer weights (Hair et al., 2014). Loadings are correlations between indicators and latent variables. Furthermore, the cross loadings were calculated to examine how the various indicators relate to each of the constructs (Chin, 2010). This included the evaluation of the average variance extracted, a composite reliability test, and an evaluation of the discriminant validity.

Furthermore, the T-statistics for the outer model were examined by performing the bootstrapping procedure. Bootstrapping is used to assess the path coefficients' significance (Hair et al., 2014).

The analysis continued by examining the structural model, which represents the underlying concept of the path model. For this purpose, the significance of the path values, their coefficients, the effect size, and R raised to the power of 2 (R-quare) are considered, since R-square values represent how accurately a construct predicts the theoretical model (Backhaus, Erichson, Plinke & Weiber, 2010; Chin & Marcoulides, 1998; Hair et al., 2014).

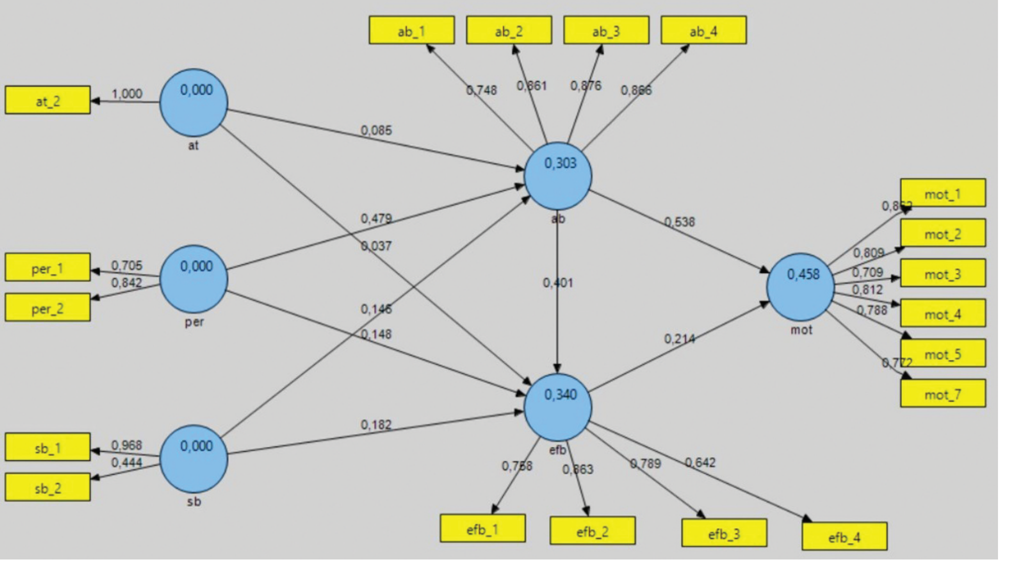


Figure 4. Final measurement model of the 1st survey in PLS-SEM (without value beliefs).

Table 1. Outcomes of the hypothesis's tests for the first sample with accompanying t-values

Hypothesis	Influence	T-value	Result
H1	Ability Beliefs -> Motivation	6,0081	accepted
H2	Effort Beliefs -> Motivation	2,1896	accepted
H3	Value Beliefs -> Motivation	excluded	excluded
H4	Ability Beliefs -> Effort Beliefs	3,9052	accepted
H5	Effort Beliefs -> Value Beliefs	excluded	excluded
H6	Attitude towards Degree -> Ability Beliefs	1,0267	rejected
H7	Attitude towards Degree -> Effort Beliefs	0,4208	rejected
H8	Attitude towards Degree -> Value Beliefs	excluded	accepted
H9	Perception -> Ability Beliefs	5,963	accepted
H10	Perception -> Effort Beliefs	1,3653	rejected
H11	Perception -> Value Beliefs	excluded	excluded
H12	Social Background -> Ability Beliefs	1,7801	accepted
H13	Social Background -> Effort Beliefs	2,0206	accepted
H14	Social Background -> Value Beliefs	excluded	rejected

2.5. Data analysis for the 1st survey

The test for validity and consistency implied that the construct value beliefs does not meet the requirements and thus were eliminated from further tests. This resulted in new outer loadings. The values of all outer loadings were sufficient except for the item sb 2 with a value of 0.444 under the threshold of 0.5. Nevertheless, the item was not removed from the evaluation, because the former validation procedure revealed a satisfactory outcome for this item. To specify significance for all indicator items and the path coefficients a bootstrapping procedure was used. By doing so, t-values for significance testing are calculated and statistical significance can be analyzed. After bootstrapping, the t-values were analyzed to see if the path coefficients of the inner model were significant. Thereby, the path coefficients were divided by the standard error of the path to calculate the t-value (Hair et al., 2014). Using a two-tailored t-test, the critical t-values are defined as follows: a significance level of 10% requires a value of 1.65 or greater (*$p \leq 0.1$), the 5% significance level requires a value greater than 1.96 (**$p \leq 0.05$), and the significance level of 1% needs a value greater than 2.58 (***$p \leq 0.01$; Hair et al., 2014, p. 198, 2011, p. 148). The results of all indicators of the structural model evaluation for the 1st survey are shown in Table 1. Each path is assigned to one of the hypotheses developed in Section 2.2. A decision about the acceptance or rejection of each hypothesis was made based on the t-values.

3. Results

Ninety-nine students participated in the first survey, with each 45 IMA (7 female and 38 male students) and 54 IMCC (39 female and 15 male students) students. According to the "10 times rule", the minimum number of samples should be 10 times the maximum number of arrowheads pointing at a latent variable (Barclay et al., 1995, p. 301). In the used research model, seven arrowheads are pointing at the latent variable motivation. Therefore, every sample size over 70 is sufficient. The extensive model was tested two times following the procedure presented in section 2.4. The outcomes of the data analysis explained in 2.5. is shown in Table 1 below.

The analysis of certain constructs on the student's motivation showed interesting results. While motivation and enjoyment correlate, the direction is unknown. The enjoyment beliefs prove to be strongest influence on motivation followed by ability and effort beliefs (path value of 0.759 (eb) vs. 0,476 (ab) and 0,270 (efb)). Another interesting finding is that the ability beliefs come from student's perceptions and influence the effort beliefs, the amount of work necessary to master new skills as shown by the high path values in PLS-SEM seen in Figure 5.

The ability beliefs are based on personal experience and social background and the social background has a small but significant impact on ability beliefs as they are part of the perception construct. Furthermore, it is surprising to find that the attitude towards the degree does not show influence in this sample. Concerning the time spent for the preparation of the course, students spend more time to prepare for ProTech than for other lectures mentioned in the questionnaire with 71% spending between 1 and 3 hours for preparation each week.

3.1. Gender and motivation

When it comes to gender, female freshmen expect less fun and feel less motivated for ProTech than their male counterparts (χ2 = 0,012). On the other hand, the results show that the students do not seem to enjoy the four lectures in their 1st semester much overall, so their motivation does likely not stem from enjoyment. However, while 58% of the male students think that learning how to program is fun only 33% of the women share this opinion. The other findings confirm these

Figure 5. Calculation results of the sem with perception as single external factor significance: * p ≤ 0.1; ** p ≤ 0.05; *** p ≤ 0.01.

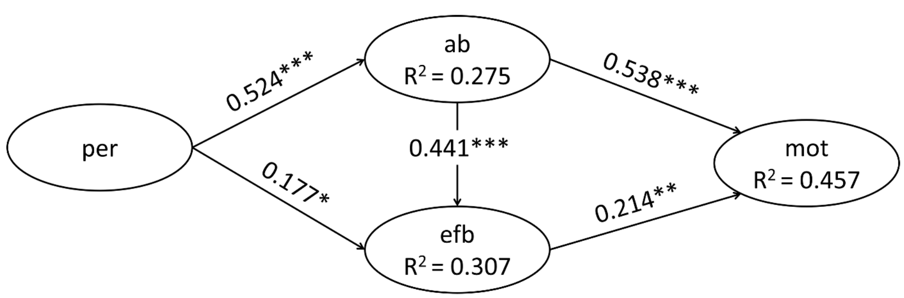
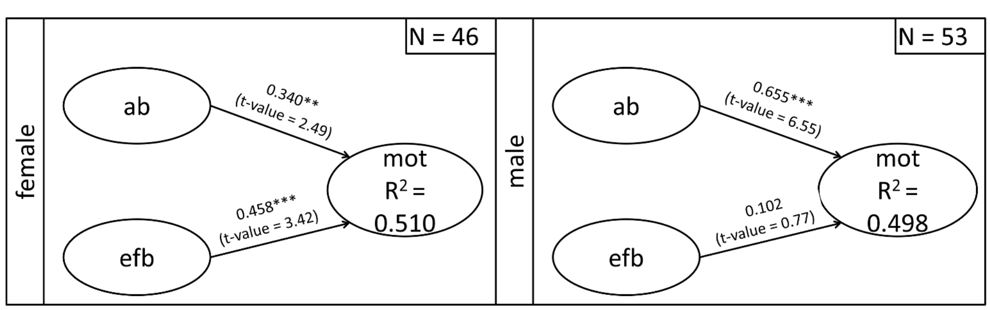


Figure 6. Structural model results for motivation with gender as moderator variable. significance: * p ≤ 0.1; ** p ≤ 0.05; *** p ≤ 0.01.



indications, as the attitude is less influential than the participants own perceptions and ability beliefs as shown by higher path significances for these than effort beliefs that are presented in Figure 6.

In this regard, the women in the sample show higher ability beliefs than the men and thus, estimate the effort needed to master the course as higher than them. The correlation between belief in one's own talent and gender is highly significant with a $\chi2$ significance of 0.006. All in all, gender in this sample is a predictor for different motivations to study a certain degree, but it does not differ between IMA and IMCC students regarding the course ProTech. Therefore, H2 is verified: much effort means less motivation. Consequently, the female students in both IMA and IMCC feel less motivated in the course ProTech than male students.

The value beliefs cannot be used for the 1st survey because of lacking validity and consistency. Concerning the perception, the student's replies showed that they wish for explanations that are more relatable and a better integration of social media in class. While the women's results show that they prefer a more detailed instruction, the men want more practical experience. Both seem not too satisfied with the lecture with a rating of 3,2 on a 5-point likert-scale. The difference between the genders and the statements preferring to work independently or with more instruction by a professor have been found to be significant ($\chi2 = 0.027$).

3.2. Study course and motivation

The students were asked to rank possible future occupations with the highest rank as the most unattractive occupation and the IT-related jobs received the worst ratings by the female IMCC students. Concerning the degrees, IMA students show a higher interest in IT overall than IMCC students with 21% of them giving the worst ratings to the IT-related occupations in contrast to only 7% of the IMA students. This is consistent with the finding that the lowest interest rates in IT-related occupations as a future perspective in the questionnaire can be observed among female IMCC students. The results create the impression that, especially for the latter group, computer science is not regarded as a possible field for specification or career. This notion is also supported by the gender-neutral results among IMA students. Albeit, both non-major degrees do not show a tendency towards negative stereotypes about computer science. The most positive attributes associated with software development are mainly about creativity (51%) and abstraction capability (43%), yet they also associate it with being nerdy (36%) and unsocial (14%).

All in all, the social background of the majority of the students is not at all or weakly related to computer science, as most of the participants of both degrees had neither parents nor siblings who work in IT-related fields in their replies. This may be the reason why the influence of social background was rather low although it was identified as a significant influence in other studies (Marín et al., 2008; Vekiri, 2013). Attitude turned out to be a single-item construct because the other possible items did not satisfy the requirements for validity and reliability. The single remaining item is the question to finish the sentence about reasons for studying IMA or IMCC. Interestingly, only 18% of the students stated that they chose the degree program because they think it matches their abilities. Hence, the decision does not seem to be influenced by the student's ability beliefs. Instead, creativity (40,4%) and many job opportunities (60,6%) were predominant motives.

4. The 2nd data collection

The 2nd survey was carried out to validate the findings from the initial data collection. This time, 181 students participated in the survey in total, 113 IMCC of which 78 are females and 30 are male and 69 IMA students of which 42 are male and 7 are female. The analytic process followed the initial design and revealed a very interesting difference from the first model. The model with inner and outer structures was built, ran the algorithm and then the invalid items were removed based on cross loadings, AVE and composite reliability values. After this, it was rerun, resulting in higher

Table 2. Shows the results of the second survey. In addition, they are compared against the results of the first survey (S1) to show similarities and differences

Hypothesis	Influence	T-values	Result	S1 vs. S2
H1	Ability Beliefs -> Motivation	1,961	accepted	same
H2	Effort Beliefs -> Motivation	2,266	accepted	same
H3	Value Beliefs -> Motivation	4,804	accepted	different
H4	Ability Beliefs -> Effort Beliefs	6,465	accepted	same
H5	Effort Beliefs -> Value Beliefs	3,351	accepted	different
H6	Attitude towards Degree -> Ability Beliefs	0,637	rejected	same
H7	Attitude towards Degree -> Effort Beliefs	1,126	rejected	same
H8	Attitude towards Degree -> Value Beliefs	0,606	rejected	different
H9	Perception -> Ability Beliefs	3,509	accepted	same
H10	Perception -> Effort Beliefs	0,847	rejected	same
H11	Perception -> Value Beliefs	1,174	rejected	different
H12	Social Background -> Ability Beliefs	0,557	rejected	different
H13	Social Background -> Effort Beliefs	0,842	rejected	different
H14	Social Background -> Value Beliefs	1,903	accepted	different

loadings in the remaining variables and after that, the bootstrapping procedure was carried out. The results for the path coefficients show which of the initial hypotheses can be accepted or must be rejected based on their t-values and corresponding p-values under 0,05.

The 2nd survey mostly reaffirms the initials surveys results, with minor differences. The construct "social background" shows a very low influence on the ability beliefs and effort beliefs when "value beliefs" remain part of the inner model. This likely stems from including the value beliefs in the model. This time, the value beliefs loadings were sufficient and reached beyond critical values so that they could be included in the final model. The effects that this difference yielded are illustrated in Table 2.

4.1. The general model

Even though one might expect major differences due to this change in the model, many similarities can be detected. The hypotheses H4, H1, H6, H7, H2, H9, and H10 validate the initial survey results.

The fact that value beliefs stayed in the model also enabled testing the hypotheses that were left out initially. This includes H3 and proves that, in fact, value beliefs have an influence on motivation and that effort beliefs influence value beliefs (H5). Furthermore, the attitude towards the degree or perception does not have an influence on value beliefs (H8 and H11 are rejected). Another model change towards the first data collection is that social background has an influence on value beliefs (accept H14) but not on the ability and effort beliefs (reject H12 and H13). This could stem from different social background loadings due to the new model.

4.2. Degree and motivation

When it comes to the results of the 2nd survey, the samples were separated for each of the two degrees and the analysis steps were repeated with the smaller samples. The smaller numbers also represent a major limitation.

4.2.1. Results for IMA

For Information Management Automotive, the results replicate the ones of the general model of the second survey. However, the differences in the hypotheses H2, H9, and H10 are worth further inspection. Most importantly is H2, the hypothesis that states that the effort beliefs influence motivation must be rejected for the subsample of the IMA students (t-value 1,358). At first, this is surprising as it contradicts other results. At a second glance, it fits into the theoretical notions as most IMA students are male and the idea of putting effort into a task is less demotivating for men than for women. Also, the lower values for the influence of perception on ability and effort beliefs could be caused by the inclusion of value beliefs in the model that led to a redistribution of the model loadings overall.

4.2.2. Results for IMCC

For the IMCC students, the hypotheses H4, H6, H7, H2, H9, and H10 reassure the initial survey results. The differences from the general model are mainly found in the rejection of the hypothesis H1 (t-value 0,975), H2 (t-value 1,311) and H14 (t-value 0,000), which is interesting as the first two represent a major string of this work. So, for IMCC the idea that ability and effort beliefs influence motivation cannot be accepted. This is a real surprise as it contradicts the initial theoretical notions. Then again, the IMCC students see themselves in many occupations that do not include computer science or programming. It is worth taking a closer look at the value that IMCC students assign to programming as it does not seem to be as important as other skills for them. Nonetheless, while H3 has the best values of the three main influences, it is still slightly insignificant with a borderline t-value of 1,658.

4.3. Gender and motivation

The findings of the initial study can for the most part be confirmed. However, there is one striking difference between the genders that is very important. Hypothesis H2 that states that effort beliefs influence motivation must be accepted only for the female participants (t-value 1,714 vs. 0,070 in the male sample). The effort beliefs of the male participants do not have an influence on their motivation. To target the effort beliefs should therefore be one of the main goals of positive interventions towards female students in computer science education.

5. Discussion

The general outcomes for the study courses and gender are discussed briefly. Then, the outcomes of the three main factors—ability, effort and value beliefs—are elaborated against related work.First, the motivation of both computer science non-major degrees in ProTech is lower than in other subjects (O'Donnell et al., 2015). Another interesting outcome especially of the second survey is that value beliefs showed to be the most dominant influence on motivation for IMCC students. Their ability and effort beliefs were insignificant and show that they see no value in learning programming, so that they are not motivated to master it (Eccles, 2007). This is supported by their career aspirations, as they mostly see themselves in marketing or communications, so that the outcomes of O´Donnell et. al. are confirmed (O'Donnell et al., 2015). IMA students show a higher interest in IT-related occupations and though they also expect to put effort into learning programming, it was less demotivating for them. This supports Wigfield and Eccles research as they showed that the perceived value of a task like e.g., working in that field in the future, has a positive influence on motivation (Eccles & Wigfield, 1995; Wigfield & Eccles, 2000).Regarding gender, men's motivation in such fields is higher and they have more fun in class than the women, which is verified by this survey as well (Eccles, 2007). The men showed higher enjoyment beliefs than the women, so that it must be assumed that the female students to not expect to enjoy the course.Ability beliefs have been identified as the second strongest influence factor in the research model. Women's ability beliefs are higher than men's in both samples, which means that they think one needs to be especially skilled to master programming (Eccles, 2007; Wigfield, 1994). The expectation to be talented and very experienced to succeed in an area was identified as a demotivational factor by Marín et al. (2008). The finding that perception influences ability beliefs also fits into the outcomes of Centra and Gaubatz (). They discovered that the perception of learning in a class is just as influential as the actual grade or test result when it comes to the evaluation of a class. Therefore, it must be assumed that the negative effect of the high ability beliefs on the motivation of the female sample group is caused by their perception of the subject as particularly demanding.Effort beliefs proved to be influential across almost all groups in both surveys. The finding that the introductory computer science class needs more preparation by all students in the sample than any other classes can be interpreted as an explanation for this influence. The more effort the students expect to need, the less motivated they are (Wigfield, 1994). Thus, the finding that women have stronger effort beliefs in learning how to program than men help explain why women are less motivated in programming. The hypotheses testing revealed that the ability beliefs and the social background are the most influential external influences on effort beliefs. As the ability beliefs of women are higher, they also expect to put more effort in the class to succeed than their male counterparts. When it comes to the influence of the social background it can be speculated that the female students expect that computer science is not worth the effort as they do not identify with the subject of the class (Meece et al., 2006). Another explanation could be that they feel like the culture in class does not foster self-efficacy for them (Fisher & Margolis, 2002). As this cannot be answered from the outcome of this study, these notions are important approaches for future research. High effort beliefs also proved to be a negative influence on the value beliefs in the second survey.The value belief outcomes are in line with Vekiris´ research, which showed that male participants value computing more than the females (2013). In the second survey value beliefs were found to be particularly influential and that low value beliefs had a negative effect on motivation in accordance to Eccles (2007). The female participants do not find a high value in programming and computing subjects since they mostly want occupations in other areas. This supports the outcomes of Marín, Barrantes, and Chavarria which identified job opportunities as a strong predictor of high motivation in females (2008). Hence, measures to support students should target the value of computing and show how a career in this sector is also attractive and valuable for female academics and non-majors. One way this could be achieved is by providing a clear and comprehensive picture of the five computing disciplines and corresponding job profiles (Courte & Bishop-Clark, 2009). In addition, the enjoyable and attractive parts of the discipline should be pronounced, f.e. by providing a playful or fascinating introduction (Gressmann et al., 2019).

6. Conclusions

The goal of this research was to get insight into computer science non-majors' influence factors on motivation. Therefore, a measurement model according to the literature review was developed. This model includes the expectancy-value model by Wigfield and Eccles (2000) as well as similar constructs based on the current state of the art about influences on motivation. Then, a questionnaire was designed to test the developed extensive model of influence factors on the motivation of the target group. Two cohorts of undergraduates were asked to participate in a survey using this questionnaire. To ensure the validity and reliability of the collected data it was evaluated with several statistical programs. Finally, the data was analysed considering the influencing variables on motivation, the constructs that were excluded from the model, and the knowledge gained about motivation. In addition, the outcomes were compared between two study courses and gender, as this proved to be important in past investigations on the subject matter. Highvalue beliefs have a positive effect on motivation, while high ability and effort beliefs can lower motivation. The three beliefs are each influenced by the attitude towards the degree, social background, and perception of the subject to varying degrees. IMA students are mostly influenced by effort beliefs, but high effort beliefs do not seem to affect them as negatively as their counterparts. They can see themselves working in the engineering and computing sector, so that putting in some effort by investing more time than in other classes is worth it. IMCC students on the other hand are mostly influenced by value beliefs as the strongest influence factor on their motivation. As they prefer other careers over working in computing their motivation for computer science classes is lower than that of their fellow students in IMA. Female participants have higher ability and effort beliefs while showing lower enjoyment and value beliefs than the males in the sample. This leads to a lower motivation overall. The male participants show higher value beliefs while their effort and ability beliefs are lower than those of the females, and they are more likely to see themselves in a computing profession in the future. Positive influence on the motivation of computer science non-majors should therefore show the career opportunities and value of computing while lowering effort and ability beliefs.

6.1. Limitations of the study

The mixed results for the value beliefs construct points towards a central issue regarding reliability. It must be assumed that not all participating students are aware of the value programming has to them since the survey was done at the beginning of the semester and their studies. It is also possible that the students misunderstood some questions. As programming has a deep learning curve, it would be interesting to see if the motivation may change during the semester by also collecting data at the end and compare the data sets. Last, but not least, the results are only valid for the sample group described in this study. More samples of computer science students need to be drawn from different universities to be able to generalize the outcomes. This would also be helpful to improve the reliability and validity of the questionnaire and make it a more powerful instrument in motivation assessment.

6.2. Future work

While the outcomes discussed before are validating a lot of earlier research, they also raise many new questions. Future work should explore if fostering self-efficacy and the identification with a subject like programming technique would yield positive effects on the effort beliefs of students with a special focus on females. Another derivate for future studies would be to study the assumed connection between ability beliefs and the perception of the class in more depth, for example, by enriching existing data with qualitative data from guided interviews. In addition, the possible effect of additional education about job profiles in computer science on value beliefs should be investigated.

Author statement

This research was conducted as part of the project EVELIN – the experimental improvement of software engineering education. EVELIN focussed on key aspects of software engineering education in German universities of applied sciences in Bavaria between 2012 and 2021. At the University of Applied Sciences Neu-Ulm the project focussed on introductory courses and gender-related issues, which were researched with an emphasis on motivation and self-efficacy in numerous teaching environments. This paper contributes to the project by providing an in-depth analysis of influence factors on the motivation of computer science beginners in higher education.

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correction

This article has been corrected with minor changes. These changes do not impact the academic content of the article.

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Appendix A—List of Abbreviations

IMA—Information Management Automotive

IMCC—Information Management Corporate Communication

at—attitude towards degree

per—perception

sb—social background

ab—ability beliefs

efb—effort beliefs

mot—motivation

S1—first survey

S2—second survey

Appendix B—Questionnaire

Dear participant. Thank you for participating on the topic of student motivation. I please read the questionnaire carefully and fill it out completely. Of course, all information will be evaluated absolutely anonymously and treated strictly confidentially.

Conclusions about your person are therefore not possible at any time!

Thank you very much for your help!

In order to guarantee anonymity and still be able to assign the questionnaire to a possible further survey, I ask you to provide it with a self-generated code. The code consists of a combination of your parents' names and your own date of birth. This code does not allow any conclusions to be drawn about your person.

Example of the code:

- Your mother's name is ELSBETH

- Your father's name is EDGAR

- Your birthday is 08.10.1988

This results in the code EL ED 08

1. Please enter your individual personal code here

2. Attitude towards studies

2.1 Why did you decide to study at the IMCC/IMA?

- First choice (desired course of study)
- One of several
- Desired degree programmes
- Lack of alternatives

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- Enrolled to be enrolled
- Other reason

2.2 If other reason, which one? (open question)
2.3 For what reason did you decide to study at XX University of Applied Sciences? (Multiple answers possible)

- Location Reputation of the university
- Recommendation from friends
- Study content Uniqueness of the degree programme
- Only place to study
- Other reason

2.4 If other reason, which one? (open question)
2.5 Please complete the following sentence: (multiple answers possible): "I study IMCC/IMA because … "

- I believe that I will be able to get a get a job.
- I have many career opportunities.
- I hope to earn a lot of money
- I am interested in all areas.
- I am interested in corporate communication/automotive area.
- I am interested in information
- it is a creative degree programme.
- it is an IT-based degree programme.
- it is a business-related degree programme.
- it is an economics course.
- the programme matches my talents.
- Other

2.6 If other, why? (open question)
First read through the following eight career fields. Rate them according to how attractive they are for you. (1 - very attractive, to 8 - not attractive at all)
2.7 Employee in an advertising agency
2.8 Corporate communications
2.9 IT consulting
2.10 Web design
2.11 Sales
2.12 Marketing/ PR
2.13 Software developers
2.14 IT service provider
2.15 What is important to you about a programming course? (Multiple answers possible)

- Examples of topics should be used that I am personally interested in.
- A social relevance should be evident.
- New media should not be used.
- Future relevance is not important.
- Work should be done in teams.
- It should be as simple as possible.
- Creativity should not be required.
- Social relevance is rather unimportant.
- A connection with my everyday life should be evident.
- Creativity should be able to be brought in.
- A relevance to the future should be recognisable.
- Work should be as free and independent as possible
- New media (e.g. YouTube videos) should be used

- Work should tend to be done alone.
- Work should be done with as much as much guidance as possible.
- Other

2.16 If other, what? (open question)
2.17 In your opinion, how well does the ProcTec lecture fulfil
these points? Give a school mark from 1 to 6.

3. Experience
3.1 Do you have any prior knowledge of programming?

- Yes - from school
- Yes - through my vocational training
- Yes - self-taught
- Yes - other
- No

3.2 What school grade would you give yourself for the depth of your depth of your previous knowledge in programming? (1 very sufficient, 6 insufficient)

4 Expectancy Beliefs
Please rate the following statements according to how much they apply to you. (1 = strongly disagree 5 = strongly agree)
4.1 I believe that I can learn to programme.
4.2 I believe that I am talented in programming.
4.3 I think that I am not good at programming.
4.4 Programming is an activity that I am not good at.
4.5 I need to put little effort into the programming lecture
to be good at it.
4.6 Learning programming is a lot of effort and work for me.
a lot of work.
4.7 It takes more time to get the same grade in the programming lecture than in other subjects.
4.8 Learning programming requires little time and effort.
4.9 Learning programming is fun.
4.10 I always can't wait for the programming lecture to be over because I don't enjoy it.
4.11 I would describe programming as interesting.
4.12 Learning programming does not arouse my interest.

5. Value beliefs
Please rate the following statements according to how much they apply to you. (1 = strongly disagree 5 = strongly agree)
5.1 The content of the programming course is of value to me.
added value for me.
5.2 I am unmotivated to learn programming because I do not see
do not see any value in it.
5.3 The programming examples should be relevant to me.
5.4 Even though the programming course uses topics that
I do not find it important or useful.
5.5 I find learning programming useful.
5.6 Programming can be used to create something useful for society.
5.7 I would also learn programming voluntarily because I find that it has added value for me.
5.8 What I learn in the programming course is also important for other courses in my degree programme.
5.9 Because this course requires a lot of effort, I don't have
enough time for other courses.
5.10 I feel that learning programming is wasted time.
5.11 For me, the costs (in the sense of effort) and the
benefit (grade; credits) of the course match.
5.12 I am happy to put the required effort into the
programming lecture.
5.13 Getting a good grade in the programming course is important to me.
5.14 Doing well in this course is important for my further studies.
5.15 Being good at programming is not important for my future plans.
5.16 For the programming lecture, the following applies to me: 4 is passed and passed is sufficient.

6 Time Expenditure and Evaluation
6.1 How many hours per week do you spend preparing for and following up on the ProcTec lecture?

- Less than one hour
- 1–3 hours

- 4–6 hours
- 7–10 hours
- more than 10 hours

6.2 Do you think that the amount of time spent on preparing and
for the preparation and follow-up of the course is appropriate?

- Yes
- No

Please tick the statements that apply to the respective lectures.

- General Business Studies
- Statistics and market research
- Design
- Marketing
- Information Technology
- Programming Technology (ProTech)

6.3 I enjoy preparing for the lecture.
6.4 I enjoy this lecture.
6.5 I invest a lot of time in preparing and following up this lecture.
6.6 In this lecture, it is difficult for me to follow the content.
6.7 It is important for me to understand the content of this lecture.
6.8 It is important for me to get a good grade in this lecture.
How much do the following statements apply to the subject ProTech (lecture with exercises)?
Strongly disagree strongly agree
6.9 I enjoy learning the lecture content.
6.10 I enjoy doing the exercises in the lecture.
6.11 The subject content is interesting.
6.12 My inner drive for the lecture is high.
6.13 I can motivate myself well to do something for the subject ProTech.
7. Social Milieu
7.1 What is your father's highest level of education?
Without school-leaving certificate Elementary school certificate, secondary school certificate Middle school certificate, secondary school certificate
Vocational school-leaving certificate, apprenticeship Abitur, Fachhochschulreife,
Technical secondary school
(Technical) university degree
Doctorate, habilitation
7.2 What is your father's profession?
7.3 What is your mother's highest qualification?
No school-leaving certificate Elementary school-leaving certificate, secondary school-leaving certificate Middle school-leaving certificate, secondary school-leaving certificate
Vocational school certificate, apprenticeship Abitur, Fachhochschulreife,
Technical secondary school
(Technical) university degree
Doctorate, habilitation
7.4 What is your mother's profession?
7.5 Which of the following terms do you associate with software development?
Teamwork Communication skills Boring
Empathy Unsocial Concentrated intelligence
Creativity Nerds Abstraction
Social skills neglected unfeminine
7.6 If another term, which one?
7.7 Do any friends, acquaintances or family members of yours
family members of yours work or study in the IT sector?
Yes No
7.8 Have you been encouraged by anyone to study anything IT related?

- Yes - by a family member
- Yes - from friends/acquaintances
- Yes - from a teacher
- Yes - from someone else

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- No

7.9 If from someone else, from whom? (open question)

8. Personal Details
8.1 Gender

- male
- female

8.2 Age

- younger than 17
- 17-20
- 21-24
- 25-29
- older than 29

8.3 Do you have German citizenship? Yes No
8.4 If no, which one?
8.5 In which federal state did you obtain your higher education entrance qualification?

- Baden-Württemberg
- Bavaria
- Berlin
- Brandenburg
- Bremen
- Hamburg
- Hesse
- Mecklenburg-Western Pomerania
- Lower Saxony
- North Rhine-Westphalia
- Rhineland-Palatinate
- Saarland
- Saxony
- Saxony-Anhalt
- Schleswig-Holstein
- Thuringia
- Abroad

8.6 If abroad, where? (open question)
8.7 Through which school education did you obtain your higher education entrance qualification?
Higher education entrance qualification?
Gymnasium (grammar school)
Fachgymnasium (comprehensive school)
Fachoberschule/ Berufsoberschule
Vocationally qualified

Different questions for IMA
2. Attitude towards studies (2.7-2.14)
First read through the following 8 occupational fields. Rank them according to how attractive they are to you.
(1 - most attractive, to 8 - least attractive)
2.7 Application developer
2.8 Optimisation of business processes
2.9 IT consulting in the automotive sector
2.10 Product developer in the automotive sector

2.11 Sales and distribution
2.12 Quality Management
2.13 Software developers in the automotive sector
2.14 Development of new services

6.2 Time Expenditure and Evaluation
Please tick the statements that apply to the respective lectures.

- Business Administration Basics
- Introduction to the automotive industry
- Basics of Automotive Engineering
- Mathematics and Statistics
- InfoTech and Data Structure
- Programming Technology (ProTech)