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Masterarbeit

Factors That Enhance Female Participation in German Computer Science Curricula: An Exploration

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Abstract

The phenomenon of women's underrepresentation in computer science programs at Germany's universities and colleges can be examined from two perspectives. The negative factors why women decide against such studies have been considered in various scientific research papers. The aim of this research work is to uncover the positive factors why women decide to study computer science. Using Kathy Charmaz's Constructivist Grounded Theory, an initial theory or taxonomy will be designed to do this. For the data genesis 5 female students of the University of Stuttgart were interviewed to find out their motivations and decisions. The parallel coding analysis and initial theory building revealed a total of 5 central factors. Interest development, which defines initiation to identification, specification, and differentiation from other interests. Related to this is the self-efficacy process, which is the development of inner conviction in one's ability to overcome difficult challenges. As the third factor of personality unfolding belongs the autonomy process, which accompanies the independence of female students until the beginning of their studies. In addition, two other factors were found. Convergence describes the convergence of both parties, which are characterized by points of contact. The decisive factor is not the number, but the intensity of the promotion of interest. Last factor describes the STEM skills, which specifically concerns the mathematical understanding of the female students. Regarding computer science, the five factors have a strong coherence, which can influence each other both negatively and positively. Knowledge of the factors and their degree of influence from outside can be used to target promotions to attract more women to such studies.

Kurzfassung

Das Phänomen der Unterrepräsentation von Frauen in Informatik-Studiengängen an Deutschlands Universitäten und Hochschulen lässt sich aus zwei Perspektiven untersuchen. Die negativen Faktoren, warum sich Frauen gegen ein solches Studium entscheiden, wurden in verschiedenen wissenschaftlichen Forschungsarbeiten betrachtet. Ziel dieser Arbeit ist es, die positiven Faktoren, warum sich Frauen für ein Informatik-Studium entscheiden aufzudecken. Mittels der Constructivist Grounded Theory von Kathy Charmaz soll hierzu eine initiale Theorie oder Taxonomie zu konzipiert werden. Für die Datengenese wurden 5 Studentinnen der Universität Stuttgart interviewt, um ihre Beweggründe und Entscheidungen zu ergründen. Die parallel stattfindende Coding-Analyse und die initiale Theoriebildung ergaben insgesamt 5 zentrale Faktoren. Die Interessensentwicklung, die die Initiierung bis zur Identifikation, der Spezifikation und Differenzierung gegenüber anderen Interessen, definiert. Im Zusammenhang dessen steht der Selbstwirksamkeitsprozess, also die Entwicklung der inneren Überzeugung in das eigene Können schwierige Herausforderungen zu meistern. Als dritter Faktor der Persönlichkeitsentfaltung gehört der Autonomieprozess, der die Selbstständigkeit der Studentinnen bis zum Studienanfang begleitet. Zusätzlich fanden sich zwei weitere Faktoren. Die Konvergenz beschreibt die Annäherung beiden Parteien, die durch Berührungspunkte geprägt werden. Entscheidend ist nicht die Anzahl, sondern die Intensität der Interessensförderung. Letzter Faktor beschreibt die MINT-Fähigkeiten, die speziell das mathematische Verständnis der Studentinnen betrifft. Hinsichtlich der Informatik stehen die fünf Faktoren in einer starken Kohärenz, die sich sowohl negativ als auch positiv beeinflussen können. Das Wissen über die Faktoren und ihren Beeinflussungsgrad von außerhalb können dazu eingesetzt werden, um Förderungen anzustreben, um mehr Frauen für ein solches Studium zu gewinnen.

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1 Introduction

The International Organization for Economic Cooperation and Development, shortly known as OECD, provides regularly issue insights on various topics such as education, development cooperation of the 38 member countries, or economic policy. In a recent publication from 2021, gender parities in STEM (science, technology, engineering, mathematics) subjects in member countries were examined [OEC21]. In this, they found that the aforementioned gender parity was achieved only in the STEM subjects of science, mathematics, and statistics, with women actually being much more represented in some states. On average, 52% of STEM first-year students in the OECD countries were women, ranging from Japan with 27% to Slovakia with 65%. In Germany, the proportion of women in STEM subjects were ahead of all other OECD countries, which is shown in the appendix in Figure A.1. However, fewer women still enroll in computer science and communication technologies curricula. For that subject group, the percentage of male students was at least 70%. The world map in Figure 1.1 shows an overview of female student beginners studying computer science or communication technologies in all participating OECD countries.

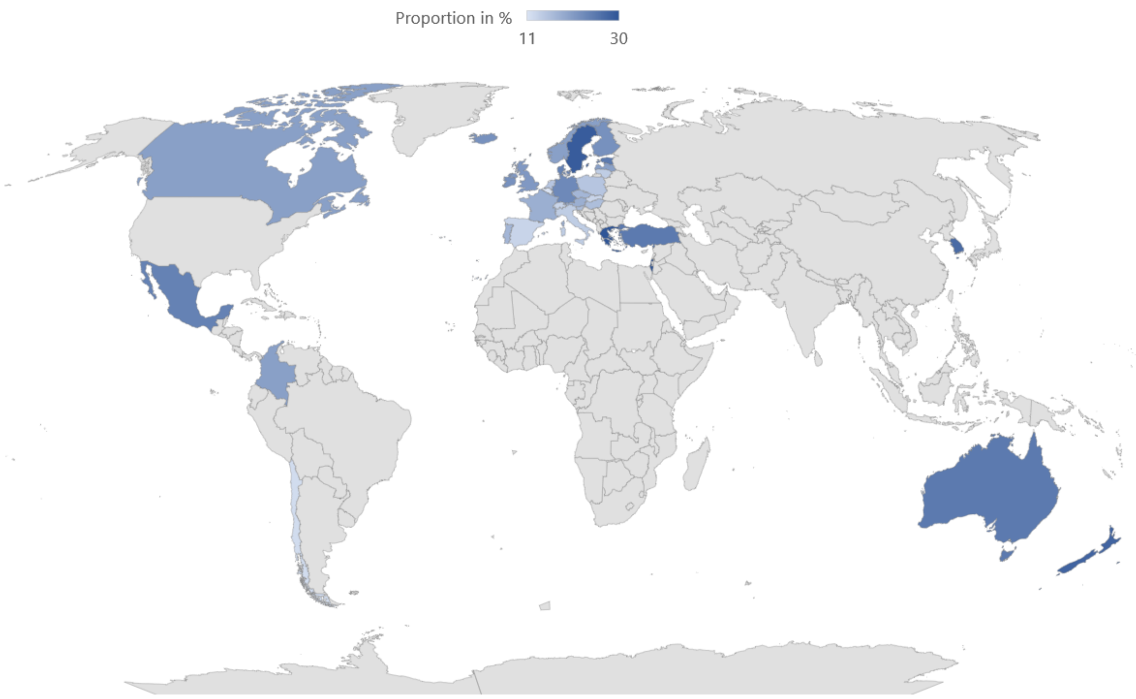

Figure 1.1: Proportion of female first-year students (in %) in computer science and communication technologies in OECD countries in 2019). Based on [OEC21]

The percentage of female students in such curricula ranges from 11% as in Belgium to 30% as in Greece or Israel. In Germany, the percentage of female students in computer science and communication technologies was in the middle range at 23%. Despite this, the number of female first-year students is visibly lower than their male colleagues. An overview of all numbers can be found in the appendix in Figure A.2.

Therefore, the underrepresentation of women in computer science curricula at Germany's universities and colleges has long been an obvious problem that also extends across state borders. For example, the student statistics of the University of Stuttgart[1] in Figure 1.2 show that the female quota has hardly visibly changed between the winter semester 2008/2009 and 2020/2021 regarding computer science and software engineering curricula. This Figure 1.2 is also part of the Section 4.1, in which the detailed research gap and problem is defined.

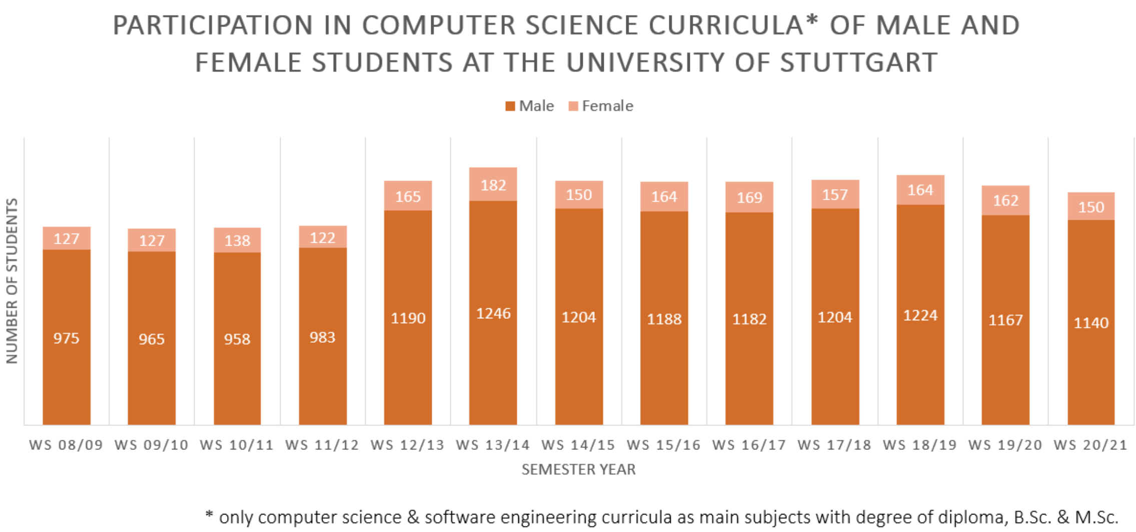

Figure 1.2: Student statistics WiSe 2008/2009 - WiSe 2020/2021 at the University of Stuttgart

Since the winter semester 1999/2000 female students at the University of Stuttgart are considered separately in the student statistics. For each offered curricula, the number of currently enrolled female students is given by the semester number and sought degree. With regard to the study courses in computer science and software engineering, the numbers of female students were significantly lower than the number of male students.

Such a low quota has also industrial and economic consequences. The shortage of skilled workers cannot be compensated exclusively by men, homogeneous project teams center the product requirements solely on the positions of men, thus limiting the margins of interest [Pöp09].

[1] The data is available at https://www.uni-stuttgart.de/universitaet/profil/zahlen/studierendenstatistik/

In order to explain this phenomenon, previous scientific work has looked in particular at the factors that prevent women from studying computer science. The factors known to be negative are used, for example, to design appropriate countermeasures that are simply intended to increase the women quota. But despite extensive research and various approaches for improvements, the proportion of women is increasing minimally.

Describing the phenomenon only from the perspective of women who decide against such studies suggests a notable intermediate space. In addition to the negative factors, there may be crucial positive factors that describe the perspective of women who chose a computer science curricula. Even factors that cannot be derived by implication from the negative factors. Based on this research gap, the thematic framework of this thesis is formed, which aims to investigate positive factors that facilitate women's participation in computer science majors. As a consequence, measures can be formed more effectively to convince more women to pursue such studies.

To achieve this goal, an inductive and qualitative research method, such as Grounded Theory, will be used to form an initial theory or taxonomy which reply to the primarily research question "What are the factors that enhance female participation in German computer science curricula?" The focus of the data genesis is on conducting interviews with female students of the University of Stuttgart. Based on the formed theory, the research gap shall be filled on the one hand and potentials for further research such as identifying improvement approaches on the other hand.

For this purpose, this thesis will be structured as follows:

Chapter 2 – Related Work In this chapter, the work of previous scientific studies is examined and presented as a research overview. Most of the discovered publications concentrated either on negative factors or increased potential interventions. Due to the focus on negative factors reveals the recognition of a resulting research gap.

Chapter 3 – Theoretical Background In order to create a foundation, this chapter is intended to pave the way for understanding the Grounded Theory (GT) methodology. For this purpose, Section 3.1 will first classify the Grounded Theory in existing research methods. Furthermore, its methods Theoretical Sampling, Memoing, Constant Comparison and Theoretical Saturation are presented. As central methodologies, the popular Grounded Theory methodologies Classic GT, Straussian GT and Constructivist GT will be presented and compared on the basis of their differences and similarities.

Chapter 4 – Tasks and Goals First, the research gap defined as a problem is thematically concretized in Section 4.1 of this chapter. Furthermore, this section includes the clear definition of the goals, by naming the initial research question which is presented in Section 4.2. As a third element of this chapter in Section 4.3, the task will be refined by means of decomposition into subtasks, highlighting the intermediate goals of this thesis.

Chapter 5 – Study Design The focus of this section is the presentation of the study design and its implementation. For this purpose, the chapter is divided into seven sections.

By using a Grounded Theory, the choice of an appropriately methodology is crucial, from which the research process and data collection methods are derived. Both are addressed in Section 5.1 and Section 5.2. Subsequently, all parameters regarding the literature review as well as the interview design are described in Section 5.3. This is followed by an explanation of the interview design in Section 5.4 and how to conduct the data genesis in Section 5.5.

Also part of this chapter is the presentation of data aggregation and processing in explained in Section 5.6. At the end of this chapter in Section 5.7 the study design will be reviews according to the quality criteria.

Chapter 6 – Research Results Based on the previously described design and implementation the interviews output research finding will be presented in this chapter. The focus is on the analytically identified factors and their evidence, which are supported by the data from interview quotes.

Chapter 7 – Discussion Regarding the research results this chapter discusses the research process and its findings. This chapter is divided into seven sections.

Section 7.1 discusses the revealed taxonomy model, addressing the individual factors and how they relate to each other. Individual factors that did not qualify sufficiently for the initial taxonomy are also discussed. In Section 7.2, the primary research question is answered. In addition, attention is drawn to the limitations of the thesis, which are subsequently evolved as extended research questions in Section 7.3. The extraction of the advantages as well as the benefits and which useful treatment points that come with the research results will be described in Section 7.4. Also, problems encountered during the research process are documented in Section 7.5 and adaptation possibilities of the model to other STEM fields in Section 7.6 are elements of this chapter. Discussing problems and expand the research results increase the credibility of this thesis. At the end, the research process and its results are reviewed on the evaluation criteria of the chosen Grounded Theory.

Chapter 8 – Reflection Within Chapter 8 the results of the research are mapped separately on the individual and personal social reality of the researcher.

Chapter 9 – Summary & Outlook Finally, Chapter 9 briefly summarizes the work and provides an outlook on future research potentials.

2 Related Work

The connection between women and computer science studies is an extensive topic, which is treated in many countries of the world within scientific investigations. For example, there are some states in the world that have significantly higher rates of women in computer science programs than others [GOK19]. Countries with low rates of women include the United States, Israel, Anglo-Saxon, Scandinavian, and German-speaking countries. High female quotas are found for example in Malaysia, Mauritius or Taiwan [GOK19]. In particular, as part of the existing scientific work explanations of those observations are looked for. This results in factors, with which women decide either for or against a computer science curricula.

An Israeli study on "Factors Influencing Women's Decision to Study Computer Science: Is It Context Dependent?" by Genut, Ori, & Ben-David Kolikant, conducted an literature review which considered both negative and positive factors in different countries. Furthermore, the author focused on the aim of finding positive factors by conducting interview but take attention on factors that occur in Israel, more precise to investigate the influence of religious background on these factors [GOK19]. During a literature review, the researchers found low female rates especially in western countries like in Europe or USA. In the foreground, a predominantly poor perception of computer science as a negative factor was found. The embodiment of stereotypical images as also among the negative factors regarding to the lack of interests and skills, as well as low self-efficacy. Whereas in countries such as Mauritius, computer science is mainly associated with a high prestige level combined with high salaries that motivate women to pursue such curricula. Also, the pressure and influence of parents or family are more prominent. Within their own study, the researchers asked female students in Israel about their motivations. All female students, independent of their religious backgrounds, agreed in self-realization, self-efficacy or affinity, and economic well-being as drivers of their desire to study computer science. In all other factors, large differences were found between different ethnic groups and are affected of various parameters such as belief or the wish of a big family.

Although some common, positive factors were uncovered, but their goal and purpose was to quantitatively examine the influence of the religious context to women's motivation factors. In addition, the underlying religions reflect the ethnic groups in Israel, but do not reflect religious contexts in Germany, which makes it difficult to generalize.

Another exploratory study conducted in the U.S., published under the title "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", also investigates the issue of women's underrepresentation in computer science [Bey14]. The goal was to uncover gender differences between women and men in terms of interests, stereotypes, self-efficacy, and values. The hypothesis that women in their first year of study have lower self-efficacy, lower interest, but greater interest in female-dominated fields of study compared to men was to be tested. Using variables such as computer self-efficacy, high interests in computer science, weaker interpersonal values and positive stereotypes, allow for predicting can predict if women are more likely to take up such studies.

Reflecting the thematic framework of this paper, their investigation focused specifically on gender differences where motivation factors of women and men were equally valued. So, the results cannot be fully reflected in the image prevailing in Germany from various points of view. The study explicitly points out that a generalization of the results to for example non-American educational institutions is not readily possible. This is due to the different educational systems. Unlike in Germany, students in the U.S. first apply for college and choose later a major curricula [Sey15]. Until then, the students enjoy the freedom of their course choice and thus, can try out different fields of interests. For this purpose, freshmen were also considered for the study who can gain study experience on computer science before deciding on a major. Moreover, in view of their goals, the study pursues the concrete differences on preconceived categories such as interests or stereotypes. Since the results are on the one hand limited to existing factors, the view of women and thus the positive factors only play a minor role and on the other hand are based on other educational conditions, the results cannot be transferred to the topic of this thesis. This results in the research gaps on further positive, potential factors, the exclusive focus on the motivations of female students, not the differences and their experiences at college, and the mapping to German universities.

Another scientific paper ”What Drives Young Women to Study Computer Science in Switzerland? - Experiences on Promoting Computer Science Studies for Female High School Graduates” by Christina Pöpper and Adrian Altenhoff, also concerned with the tipping balance women and men in computer science programs in Switzerland but looking more closely at measures to promote women [Pöp09]. At the largest technical university in Switzerland, the female student quota was just about 10% in 2009. Possible reasons cited for the imbalance include the early decision of men based on their affinity and interest. Women might be more influenced in their decision making by public perception. The problem of the high dropout rate among women is also briefly addressed. Overall, as a result fewer women achieved a degree, which decreases their success rate. Since the goal of the scientific publication is to investigate approaches for improvement, support measures such as *Schnupperstudium* were examined which demonstrates apparent positive effects in their study. This, in turn, demonstrates the potential of positively influencing women in terms of deciding on a course of study.

Although the proximity to Germany offers the possibility of a connection to the subject of this work, but the goals and purposes of the Swiss' work is directed toward the investigation of approaches for improvements, not the underlying factors. The negative factors mentioned are repeatedly reference to men, whereby gender differences are the focus of interest as in the previous article. Therefore, an exclusive study of women's factors of motivation was only made in the presented publication from Israel [GOK19].

Further scientific work increasingly focuses on negative factors, on proposed solutions to close the gender gap, or deals with experiences during studies. A German-Czech scientific cooperation work is offered by the paper ”Frustrations Steering Woman away from Software Engineering” by L. Happe and B. Buhnova at [HB21]. The goal was to determine the kinds of frustrations women encounter on their way to a software engineering degree and to identify promising solutions. In total, five frustration factors were identified. These are access to adequate instruction, extensive support respectively encouragement, and access to a functional computer. As a second, impactful factor the author mentioned stereotypical thinking, perceive or belief about computer science and scientists. Regarding other factors the author identified self-confidence concerning self-efficacy as a negative factor, thus to play down their own ability, which is also known as Imposter syndrome, and the perception of missing experiences. Demotivating factors are also the lack of a sense of belonging, such as the discomfort of expressing oneself, sexism and unwanted attention. The last factor to be mentioned is the lack of appreciation, expressed in the defensive culture or referring to the women themselves or their non-stereotypical abilities or interests.

Reflecting on the thematic framework, the focus of the researchers are only on negative factors, namely as frustration factors. An idea of possible positive factors is also left out here.

The problem of underrepresentation of women in computer science courses is also well known in universities in the UK. Although several papers try to explain the gender inequality, there is a lack of sufficient qualitative data. The aim of the work ”Female computer science students: A qualitative exploration of women's experiences studying computer science at university in the UK” was to conduct such a study with the aim of a deeper understanding [YP21]. The focus was particularly on the experiences of everyday university life. For this, the work first looked at existing research regarding negative factors, which is summarized under the aspects of masculine culture, the lack of early contact and low confidence in one's own abilities. Factors stemming from the narrated experiences of current study included feeling stupid due to external conditions stemming from pre-college years. These included negative perceptions of computer science, the high demands placed on future students, and the different initial levels of experience also caused problems for female students. In addition, men exude higher self-confidence in contrast to women. Further negative factors refer preferably to experiences during the study such as stereotypical thinking, which is emitted by male fellow students. However, it turned out that there was no lack of a sense of belonging which previous work dealt with.

Similar to the previous publication, either the negative factors are emphasized or a gender comparison is gone through, where the positive factors of men's motivation are dealt with.

Austria, a neighboring country, also records a low female quota at their colleges and universities. Based on known negative factors, the scientific paper ”Female Computer Scientists Needed: Approaches For Closing The Gender Gap” welcomes various initiatives employed as countermeasures [KGSK20]. Among the negative factors a lack of interest in the field of computer science due to existing stereotypes is stated. Likewise, differences in self-image or performance are found between girls and boys. While young women underestimate their abilities in mathematics and computer science, their male fellow often overestimate their abilities, although both show equally good performances. Furthermore, girls classify computer work as unattractive. In addition, there are still high dropout rates among women in computer science programs at the bachelor's level. In particular in software development exams register higher dropout rates of female students.

As before, the negative factors of women against studying computer science are identified and compared with the other gender. From the set of publications listed, only the first study from Israel [GOK19] makes reference to positive factors on computer science study choice for women, but with the central aim to investigate the degree of influence and differences between ethnic and religious groups. The other publications focus on gender differences and their comparison, preferably referring to the negative factors of women and the positive aspects that motivate men. Based on these comparisons, the research gap is formed, an open exposure of positive factors of women, unbiased of their status, backgrounds or other limitations and independent of the motivations and decision factors of men.

3 Theoretical Background

This chapter presents the theoretical foundations needed for the Grounded Theory methodology. For this, first a brief classification of research methods is made in order to embed the research method of Grounded Theory. Next, the underlying principles of Grounded Theory are presented. Based on this, the chapter differentiates the three central methodologies and compares them.

3.1 Research Methods

Research methods are instruments to systematically investigate scientific questions. For this purpose, research methods can be distinguished according to their approaches and goals. Inductive and qualitative research methods form with the help of just few observed cases a theory that can be mapped to the general public. This step is called *generalization*. Whereas deductive research methods, based on existing theories, form hypotheses that are either proven or disproven in a systematic procedure. These are quantitative methods whose data base is rest on a particularly large number of observations, which ideally represents the generality and concludes thus on few cases [WH07]. Therefore, both research methods distinguish in the terms of discovery for inductive processes, such as Grounded Theory, and verification of hypotheses with deductive methods, such as experiments [Brü08].

3.2 Grounded Theory

The method of Grounded Theory (GT) was first published by Barney G. Glaser and Anselm L. Strauss in a medical sociological context. In their book, "The Discovery of Grounded Theory" (1967), they address the inductive development of theories based on the systematic collection and analysis of qualitative data [BS19]. For study, the authors investigated the experiences of terminally ill patients who had different levels of knowledge of their health. The goal was to more closely assess patients' responses to their diagnosis, their path of recognition and the nurses' reactions in more detail [CBF19].

Fundamental was the rationale for the development of a theory and the theory itself based on empirical data and observable actions of everyday social life. Instead of verifying previous hypotheses, participants' needs and social realities could be derived to built up theories based on their experiences. One of the basic teachings to be observed is impartiality on the part of the researcher towards the subject and openness to resulting theories [HMG+11]. For the implementation and development, work steps consist of data acquisition, data analysis and theory building, which are not sequentially but effectively carried out in parallel and continuously. Through simultaneous processing, a mutual positive influence of the three steps is achieved. Results of data analysis do not only contribute to the design of the theory, but also influence the process of data collection. The same applies to the development of the desired object-related theory, which for example uses other data types or modified forms of data genesis [Str14; Str19]. Already with the first data collection the analysis process starts which leads to an implied first theory. Conversely, the building of a theory in turn influences the elicitation of data. Figure 3.1 shows an overview of all sub processes of Grounded Theory and how they are related to each other.

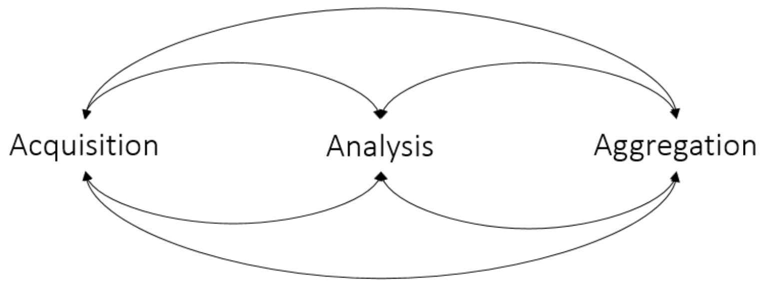

Figure 3.1: Procedure of Grounded Theory. Based on [Str14]

As the new abstraction research method became known, the approach spread rapidly among scientists, such that in a very short time different variants with different focuses developed. Characteristically, three central grounded theory methodologies have established. The original form, known as the *Classic GT* by Barney G. Glaser, the first variant of the original form by Anselm L. Strauss in collaboration with Juliet Corbin, the *Straussian GT*, and the latest variant by Kathy Charmaz from 2006, the *Constructivist GT*. All three types differ greatly from each other, but retained the following five core elements, which are closely interwoven [HMG+11; SRF16].

3.2.1 Theoretical Sampling

Theoretical Sampling is a core element of Grounded Theory and describes the collection of data. Applying the Grounded Theory, only the process of data acquisition, known as Sampling, is carried out sequentially. Data refers to texts such as transcripts or existing literatures, pictures or films. Differences are made between Selective and Theoretical Sampling. While Selective Sampling focuses on the identification of populations and the setting for data collection, the selection of a data source, a case or a sample takes place against the background of theoretical considerations. The sample is not defined a priori, but is constructed successively [Str14; Str19]. Starting with Selective or Purposive Sampling, initial theories can be formed with the first obtained data. Through the emergence of the formed theory in the process of data collection, there is a change from Selective Sampling to Theoretical Sampling. In this respect, the constructed theory, influences directly the selection of the data source and the data genesis. Here, Glaser recommends strategies to adapt, for example by changing the interview style, the group of participants or creating new categories in the event of theoretical saturation. It is up to the researchers decision, if there is a need of such a change [CBF19; DMRR07].

3.2.2 Coding

The process of data analysis, known as *Coding*, is a continuous and multi-layered approach whose core is composed mainly of the systematic coding process and therefore acts as a core process in Grounded Theory [Hol07].

Data collected during Theoretical Sampling are initially presented in a closed form, the meaning of which has to be determined with the help of Coding. Coding refers to the marking of data segments with labels. Depending on the envisaged coding levels, the codes aim at a simultaneous summary, categorization and conceptualization. In particular, the accessed data segments are broken down in order to create a thematic approach and to make theoretical genetic perspectives available. By conceptualizing (core) categories, relations and theoretical concepts, the fragmented coding fragments are joined together to form initial theories.

With the first data collection, a coding process starts automatically, which is continuously determined by data connected to a first theory genesis and is therefore closely interwoven with the method of Theoretical Sampling described in Section 3.2.1 [DMRR07; Str14]. The coding process either does not follow a fixed sequence, nor distinct the individual stages from each other. To generate an associated code, first analytical steps such as data checks are necessary. A code is characterized by an active, short, simple and precise form, whereby the label content is matched to the objective of the coding level. Reduced to the three central Grounded Theory types, they are based on a three-stage coding concept. Within the first step, known as Initial or Open Coding, the data is broken down into meaningful segments which will be labeled. In an intermediate Coding, core categories are formed based the labelling step before. Finally, the individual parts are put together by conceptualization using a glue code which represents the core category. At the end, the resulting knowledge is integrated into the theory, which is executed in advanced Coding or final development [CBF19; HC04]. The phases of Coding are by no means traversed linearly, but are shaped by forward and backward steps. However, the process is used more often at the beginning than at the end of Grounded Theory. The aim of Coding is to obtain coding schemes from behavioral patterns, similarities and differences, and to be able to form categories, theoretical concepts [BS19; Str14; Str19; TC+14]. In the following five coding procedures are presented, which are used in the three central Grounded Theory methodologies.

Open Coding

Open Coding is a component of Substantive Coding, which directly processes the obtained data, i.e. breaks it down into smaller data segments and analyses them.

Initially, it is started with an Open Coding, in a special form also known as Initial Coding. The qualitative data obtained from the previous data acquisition process are broken down into meaningful, discrete components. Its size ranges from a word, a line, a sentence, a paragraph, a specific segment, an incident or even a complete document [Cha06]. The aim is to achieve complete theoretical coverage in the form of individual categories as far as possible without using one's own opinion, bias or assumptions. In particular, coding appeals to the researcher's openness to new theoretical possibilities. For this purpose, the individual components are actively questioned. "What is this data a study of?", "What kind of study are the data appropriate?", "What category does this event indicate?", "What happens in the data?", "What category does this incident indicate?", "What is the topic here?", or "What is relevant to the research question?". At its core, the text is to be critically interrogated with regard to the underlying phenomenon using the familiar wh-questions. These questions can be used to generate codes for the respective blocks that summarize the segment content and categorize it by relations. Finally, the individual parts get a substantial label, which in a second phase of Substantive Coding emerge into a core category. With the help of the developed labels or codes the underlying phenomenon will be named, described or even classified [BS19; Hol07; SRF16; Str19; TC+14].

Focused Coding

By means of *Focused Coding*, a higher level of abstraction is reached, in which the most common, relevant, important and repeating codes are selected for abstraction within categories. The goal is to find recurring patterns and relationships between the codes. Developed categories are also already integrated into theoretical frameworks [BS19; SRF16]. To generate focused codes, questions such as "Which of these codes best explain the data?", "What is the conclusion of a code comparison?", "Do the focused codes have gaps?", "What kinds of theoretical types do the codes indicate?" need to be answered [BS19].

Selective Coding

The second phase of substantial Coding is composed of *Selective Coding*, where the two coding stages are not follow a necessarily fixed sequentially. Selective Coding describes a process in which the developed categories from the previous coding stages are concentrated and limited to a central core category, such as a specific core variable like a behavior pattern. In this process, the core category usually manages systematic relationships with a majority of the theoretical concepts already developed, i.e., the properties, dimensions, and theoretical connections of the central category match the relevant related concepts. The goal is to transform running the data to delimitation around a core category that amounts to the integration and refinement of the theory to be built [Hol07; Mog06; WM06].

Axial Coding

After the data have been broken down into their building blocks, *Axial Coding* reassembles them by linking categories to subcategories at a higher level of abstraction. If there are only codes available, for example from the Open Coding, without further categorizations, these are grouped at the latest in this step to categories, to so-called axes. By extraction of the code relations and integration into the axis, the associating codes are held together. If categories already exist, the analyst treats them as an axis to outline their properties and relationships and specify dimensions. The goal is to reassemble the data into a coherent and cohesive whole after the analyst has broken it down into small components. Axial Coding thus contains selection elements similar to Selective Coding, but aims to select categories for which the coding process uses coding paradigms [BS19; Hol07; SRF16]. If a core category is not clearly identifiable, for example, a conditional or consequential matrix is applied [Mog06]. Specifically, these are used to identify contexts, conditions, strategies, and consequences [SRF16].

Theoretical Coding

Based on previous coding steps, codes and categories are further abstracted, conceptualized, and condensed within *Theoretical Coding*. However, this does not mean descriptive and content-reducing activities. Compared as a relational model, the substantive codes respectively categories shall be related to each other and to the core category leading to the development of hypotheses. In particular, the goal is to work out interrelationships of groups of subjects in addition to relationships and to integrate them into a coherent theory [Her09; Hol07; SRF16].

3.2.3 Memoing

Memoing means the documentation of thoughts and potential hypotheses of the researcher concerning the data collected and to be analyzed. Memos are especially used to organize the analytical thoughts and thought process in order to capture and promote possible connections, relationships, patterns, but also outlooks into the future. Specifically in data analysis, the rationale of emergent codes or categories can be noted. On the one hand, the simple and short notes represent an abstraction possibility for the researcher, so that he can still orient himself to the true data during the analytical strategy. On the other hand, it is intended to reduce disruptive influences on the researcher, as any thoughts that arise can be written down and revisited at another time. Memoing as a tool should improve the entire research process, in which the notes from different data analyses are constantly compared on equivalences and differences. Thus, influences in the form of Theoretical Sampling or acting on Grounded Theory can be carried out [BCF08; BS19; SRF16].

3.2.4 Constant Comparison

The method of permanent *Constant Comparison*, is a data analysis technique in which data mining and data analysis take place in parallel. With the help of Constant Comparison, similarities, differences, and patterns in the data are identified, thereby influencing data collection, analysis, and theory development [HMG+11; SRF16]. The comparative method is used to develop concepts within four steps which are evolved by Glaser & Strauss. These stages are composed of comparing incidents applicable to each category, integrating categories and their properties, delimiting the theory, and writing the theory [Kol12].

3.2.5 Theoretical Saturation

The process toward Grounded Theory is limited by *Theoretical Saturation*, i.e., the researcher terminates data collection and data analysis when the theory components are sufficiently supported to the point that further data would not produce change [SRF16]. An example shows how this works as follows. After collecting data of the first case, a the first analysis based on the coding will be done. With the help of the Constant Comparison a parallel analysis and further data collection is possible. Based on the intermediate results of the analysis an initial theory can be developed. At the same time, the intermediate results influence the data collection process, for example by changing the study parameters such as the interview questions. Through the constant change, Theoretical Saturation occurs, namely when no more data are needed. Since the theory is sufficiently grounded in the existing data.

3.3 Classic Grounded Theory by Glaser

About ten years after *The Discovery of Grounded Theory* by Barney Glaser and Anselm Strauss (1967), Barney Glaser (1978) extended the inductive development of theories by detailed concepts such as Theoretical Sampling, Coding and Memoing [HC04]. The method is constructed according to the principle of objectivity, in which Grounded Theory would only have to be uncovered by the researcher, since a single correct description of reality exists [SRF16]. In doing so, the Glaserian approach also builds on the process of data collection, data analysis, and theory building. At its core, however, the method focuses more on the inductive approach. This is described by Glaser as a key process, in which an empirical generalization and finally a theory is developed from data. Accordingly, research implementation and theory building is done according to the principle of laissez-faire generation [HC04; HMG+11]. An analysis overview of Glaser's Classic Grounded Theory is presented in Figure 3.2.

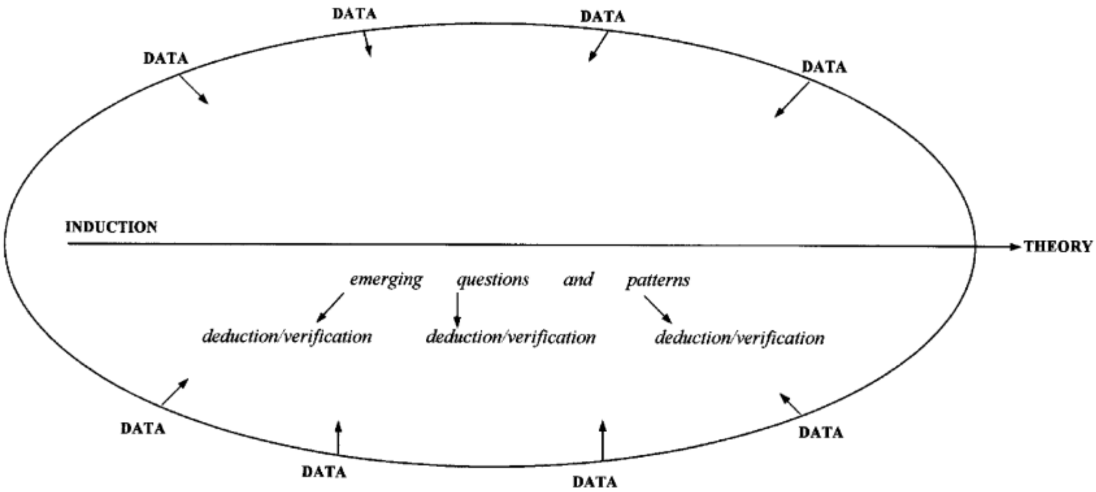

Figure 3.2: Glaser's classic Grounded Theory (1978) [Her09]

Therein, all data are considered equally important. Induction is presented as the main drive of the method, with deduction and verification steps supporting adherence to emergence. This is because generated concepts must be verified by data again and again, and categories must be constantly adjusted as results are compared between old and new data. However, frivolous verifications can lead to data forcing, of which the researcher should be aware at the point [HC04].

The implementation of such a clear and rigorous approach is already realized in the design of the setting of a grounded theory study by Glaser. Neither the identification of the problem domain nor concrete a priori research questions are initially allowed elements. In particular, this refers primarily to literature reviews, which are intended to target potential research problems [HMG+11; SRF16]. According to the developer, the focus of Classical Grounded Theory is on emergence, which should be reflected in all processes [HC04]. Instead of specifically defining a problem without proving its relevance value to the state of the art in research and technology, the goal is to first explore an area of interest preferably an unknown area to form a Theoretical Sensitivity to draw attention to potential problems. Only through this a relevant problem area will emerge for which a research question may be evolved. However, once a problem area has emerged, further literature reviews must be prohibited because of the risk of influencing the initial theory building. The reason is based on the literature comparison that takes place and influences the unaffected mind of the researcher. The purpose of the literature review is to place research findings in the corpus of previous knowledge and compare them with the main body of relevant literatures. If such a selective comparison occurs, then its focus is on the comparison of concepts, which means it is conceptual. In contrast to the contextual way, data sources are irrelevant. In order to identify relevant literatures for a conceptual comparison, the emergence of stable concepts such as a theory is necessary to avoid the influence of existing concepts from the literatures on theory development. For this, only empirical data will be emerged. Furthermore, a literature review and comparison to a later stage after development of a theory is allowed [Chr11; HC04; SRF16].

Coding is the core process in Classical Grounded Theory, which includes three coding procedures. The Substantive Coding, consisting of Open Coding and Selective Coding and the Theoretical Coding. Initially, Open Coding is started by breaking the data into building blocks as explained in Section 3.2.2. Therefore, the Open Coding is completely dependent on the obtained data. Then, in the intermediate phase, Selective Coding follows, in which the generated codes from the previous procedure are drawn in relation to others, to categories, and a continuous comparison with the previous phase, focusing on data, takes place. The goal is, among other aspects, to achieve a higher abstraction and revision of the categories. Also a possible emergence of frameworks could be evolved in this section. In the final development the Theoretical Coding is implemented, in which further conceptual relations between the substantive codes are uncovered, to so-called *Coding Families*, which continue to lead to hypotheses. Categories that have already emerged are further abstracted, revised and refined, and integrated into a core category. This is used, among other things, to refine the data search [HC04; HMG+11; SRF16]. During Coding and data analysis, typical questions such as ”What is this data a study of?”, ”Which category or which property of which category indexes the incident?”, ”What is happening in the data(building blocks)?” [SRF16].

Through recurrent checks on the fit of categories and data, and incorporating Theoretical Sampling, Memoing, and Constant Comparison, theory to be developed gradually stabilizes. When Theoretical Saturation is reached, where any further data genesis added will not produce any change, theory genesis is complete. However, it must meet certain evaluation criteria to be considered fully completed. If care is taken during emergence to ensure that the data obtained fit the theory, it follows that, conversely, a developed theory must also fit the empirical data. As is well known, therefore, a complete function of the theory is intended, in that it has ability to explain and predict what will happen. However, if new data emerge, then the theory must still remain modifiable to some extent in order to adapt to new circumstances. In particular, the condition of the relevance factor is an authoritative evaluation criterion on which Glaser’s classic GT relies at the outset. In it, a goal-oriented literature review is prohibited and a priori research questions remain undefined at first [HC04; HMG+11; SRF16]. However, Glaser emphasizes that revealed theory requires less detail than parsimony, scope, and modifiability [HC04].

3.4 Straussian Grounded Theory by Strauss and Corbin

After Anselm L. Strauss, together with Barney Glaser, contributed to the uncovering of Grounded Theory, he published in 1990, in cooperation with Juliet M. Corbin, a prescriptive Grounded Theory methodology based on objective pragmatism and symbolic interactionism. In it, reality is constructed through reflexive interactions using language and communication of the actors involved [BS19; SRF16]. In particular, the authors' focus is on developing an analytic technique characterized by more systematic rules to facilitate the applicability and comprehensibility of junior researchers [HC04]. The variant is considered the first deviation from the original form and thus aims to increase the transparency of the researcher [HMG+11]. In contrast to the approach of Glaser, the inductive development is evaluated by the authors as too overrepresented, whose presence accordingly loses clarity in the Straussian methodology [HC04]. For this reason, theory development and research implementation is characterized by a paradigm model as presented in Figure 3.3.

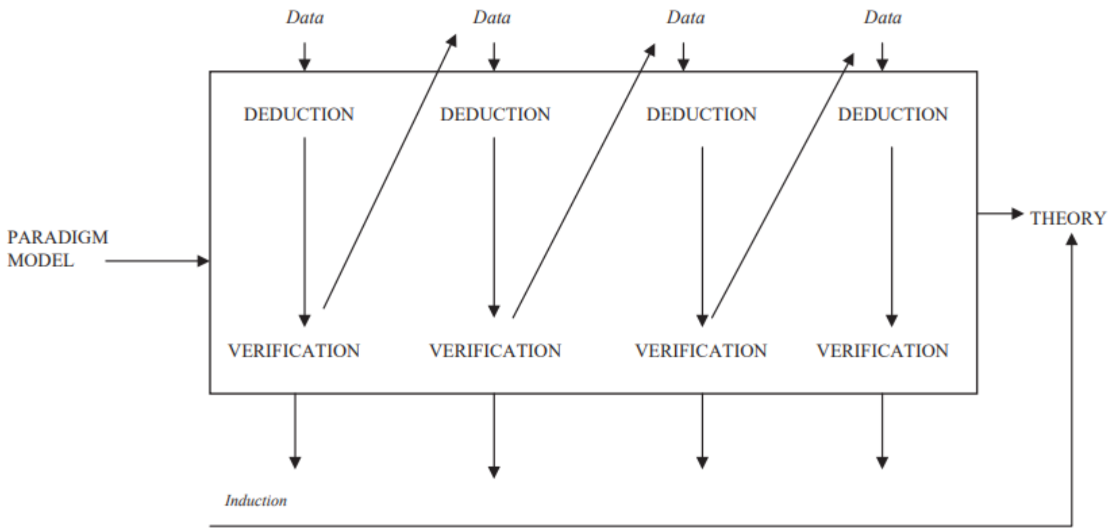

Figure 3.3: Straussian Grounded Theory by Strauss and Corbin (1990)

The induction aspect is presented as a secondary process to the development of the theory, whereas in the paradigm model, the theory being developed is steadily verified by deduction. However, the term verification is replaced by the terminology of validation in a second published book by both authors [HC04; HMG+11].

For data genesis, the problem domain and the associated research question are first identified. Experiences from the researcher's side as well as literatures from which possible questions can be derived serve this purpose. Likewise, the exchange of information between research colleagues is supported, from which research questions may equally arise. Its form must describe the identifying phenomenon and discuss what is known about the topic so far. In most cases, the definition of the research question is broadly stated and offers an open-ended approach to be refined as the process unfolds. Literature influence is incorporated particularly early and throughout the process, whose intentions include stimulating the researcher's theoretical sensitivity to help generate hypotheses [HC04; HMG+11; SRF16]. In addition, it can be used to determine questions for data collection and analysis, to suggest potential areas for theoretical sampling, or, if possible, to directly [SRF16] concepts from the literatures. Concerns are expressed by several researchers who recognize a general problem with it. The specification of the problem area is not triggered by the problem area itself, but by the interest of the researcher. Through which biases and prejudices of the researcher shape the research and its process to the detriment of the problem field. A relevance towards the research field is thus excluded [HC04].

In the subsequent analysis step, three different types of coding are used. Starting with Open Coding, the data is broken down into building blocks, initially word by word. Only later are they broken down into larger segments of meaning, as explained in Section 3.2.2. Through labeling, emergent phenomena such as similarities and differences are conceptualized through codes. Within the Straussian methodology, this refers to events, actions, and interactions that are compared to each other. If similarities between phenomena occur, conceptualization under the same code is possible. Through this step, similar events, actions, and interactions are grouped into categories and subcategories [CS90]. If other data are available, prior knowledge of the researcher can be used. Emerging concepts are then aggregated into categories at a higher level of abstraction. In this, the character traits and dimensions of the categories are elaborated. By dimensions are meant the interrelationships of the characteristics within a category. Thus, differences between categories can be specified [HMG+11; Ros17; SRF16].

In the intermediate phase, Axial Coding is applied that reduces the number of categories by aggregation and clustering using paradigm model in which relationships between categories are drawn [HC04]. The decomposed data is reassembled. This is accomplished using Paradigm Model, in which causal conditions, context, intervening conditions, action and interaction strategies, and their consequences are coded. In summary, causal conditions lead to the occurrence or development of a phenomenon or event. The context represents the conditions in which the action and interaction strategies take place. These, in turn, described how the phenomenon is dealt with or their response and coping [CS90; Ros17; SRF16]. An explicit, strict separation of Open Coding to Axial Coding is not intended, rather the processes should alternate, whereby the axial coding can always build on the Open Coding [Ros17]. During the analysis, typical questions such as ”When?”, ”Where?” or ”How?” are asked, mainly to uncover important ideas about the theory [CS90; SRF16].

In the final development, the third coding process is Selective Coding, in which a detailed development of the categories is carried out. Based on the results of the previous coding procedures, the categories can be further abstracted and all integrated into one core category [CS90; HC04]. In this process, the selection of such a core category is done on the emergence of abstracted categories. Core categories should thus specify as many relations to other categories as possible, under the pretext of explaining the object of research as diversely and accurately as possible, but appearing just as frequently in the data material [HMG+11; Ros17; SRF16].

The result is a theory that describes a complete, detailed, and dense process [HC04]. However, in order to also be considered sufficiently fulfilled, some evaluation criteria suggested by Strauss and Corbin [KMB20; Ros17]. These refer both to the empirical development, for which eight criteria are provided, and to the research process, for which seven criteria are proposed. For the research process, for instance, it is asked how the original sample was chosen or which core categories emerged. Specifically for empirical grounding, summary criteria have been proposed such as for rigor in the coding and research process or significance of theoretical findings [CS90; KMB20]. To evaluate a theory, the evaluation criteria must address validity, the reliability, credibility, and efficiency [CS90; HMG+11; SRF16]. However, Strauss and Corbin emphasize that these criteria should not be followed too rigidly, but should be adopted as a guideline [CS90].

3.5 Constructivist Grounded Theory by Kathy Charmaz

In 2006, the most recent variant of the original Grounded Theory was first published in the book *Constructing Grounded Theory - A Practical Guide Through Qualitative Analysis* [Cha06]. In this book, the third central Grounded Theory methodology is presented, *Constructivist Grounded Theory* by Kathleen C. Charmaz. The focus is on constructivism as a research paradigm, according to which the world is realized by the collective construction of each individual. The existence of a pure objective reality is vehemently denied. Instead, individuals distinguish and shape themselves through lived experiences, history, or cultural influences. All of these factors individualize and construct the relative position on issues such as truth, rationality, reality, culture, particular paradigm or schema. The collective of all individual realities influenced by context construct the world, what is known as the social reality. Using this research paradigm, to describe reality and the world, the role of the researcher is actively integrated as a human being as part of the research process, whereby their experiences, own values, views and meanings are also included in the research results. From an objective observer, becomes a non-neutral participant in the role of a co-constructor [HMG+11; MBF06; SRF16]. By means of Constructivist philosophy, the unfolding of creativity in terms of interpretation and openness to new perspectives is achieved. This sense-making is adhered to through each stage of the research process [KF15]. Co-construction and reconstruction of data to theory encompasses the entire research implementation and theory development [HMG+11].

The problem area in which the initial research question is set up is identified on the basis of discipline-specific concepts. In doing so, the initially established research question can be developed and further differentiated during the course of the study [HMG+11; SRF16]. To answer the question of including academic literacies, the principle of the philosophical approach is used, in which the creativity of the researcher is not subjected to any forced rules. After that, it is possible to include literatures in a specific, separate literature review, in which the achievements are summarized in a separate chapter. However, this step is to be implemented appropriately only after the data analysis in order not to limit or even stifle the creativity and flexibility of the researcher, for example, by restricting concepts from literatures [KF15; SRF16].

A smooth transition of philosophy can also be seen in the coding process and guidelines. Rather than following concrete rules, the guidelines are meant to remain adaptable and flexible for witty engagement with the data. Acceptance of ambiguity and openness to new strategies and categories that underlie the prevailing research paradigm should be pursued. At least two stages are envisioned for the process [KF15].

Starting with an Initial Coding or Open Coding, the data are broken down into building blocks [SRF16]. The Initial Coding corresponds to the Open Coding of Glaser's developed Classic Grounded Theory. The Coding is accompanied by the two main questions "What is the main concern of the participants?" and "How is this solved?". Unlike in the previous methodologies, the codes are not intended to conceptualize thematically, but rather according to actions and potential theoretical cues, which should also be reflected in the presentation of the codes. The use of gerunds, that is, the transformation from verb to noun, is intended to improve the description of actions in the module and thus help reveal implicit processes to establish relationships between codes. Instead of using verbs such as define, it is recommended to use defining instead. In the case of transcripts, the use of *In Vivo* codes is also possible, in which the language of the participant is adopted [KF15; SRF16].

As a subsequent second stage, Focused Coding is used to identify particularly significant, relevant, and recurring codes that make a significant contribution to uncovering the phenomenon. Such codes in turn serve as a preliminary theoretical categorization of the data. Such codes usually possess analytical momentum. With the help of Focused Coding, particularly large data sets can thus be synthesized more easily [HMG+11; KF15; SRF16].

Subsequently, different coding strategies can follow, which do not have to be necessarily implemented, however. With the help of the Axial Coding relations between categories are formed, likewise relations between categories and subcategories are formed. Mainly, core categories are developed in the Axial Coding process and the decomposed data fragments are reassembled. If this procedure is omitted, Theoretical Coding can also be used to define relationships between categories, which will be embedded in a coherent theory [BS19; HMG+11; SRF16]. Continuing analysis will include further supplementary questions such as ”What is this data a study of?”, ”What does the data suggest? What is being emphasized? What is omitted?” and ”Who is the view from?” guided [SRF16].

Charmaz proposes four criteria for evaluating the empirical study, although these may be expanded to include additional criteria, since the expectations of such a study vary depending on the framing discipline. These include credibility, such as whether there is sufficient data to substantiate claims or claims. In combination with the criterion of originality, whether the categories developed also provide new insights, the third criterion is resonance. This is to determine whether the Grounded Theory makes sense to the participant at all. The fourth and last criterion is the usefulness of the study, especially in terms of useful interpretations and possibly benefits to make the world a better place. For the evaluation of the theory, it must first be placed in the context of place, time, and culture, which can be represented from the researcher’s perspective by means of a reflexive rendering [HMG+11; KM07; SRF16].

3.6 Comparison of Classic, Straussian and Charmaz Grounded Theory

The methodology of Grounded Theory has been a complex and not easy to implement research method starting from its first publication until today, and many researchers have been burned by it. This is shown by many publications on Grounded Theory and its handling, in which authors tell about their disregard and missteps to save young researchers from the same problems [SRF16; VR09]. In particular, the issue of conceptualization seems to be a common weakness that researchers and grounded theory discoverers Barney Glaser and Anselm Strauss in particular tried to counteract.

Due to the emergence and development of different variants that aimed at improvements, the difficulty is further increased by the choice of an appropriate Grounded Theory. Because, not as it seems at first sight, the different approaches differ fundamentally. Several researchers have already fallen into such a trap, in which they understood the Classical, Straussian and Constructivist GT methods as homogeneous or interchangeable units because of common essential Grounded Theory basics and combined them, which in retrospect turned out to be a big mistake and contradiction. Therefore, it is a necessary step to become aware of the commonalities and differences of the three main methodologies. Only then, on the basis of the situational context, the most suitable approach can be selected, to which it is necessary to strictly adhere, even if the temptation exists to use a procedure foreign to the methods at a point in the research process [KF15]. For this reason, the congruencies and incongruencies of the three GT methodologies are contrasted below.

	Classic GT	**Straussian GT**	**Constructivist GT**
Research question	No a priori	A priori	Initial, a priori
Role of literature	Delayed	Constantly	Partly delayed
Coding	Open Selective Theoretical	Open Axial Selective	Initial Focus Axial/Theoretical
Research paradigm	Positive objectivism	Symbolic interactionism	Constructivism
Evaluation criteria	Emergence Relevance Modifiable	Validity Reliability Credibility Efficiency	Credibility Originality Resonance Utility

Table 3.1: Comparison of the three methodologies Classic GT, Straussian GT & Constructivist GT

Similarities and Differences

Grounded theory is defined by all three approaches as a qualitative analysis research method used to carry out a series of systematic procedures that lead to the development of an inductive theory. The generated theory results from the data that are anchored in it. For this reason, Grounded Theory is also referred to as object-based or object-anchored, in which all methodologies agree. Even though the research method was uncovered in a socio-medical setting, it is not disciplinary, making it available to a wide audience. However, the method does require a creative streak on the part of the researcher, which is used to attempt to break out of old, existing concepts in order to generate new concepts from obtained data [VR09]. This step of conceptualization and abstraction is also a part of every Grounded Theory methodology, which, however, can differ in the extent of implementation from method to method, which, among others, is also criticized by the original discoverer Barney Glaser.

Basically, the core foundation of Grounded Theory consists of the five core elements Theoretical Sampling, Coding, Memoing, Constant Comparison and Theoretical Saturation, which are described in more detail in Section 3.2. It is through their collaboration and cohesive intertwining that Grounded Theory awareness can be realized in the first place.

However, differences can already be found in the differentiation of the core elements, so there are different types of coding procedures that distinguish the three approaches from each other. These and others can essentially be aggregated to five main demarcation principles, the handling with research questions, the different, as well as temporal, application of literatures, the competing coding procedures, the contrasting research paradigms, and the evaluation of the built theory [KF15]. An overview of congruencies and incongruencies are presented in Table 3.1, which was summarized from the above presentation.

4 Tasks and Goals

The underrepresentation of women in computer science programs has long been a major problem, which is also reflected and perpetuated in business and industry. Instead of clarifying why women don't choose a study computer science curricula, the Grounded Theory methodology will be used to uncover positive factors why women study a computer science curricula.

Therefore, in the interest of the thesis and qualitative research, this chapter will start by classify the phenomenon within the context of the problem. This will be explained in Section 4.1. The focus is on the definition of the phenomenon. Combining the results of this section with the formed research gap, the goal of the work will be presented in Section 4.2. This section formulates the research question of the work. The third and last Section 4.3 subsequently describes the concrete tasks that are necessary to answer the research question.

4.1 Problems

Augusta Ada Byron, Admiral Grace Murray Hopper, or Judy Clapp were female pioneers in their (computer science) fields. As the first conceptual programmer or creators of programming languages such as COBOL, they made great contributions to computer science development [Gür02]. In contrast to today's picture, in which common names of men, inventors, and large companies are the most prominent, popular names of female computer scientists are rather unknown.

The *International Organization for Economic Cooperation and Development* (shortly known as OECD) provides regularly reports on various topics such as education levels in 38 member countries. In the most recent report of the year 2021 they examined the distribution of male and female students in STEM subjects. They found that gender parity was only achieved in science, mathematics and statistics. For subjects such as computer science, which is part of the computer science and communication technologies subject group, a larger gender gap was reported. The OECD average indicated a male participation of at least 70%, meaning that women made up only 30% of computer science students. Countries such as Israel or Greece achieved this rate.

The underrepresentation of women is also reflected in the student statistics of computer science curricula in Germany. In the following, the student statistics of the University of Stuttgart is presented as an example.

Since the winter semester 1999/2000 female students at the University of Stuttgart are considered separately in the student statistics. For each degree program offered, the number of currently enrolled female students is given by number of semesters and degree sought. With regard to the degree programs in computer science and software engineering, the numbers of female students lag significantly behind men. An overview of the participation proportions of female and male students in the first semester is presented in Figure 4.1.

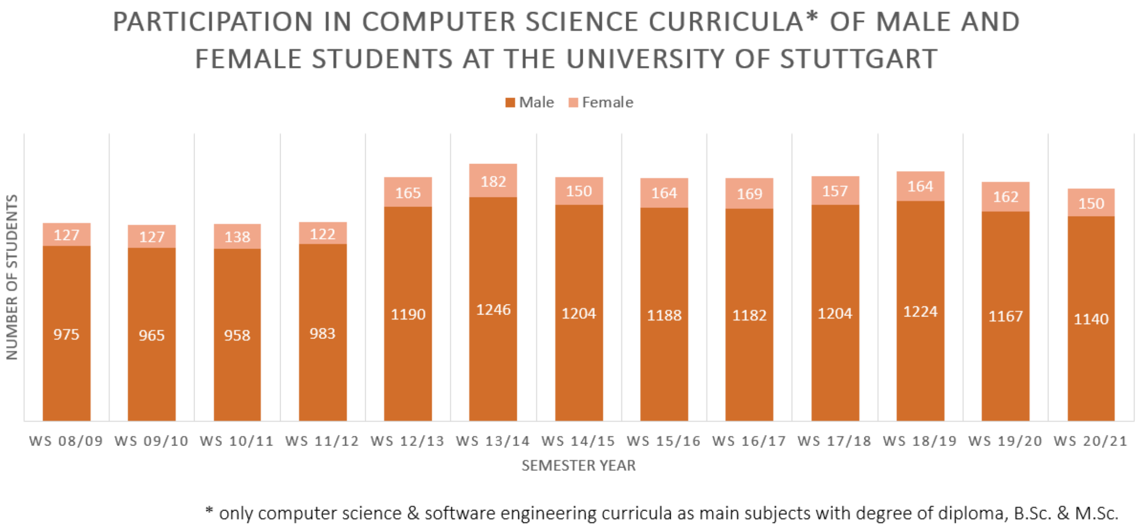

Figure 4.1: Student statistics from WiSe 2008/2009 - WiSe 2020/2021 at the University of Stuttgart.

Only study courses in computer science and software engineering with the intended degrees of Diploma, Bachelor or Master of Science were taken into account. Teacher training programs and specialized or combined programs such as computer science in economics were filtered out. Between the winter semester 2008/2009 and winter semester 2020/2021, female student numbers fluctuate within 122[1] and 182. Compared to a minimum of 958 and a maximum of 1246 for their male counterparts. The percentage of female students ranged from 12.41% in the winter semester 2011/2012 to 14.61% in the winter semester 2013/2014. In contrast, the percentages for male freshmen range from 87.25% for the winter term 2013/2014 to 88.96% in the winter term 2011/2012. The imbalance of both parties extends across all semesters and could not be greater. A similar image can be seen at other universities and colleges in Germany. At the University of Applied Sciences in Munich, for example, the proportion of women in computer science is currently about 10%.[2]

This problem is also visible outside of Germany. In the U.S., the share was about 18% in 2016 [LSZ16], and in Brazil, the female student quota was even found to be less than 5% [Med05].

Furthermore, this problem has an impact on industry and the economy. The labor market lacks suitable skilled workers, the shortage of which could be compensated by more women in computer science. Project teams composed mainly of men develop applications that meet their needs and requirements. However, these usually have to be used by all stakeholders, so women take an important role in the development processes [Pöp09]. Although university institutions and associations try to offer support programs for women, but the numbers are increasing very slowly [Pöp09]. The problem, the visible phenomenon, namely the

Underrepresentation of women in computer science study programs,

[1]The data is available at https://www.uni-stuttgart.de/universitaet/profil/zahlen/studierendenstatistik/
[2]The data is available at https://www.cs.hm.edu/die_fakultaet/ueber_uns/laueninformatik_1.de.html

still persists. In addition to societal and cultural problems, different levels of education also prevent a balance between women and men in computer science majors.

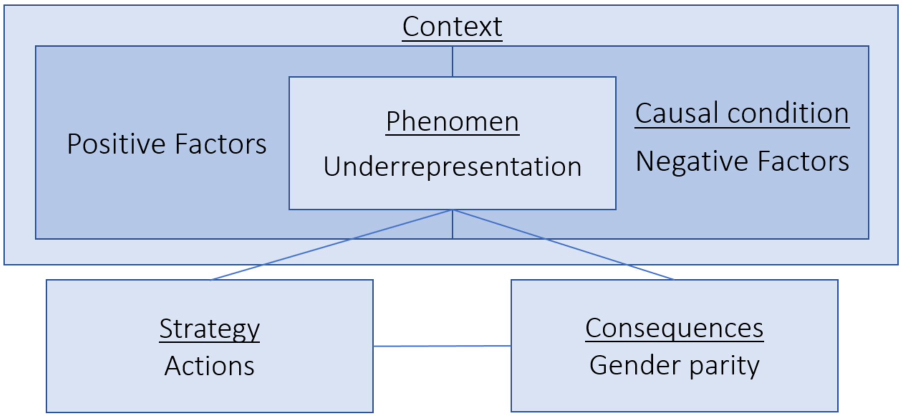

Figure 4.2: Possibilities of investigating the phenomenon of underrepresentation of women in computer science curricula.

In order to describe the phenomenon of underrepresentation, different aspects have to be considered which are presented in Figure 4.2. Strategies to attract more women to study computer science already exist, and the consequences are also being felt in industry and business. The causal conditions can be traced to the negative factors. In order to fully understand the phenomenon and its context, it is necessary to consider two perspectives. The first perspective deals with the issue of why women decide not to study computer science, the negative factors. Conversely, however, another goal is to find reasons why women choose a computer science curricula. This perspective deals with positive factors. Nevertheless of negative factors, female students still choose a path in this technical direction.

4.2 Goals

To solve the problem of low percentages of women in computer science courses at German universities and colleges, positive factors that can answer why women study computer science or software engineering are now to be uncovered with the help of a qualitative, exploratory research method. The reason is that previous scientific research only examined one perspective of the phenomenon, namely exclusively the negative factors. However, a conclusion from negative to positive factors has not been proven by any qualitative and investigative research so far. To this end, an exploratory research method provides the ideal ground of such initial investigation. Thus, the first, initial research question can be defined as follows.

What are the factors that enhance female participation in German computer science curricula?

Factors refer to the choices and motivations that engage women to pursue such studies. By answering these question, it should be possible to explain how this knowledge can be used to attract more women. In other words, strategies can use these findings to their advantage, for example, to design measures more precisely. Therefore, either the development and elaboration of an initial, exploratory theory or taxonomy need to be build.

4.3 Tasks

Embedded in the problem of underrepresentation of women in computer science courses, the goal is defined to uncover those factors that facilitate an increase of female participants in said courses. This section explains what the tasks are to achieve the goal.

As an exploratory and qualitative research method, grounded theory will be for conceptualizing a theory from a few cases. Therefore, it is crucial in the first step to select a suitable Grounded Theory methodology that fits the research discipline.

Depending on the selected Grounded Theory, there are two tasks. On the one hand, data must be collected by carrying out interviews. For this, the interviews need to be planned and designed. On the other hand, a literature review needs to be done to search for existing texts fitting the topic and research question. Suitable candidates should be analyzed and their results examined.

Based on the results, the initial research question might even be expanded. A theory or taxonomy will be developed which can answer the research questions presented in Section 4.2. The individual tasks are listed in the following enumeration:

1. Review the three main Grounded Theory methodologies and decide which to adopt.
2. Review existing literature on positive factors that enhance female participation in computer science curricula (not necessarily limited to Germany).
3. Consider expanding the research question, if the chosen Grounded Theory method allows for it.
4. Design and apply the methodology with female students of computer science at the University of Stuttgart.
5. Develop an initial exploratory theory, or taxonomy, of factors that enhance female participation in German computer science curricula

5 Study Design

This chapter describes the planning and design of the research process, for this, the chapter is organized as follows.

Building a theory is done with the help of Grounded Theory, with the attempt to explain an occurring phenomenon in detailed way based on observations of only a few cases. For planning and execution of a Grounded Theory, there are additional important aspects to organize, which will also be explained in this chapter. The choice of a suitable methodology is crucial, which is presented and discussed in Section 5.1 (the theoretical background for the decision is presented in Chapter 3). The next sections (Section 5.2, Section 5.3, and Section 5.4) present the data collection methods and their design. Section 5.5 explains how these are implemented. Furthermore, in Section 5.6 the subsequent data acquisition and processing is elucidated. At the end of this chapter, the used methods are evaluated according to their quality criteria in Section 5.7.

5.1 Selection a Grounded Theory

The basic pillars for choosing an appropriate Grounded Theory methodology are the framework of the problem, the associated phenomenon, and the explanatory goal. Consequently, the first step towards theory building is the extensive discussion and review of existing approaches. The main approaches of Glaser, Strauss, and Corbin, as well as the most recent approach of Kathy Charmaz, were used as a selection, which was reduced to in the assignment.

This section explains why Charmaz's methodology was chosen for this work.

In Section 3.6, three methodologies were compared on the basis of five factors - research question, the role of the literature, coding procedures, the underlying research paradigm, and the evaluation criteria. The latter and the coding procedures are factors that are independent of the phenomena and do not play a role in the selection. Their attention is focused on processing the data base and the resulting findings.

As in all three approaches, the definition of a research question is mandatory, but the timing differs. While Straussian GT and Constructivist GT of Charmaz allow an initial research question that may also be further developed in the course, Glaserian GT prohibits an a priori research question in order to continue to ensure Theoretical Sensitivity and to keep relevance in mind. The former rationale is also reflected in the use of a prior literature review. To eliminate any influence, the Classic GT suggests a review only after a theory has been developed. Strauss and Corbin's approach on the other hand recommends constant involvement throughout the process. Charmaz's approach also plays with the idea of delayed involvement of literature reviews such that no interference with the

	Classic GT	Straussian GT	Constructivist GT
Research question	no a priori	a priori	initial, a priori
Role of literature	delayed	constantly	partly delayed
Research paradigm	positive objectivism	symbolic interactionism	constructivism

Table 5.1: Differences and Similarities of the three Grounded Theory methodologies.

creativity and flexibility of the researcher occurs. However, this principle is not outright forbidden. Fundamental and crucial to the decision of a right methodology is the third factor, namely the research paradigm in which the entire methodology is embedded.

According to Barney Glaser, if a certain phenomenon occurs, then there exists exactly one correct description of reality, which describes the phenomenon and needs to be uncovered by the researcher with the help of classical theorizing. If one compares this approach with the framework of the phenomenon of underrepresentation of women in computer science courses, the philosophical approach concludes that all female students follow the same motives and decision factors of a single reality and no further differently thinking outbreaks are expected. Thus, individual views are left out. This approach, however, is not consistent with the phenomenon under consideration, since it is a female collective, in which female students decide independently and individually for such a course of study. These decision factors are directly linked to the individual, may differ from woman to woman, and cannot be explained by a single described reality image without adding further cases. On top of objective pragmatism and symbolic interactionism lies Straussian GT, in which reality is constructed through reflexive interactions using language and communication between the actors therein. Mapped to the framework of this thesis, neither constructing interactions nor communication between the female students can be determined to reflect the reality. Since in particular the female students do not know each other before the study. Based on this, the philosophical influence of the research paradigm is also inadequate to explain the phenomenon here.

Charmaz's Constructivist GT constructs social reality as a collective of all individual realities, in which the researcher is also involved as a co-constructor. As before, mapping this paradigm on the framework of the phenomenon, this approach is the only one that pays attention to the individual and subjective realities in which the decision-making power is grounded by the personal world of the female students. The reality collective, thus describes the social world in which the equivalences and parallels between individuals meet. Not only the factors of a single person, but the totality serves to explain the phenomenon through the targeted theory. Due to this positive mapping, whose reality construction coincides with the observable reality, Charmaz's methodology was chosen for theory building. In Table 5.1 an overview of all compared factors are summarized. The green font marks appropriate matches between methodology and subject matter, the red font the opposite.

5.2 Data Collection Methods

To develop a theory, Kathy Charmaz's methodology proposes a combination of several data collection methods. On the one hand, it requires rich, detailed, focused, and complete first-hand data from interviews or extensive field notes from self-conducted observations. On the other hand, interview methods or unfilled gaps can be supplemented by existing texts or second-hand information. However, these are often subject to a specific purpose and goal due to human constructions. The researcher has no influence on this, so the choice always depends on the topic and access.

Since the quantity and quality of existing texts is unknown at the beginning, the data collection will be based on two methods. Besides a less in-depth literature review, the review can be guided and optimized by interviews with female students of the University of Stuttgart. Their planning and procedure is described in more detail below.

5.3 Literature Review

According to the expectation of the Constructivist GT, the inclusion of any existing literature should be conducted only after an independent analysis of interview data has been developed. The reason aims at the influenced and limited creativity and flexibility of the researcher. If the researcher is previously confronted with concepts and categories of data constructed by others, there is the possibility to be less open-minded for own, new concepts. In this respect, the analysis of the literatures will be conducted according to Charmaz's suggestions. Some of these guiding questions are listed below. For a complete overview, see Charmaz's book [Cha11].

- Where do the data come from? On what facts are they based?
- How, when, and by whom are the texts produced?
- Who is the target audience?
- What purpose is achieved? Does an unspoken purpose exist?
- What is omitted?

The goal of the literature review is, on the one hand, to get an overview of existing related scientific works and beyond. On the other hand, from a thematic point of view, to look for reasons for studying computer science from the perspective of women and to explore the phenomenon, also beyond the borders of Germany'. Therefore, among the literatures not only scientifically based works should be examined, but also blogs, newspaper articles or information pages of organizations promoting women should be searched. Using the search string

why (female students XOR women) AND study computer science

Not only scientific papers were examined, but also blogs of female students from different universities and articles from different online newspapers. In total, 16 of existing texts of an analytical review and coding were trawled through. The country origins extended beyond the German and European borders and covered every continent at least once if possible. Once the putative factors were repeated, the search was terminated. Meanwhile, memoing notes were created in parallel according to the Grounded Theory methodology, which were compared with each other in the course of the study using Constant Comparison, presented in Section 3.2.4.

However, only negative factors were found that argued against studying computer science or focused more on solution paths and hardly looked at the underlying factors. Just one paper mentioned some positive factors, but the findings cannot be completely transferred to German conditions. The reason for this is that the aim and purpose of the paper deals superficial with religious backgrounds. A list and short description of all interesting papers can be found in Chapter 2. In the same chapter, a brief reflection on the thematic framework of this thesis is also carried out for each paper where the research gap is formed.

5.4 Design of the Interview

The preparation and planning of an interview is an essential part of its successful execution. In this area, there are various guidelines or key points that should be taken into account to ensure qualitatively valuable data. In addition to the principles of Constructivist Grounded Theory by Charmaz, the following design is also based on the report *Qualitative Interview Design: A Practical Guide for Novice Investigators* [Tur10] by Daniel W. Turner.

5.4.1 Participants

Due to the thematic scope of this thesis, only female students will be allowed as participants for the interviews. Furthermore, in accordance with the terms of reference, only female students who are or were enrolled at the University of Stuttgart at the time of the interview are permitted to take part in the study. This also includes former female students of the University of Stuttgart who are working on their PhD thesis during the period of the interview. In order to ensure comparability to other universities and colleges, only female students of computer science and software engineering curricula are interviewed. For this purpose, the thesis defines a computer science curricula or computer science, also as the study of software engineering, unless it is specifically mentioned.

A total of five (former) female students could be recruited for the interviews, with three of them studying or studied computer science and two software engineering. No prior differentiation of participants by age, highest degree, or other parameters was made in beforehand, as the work focuses on the described goals. Forming this information in advance as categories is not compatible with the scheme of the chosen methodology. The aim of the researcher is to preserve an open and flexible mind. Thus, those parameters are not defined as influencing the motivation and decision factors for studying computer science, which have an impact on possible interventions or current enrollment. Furthermore, the female students were not distinguished on the basis of their study course or their current level graduation such as bachelor, master or doctorate.

5.4.2 Organization

Before the actual interview can be planned, some preparatory, organizational cornerstones must be clarified that precede a design. First of all, this includes answering the question of how suitable participants can be recruited for the interviews. Three potential ways were identified. The direct approach of female students, also former students, the creation and distribution of an invitation email, presented in Appendix A.3, via courses and the reaching of further participants via third parties. Participants were finally recruited through all three channels. As soon as participants come forward, they will be informed about the formalities.

In order to educate each participant about the project and important information, an education and consent form was created, which can be found as a complete document in Appendix A.3. The forms provide in addition to a thank you for participating, a briefly clarification about the master's thesis and also the specific purpose and meaning of the interviews. Additionally, the students will be asked about their study program, important key points about the interview environment. This included questions about preferred video conferencing tools or language which should be used in the interview or about the willingness to use the webcam during the interview, since it has to be conducted online. Although the recording of facial expressions and gestures is an essential part of the data basis. It cannot always be assumed that every student has such technology at her disposal. Another element of the consent form is the information of the student about her rights and duties, in which, among other things, the confidentiality as well as the deletion of the recording were guaranteed.

Since both the number of participants and the timing of their responses were unknown at the outset, the timing and distribution of interviews was based on the candidates. Within a period of three weeks, participants were recruited as well as all interviews completed. The intervals between two interviews were between one and six days. By means of this rhythm, the data collection phase was able to correlate with the GT corresponding coding analysis and initial theory building.

The final point is a clarification on the use of tools during and after the interview. Since each interview was conducted using the *Webex Meetings* [Sys22] tool provided, the recording function could be used to record the entire interview with video and audio material in mp3 format. However, no suitable transcription tools were found for the subsequent translation from audio to a written form, so this had to be done manually.

5.4.3 Design

Planning and preparation steps are essential actions before an interview is conducted. With the help of these measures, many discrepancies can be solved in advance so that the interviews can run smoothly. An important point is the visualization of the goal as well as the decision of the required interview type in order to adapt the richness of the data to the goal and method. In contrast to deductive methods where quantitative interviews are appreciated, inductive research methods such as in Grounded Theory need qualitative interviews that bring in a rich and valuable data set. Different structuring forms target the different meaningfulness of the data.

The philosophically constructed principle of Charmaz's Grounded Theory is based on the collective of individual worlds, which are individually shaped by personal events, experiences and activities. That is, by means of the interview, the interviewee's individual view of reality should be mapped and comprehended as much as possible. An immersion into this personal world makes it possible to understand the exact background of the decisions. For this purpose, it is necessary to interview a biographical section of the student's life from birth to graduation. The so-called Narrative Interview serves as a suitable form [AK16; Tur10].

The focus is on the interviewee's free and open narrative, which the interviewer encourages and initially restrains himself with interruptions and questions. Subsequently, questions, in particular follow-up questions are provided according to the interview and flow of speech. These questions may be semi-structured as well as narrative and casual [AK16]. At the same time, however, Charmaz's suggestions should also be included, in which general questions cover a broad range of experiences but narrowly enough to elicit and elaborate on specific experiences. The sensitivity of the interviewer is needed in getting the participant to share, describe, and reflect on her experiences so that thoughts and feelings also find a place [Cha11]. The form of the interview thus depends on the extent to which the participant engages with the interview.

Nevertheless, the beginning and the end of the interview can be designed similarly for each interview. Essential are the first opening words, in which on the one hand the first impression, a basis of trust is aimed at and on the other hand the participant is prepared for the interview. By an initial greeting and thanks for participating, the function of the tool and sound is checked at the same time. In addition to a brief instruction and repetition of important points of the information and consent form, reference is made once again to the upcoming recording. Likewise, the goal and purpose of the interview, the honesty and openness of the interviewee are among other points that are repeatedly addressed. Once the comprehension questions and other questions from the participant have been clarified, the narrative interview starts with an announcement of the beginning of the recording.

The end is structured in a similar way. It includes a short thank you for the participation as well as a question if the participant would like to add something or if she has thought of something she would like to say. Also part of the conclusion is the question for feedback on the interview and interviewer. If this is not the case, brief information is given about the next steps of the transcription. In the course of possible, technical disturbances concerning the recording the researcher is asked to be allowed to inquire for this purpose by mail and furthermore to offer contact possibilities, if there is interest in the result of this thesis. An overview of the procedure of the narrative interview is presented in Figure 5.1.

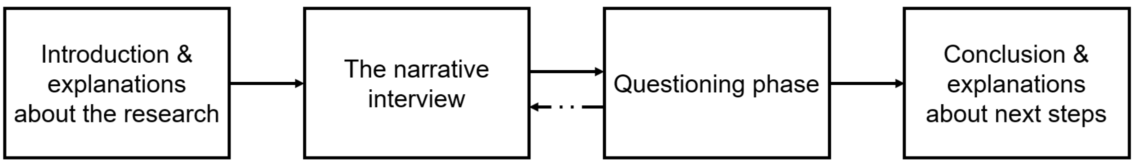

Figure 5.1: Four phases of a Narrative Interview. Based on [Tur10].

The interview itself begins the same for all female students and starts with the question

Why did you decide to study computer science/software engineering?

The goal is to find the reasons that come to the interviewee's mind first, without being influenced by the interview beforehand. The second prompt introduces the narrative interview with.

Can you tell me how you grew up?

From this point on, the interview is guided by what the student said and not said, the tacit or subliminal information and is no longer subject to pre-structured control. The reason is based on the intention of Constructivist Grounded Theory, where according to the researcher should always approach the participants with an open mind [Cha06]. In which he tries to understand the personal world, immersed in it, to demand the background, the context, which are crucial for the analysis. For this purpose, Charmaz's proposed questions were used in turn as a guide. In accordance with the narrative interview style, very open-ended questions follow first, as Kathy Charmaz also presents in her book.

- Tell me about what happened [or how you came to computer science/CS course/interested in computer science/software engineering/...].
- When, if at all, did you first experience with computer/computer science/software/STEM/... [or notice computer science/software engineering/your interests/affinity/...]?
- If so, what was it like? What did you think then? How did you happen to computer science/software engineering/...? Who, if anyone, influenced your actions? Tell me about how he/she or they influenced you.
- Could you describe the events that led up to computer science/interests/...?
- How would you describe the person you were then?

In addition to the intermediate WH-questions, the following question constructs were also used.

- What happened next?
- Who, if anyone, was involved? When was that? How were they involved?
- Tell me about your thoughts and feelings when you learned about computer science/math/-computer/games/....
- Tell me about how you learned to handle implementations/programs/problem with computers/....
- As you look back on your computer science class in school. Are there any other events that stand out in your mind? Could you describe [each one] it? How did this event affect what happened?
- Could you describe the most important lessons you learned through experiencing with computers/computer science/lessons/implementing/...?

To the suggested end questions from Charmaz, more should be added to finish the interview little by little.

- How did you discover computer science/your interests? How has your experience before not knowing about computer science affected how you handled it?
- After having these experiences, what advice would you give to someone who has just discovered that he or she likes computer science/...?
- Is there anything that you might not have thought about before that occurred to you during this interview?
- Is there anything you would like to ask me?
- Do you have any requests for improvement or feedback on the interview?

For traceability, all questions can be found for each interview in the list of questions in Figure A.3, A.4, A.5, A.6 and A.7.

How long this process lasts and when the transition to the question phase occurs also varies from participant to participant. However, some points that should be asked of each person later in the process are questions about favorite toys, interests, hobbies, passions, and role models in early life. Likewise about school years and favorite or major subjects, if these have not already been told.

In order to minimize the degree of influence on the interview results, the acquisition of interview skills is also one of the planning cornerstones that must be considered. For this purpose, in addition to reading through various guidelines, an important pilot training was also relied upon. The first goal was to measure the time of the interview so that possible participants would be given important key data in advance. The measured time was about one hour. However, the pilot training also served to practice one's own interviewing skills and to be able to incorporate feedback. This includes, for example, the flexible adaptation of questions and the use of the senses, such as listening well, interpreting facial expressions and gestures, and sensing where the qualitative data can be found.

5.5 Implementation

The data genesis, both literature review and interviews will be implemented according to the organization and planning strategies.

By means of the former described search string in Section 5.3 existing texts that contain these keywords are reviewed. However, the majority of the reports and articles visited dealt with factors that are directed against the research question. That is, they looked for factors why women chose not to pursue such studies. Additionally, the texts focused on finding a solution or an improvement rather than looking more closely at the problem. These articles are listed in Chapter 2 with a short summary and reflection on the thematic framework of this thesis. Derived of such as reflection the research gap is formed, which creates the primary research question presented in Section 4.3. How this reviews is designed and what parameters are used was briefly introduced in Section 5.3. After finding the first literature, a coding analysis is performed directly on the document.

All found texts are analyzed by Coding in parallel to the search and the intermediate results were transferred to the memoing notes, where all other thoughts during the process also ended up. The plan behind this is not to transfer the potential categories into a theory yet, so as not to influence the interview planning phase with preconceived categories. For this process, the researcher needs to ensure a clear separation in order not to lose openness and flexibility towards the interviews. Only with the building process of an initial theory a comparison between the interview results and the categories respectively concepts from the literature review will be done.

After a literature review, the interviews are prepared according to the explanation above. For the search, two students were contacted directly by mail, two others volunteered and a fifth student was recruited through an already interviewed participant. The interviews are conducted according to the interview preparation, using the time between interviews with transcription, means translating the video recording into written form. Then, the transcription script is analyzed by Coding. This allows for implementing Theoretical Sampling and Constant Comparison, which is typical for Grounded Theory. By influencing analysis and initial theory building on interviewing, a Theoretical Saturation is achieved. That means, possible gaps could be closed or certain thematic errors could be deepened in the further interviews. For ordering all thoughts, analysis and conceptualization ideas or results of the Constant Comparison, Memoing is used.

After the narrative interview presented in Section 5.4, the interview is guided by what the interviewee said in the Questioning phase. Both a return to the narrative and the asking of follow-up or unstructured questions were possible here. In particular, listening intently to the female students, understanding them, being attentive, and following the guidance are difficult aspects to master. The way the interviewee will narrate, which facial expressions and gestures she will use, have to be made dependent on how and which questions will be asked or even allowed in her own opinion. In some cases, it became apparent that certain topics are rather unpleasant for the participant, so that questions could only be asked very cautiously. Although the participants are allowed to skip or cancel personal questions, but in the end none of the students made use of this.

5.6 Data Collection and Processing

The data collection and processing of the literature review and the interviews are managed separately. Both overlapped only in the memoing processes.

A literature review is processed as follows. After the first reading, checking the questions if the literature is suitable for the thematic framework, the initial coding is performed. For this purpose, marking colors are first defined with which the individual segments are to be colored for coding. This ensures that the document is both color coded and open coded. This makes it easier to understand later which areas belong to which topic. A total of five marking colors are available.

- Yellow - Underrepresentation of women in computer science
- Blue - Why women study computer science
- Green - Measures and counter measures
- Red - Explaining unbalance or problems
- Pink - Experiences of women

For each marked segment, an open code is attached directly to the document either to the left or to the right of the text, closely following the language of the text such as using in vivo coding. Depending on the text, both word-by-word, sentence-by-sentence, or larger segments were coded. Higher Focused Coding is performed in a separate document where all codes are collected, grouped, and sorted out by relevance. Then, for each grouping, a connecting axial core category is developed that links the included codes together. Depending on whether the core categories can be linked or conceptualized, the analysis is completed for the corresponding text.

Collection and processing data from interviews is handled somewhat differently. First, the interview is recorded as an mp3 video. For this purpose, each participant voluntarily consented to both camera use and video recording. Each recording contains only the Narrative as well as the Questioning phase. The reason is to try to use the first and the fourth interview parts for free expression, for feedback, for anecdotes, for any conversation.

After that, the interview should be transcribed. The applied transcription rules are based on the suggestions of Charmaz [Cha11] as well as on the extended content-semantic transcription of Dresing and Pehl [DP12]. That means, no corrections are applied to what is spoken. Additionally, conspicuities in facial expressions, gestures, and phonetics are included. For reasons of data protection and also at the request of the participants, it is not possible to provide examples of entire excerpts of the interview. Only quotations from which the data attributable to the person were taken are shown in Chapter 6. The average transcription time was between five to six times of the interview duration. Similar to the processing of the literature review, the final transcript will be analyzed using coloring and lateral coding. The Focused as well as the Axial respectively Theoretical Coding are carried out in a separate document. The evaluation of the first interview leads to changes and adjustments of the questions by using the Theoretical Sampling and the Constant Comparison, whereby the appearance, the design and also the amount of questions are evolved after each interview until a Theoretical Saturation occurs.

5.7 Quality Criteria

Quality criteria are used in qualitative research and ensure the quality of a scientific study with regard to the data collection and analysis processes. These are defined as Objectivity, Reliability and Validity which are checked in the following sections [Fli10; Ste04].

5.7.1 Objectivity

Objectivity refers to the researcher's influence on the research event, i.e., to what extent are the research processes and results linked to the researcher's views, opinions, and influences [Fli10].

For the interviews, the researcher and participant did not know each other personally in beforehand or there was no prior closer contact. All participants received the same clarification and consent forms, and the same applies to the interview conduct and termination. Asked questions during the narrative interview, as well as the topic areas for questions in the Questioning phase were the same. The latter had to be adapted according to the interview content, as openness differed between participants.

In terms of the design and execution of the research processes, they are strongly based on the principles of Constructivist GT. However, its research paradigm is based on the collective of all individual social worlds, thus including the researcher as co-constructor [Cha11]. The development of categories and concepts is always connected with the thoughts of the researcher and have there influence possibilities. Thus, it is not completely excluded that the researcher, especially from a thematic point of view, will be an unavoidable part of the research work. For this reason, the own view and reflection on the research results is explicitly stated in separate form in Chapter 8.

5.7.2 Reliability

Reliability ensures the repeatability of the research results [Fli10]. For the literature review, the mentioned search string in Section 5.3 applies, so all literatures can be found online via this string. Directed toward the interview, questions were designed to probe the participant's personal world. The initial entry questions were asked exactly the same for each participant. Depending on the scope and openness of the narrative, questions were set to sample the same topic areas when possible.

5.7.3 Validity

This criteria describes the validity of the research work, which is subdivided into internal and external validity [Fli10].

The internal validity describes whether the measurement instruments measure what is intended to be measured. That is, mapped to the research work, whether the search string or the questions actually reach the qualitative data on which the theory is theory is sufficiently grounded. If all parameters and results can be reproduced, the credibility of the research results increases. This also fulfills the evaluation criterion of the Constructivist GT. In order to fulfill this criterion, all steps of the performed methods and processes, as well as the processes, the search string and the list of all interview questions have been disclosed.

The external validity describes whether the results can also be generalized outside of the research. A generalization is achieved by applying the analysis and conceptualization steps of the of the Grounded Theories. The qualitative data, which are collected from few interview cases, are first analyzed through the Initial Coding. Subsequently, the relevant and repeatedly salient codes are conceptualized through linking categories to such an extent that a generalization of the research results starts.

6 Research Results

The unbalanced number of men and women students in computer science majors is a well-known problem. In the winter semester of 2020/2021 just about 12% of all students in computer science curricula at the University of Stuttgart are female students. In order to approach this problem and to be able to explain the context of the phenomenon two points of view can be portrayed. One, perspective, which is rather intuitive, is concerned with the reasons why women decide to not pursue such a course of study. Since there are numerous research studies that can be found that try to explain this view, the other approach offers a potentially undiscovered area of research. This approach deals with factors that motivate women to take up such curricula, which prepare the primary research question “What are the factors that enhance female participation in German computer science curricula?”.

In order to address this initial research question, the specific problem, goal and task definition are precisely elucidate and classify in Chapter 4. With the help of the Constructivist Grounded Theory an initial theory or taxonomy will be developed, whose research process with its design and implementation is described in detail in Chapter 5. The aim of this chapter is to present the research results from the conducted and analyzed study in order to answer the central research question.

The presentation of the results is structured as follows. All codes that were identified by Initial Coding of the interview transcripts and classified as relevant and repetitive by means of Focused Coding are underpinned and justified by the corresponding quotations. These are organized according to the relation-giving core categories and core concepts that emerged during the Axial and Theoretical Coding. Since no meaningful positive factors emerged from the literature review, they are not included here and are only compared with factors conceptualized from interview data in the discussion in Chapter 7.

It is noted that the presentation of the research findings does not correspond to the exact procedure of the development process, since methods such as Constant Comparison or Theoretical Sampling had to be performed continuously and simultaneously. Furthermore, the Grounded Theory process is characterized by a back-and-forth step, which complicates the presentation of results. The description of the implementation of the procedure process can be found in Chapter 5 (or in an overview of the Constructivist Grounded Theory in Section 3.5).

The citations will indicate only that information that is is relevant to the codes. All private data that can be traced back to the interviewed person, will be removed without any condition to protect the privacy of the person. The participants were informed and protected about the signed rights and obligations statement, which can be found in Appendix A.3.3. In addition, interviewees and corresponding interviews are numbered consecutively with 1 to 5 uniformly at random in order to distinct between the quotes. Thus, the numbering is not consistent with the chronological order of the interviews or the interviewees. So, a clear traceability is to be excluded. Only the researcher has the possibility to trace the quotes as well as numbers back to the persons. With completion of this thesis, the transcripts were deleted. The numbering is consistent throughout the paper. Since all interviews were conducted in German, the quotes were translated into English.

6.1 Enhancement Factors

This section presents the factors that answer the initial research question of why women study computer science. Using a Grounded Theory methodology, a literature review and 5 interviews were conducted for data collection, which were in constant rotation and comparison to the data analysis and initial theory building. Since the results of the literature review either focus on the negative factors or do not focus on as federal territory of Germany, the discovered taxonomy is grounded based on the interview data.

6.1.1 Taxonomy Model

In total, five key factors were uncovered from the interviews. These are composed of STEM skills, development of interests, convergence, personality development toward the self-efficacy process, and the autonomy process. All of the above factors have a very strong coherence and thus interact with each other. The interrelationships and relationships of these factors is depicted in Figure 6.1.

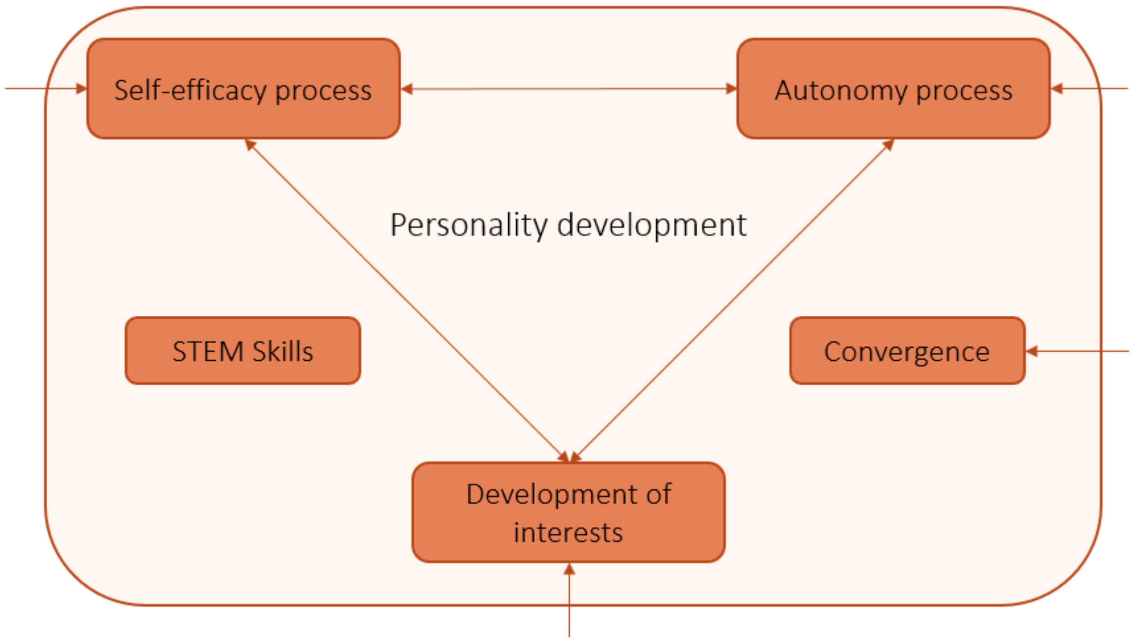

Figure 6.1: Taxonomy: What Are the Factors That Enhance Female Participation in German Computer Science Curricula?

The development of the individual personalities is to be directed in relation to the self-efficacy process and the autonomy process. Self-efficacy as such refers to the recognition and confidence in one's own competencies. On the basis of the female students' narratives, different levels could be drawn, whereby a steady process could be recognized. Autonomy means the self-determination and freedom of decision of the personalities. But the participants have developed during their growing up. However, the development of the personality is not a decision-making factor on its own. Only in the dialogue with the STEM abilities, i.e., the innate or learned ability in the example mathematical area to be successful, the convergence, the approximation of computer science or software engineering with the future female students and the interest development, the processes of the personality development are supporting factors. In particular, the development of interest, that is the process from an initial or initiated interest to emphasizing interests in computer science over others, is an important factor of the taxonomy model.

The basis on which the factors were conceptualized will be described below for each factor. For this purpose, the philosophical research paradigm of Constructivist GT will be used. Since, according to this paradigm, social reality is constructed by the collective of all individual worlds, it is obvious that the following explanations and descriptions of the central factors and their derivation are closely based on the individual worlds of the interviewed female students by means of quotations. For a manageable overview, the initial codes as well as their changes or adjustments are not mentioned, but explained. Only the developed core categories are used to subdivide the factors.

6.1.2 Development of Interest

The choice of a study course is indirectly or immediately related to the students' interests. Interests are seen as the propensity, inclination or preference to a thing, the object of interest. The shape of the thing may be tangible, such as a particular object, or intangible, such as a complex of subjects. The extent to which the inclination to an object of interest extends can be measured by certain clues. For example, a beloved childhood toy, a hobby pursued specifically, or more far-reaching endeavors. While these can be varied, an inclination toward a particular field is not always sufficient to turn an interest into a profession. Interests remain only interests that are continued as hobbies or are simply not suitable for permanent exercise in the form of a profession due to lack of talent. On the other hand, propensity can become former interests, if possible, factors like bad experiences have an effect.

In this respect, the interviews revealed the following. An interest is always initiated at first. This can be done in a very young age or as late as in school. Here, it also plays a role whether the person has an affinity or skills in this regard that strengthen a connection to the object of interest. For example, in the STEM field, especially computer science, these are first points of contact with technical toys or, in the early school years, a proficiency in mathematics. In this phase, it already becomes apparent whether an interest can be awakened at all or even fades away if there is no further pursuit. This can show itself in various forms, such as in the form of positive emotions, for example the fun factor. Thus, an interest is not only a temporary state, but an ongoing development that the female students experienced. To finally recognize what they like and what they actually want.

This means that in the subsequent phase, it is necessary to maintain the interest, for example by maintaining or further developing the meaningfulness, a thematic classification or the positive emotional attachment to the matter. Further development on one's own initiative is already an indication that a high degree of interest formation can be achieved. Not only that the interest was aroused, but that even more would like to be found out about it. This also includes the autonomous, intensified pursuit of the interest, for example as an excessive hobby or passion. Within the third phase, conscious identification, specification, and differentiation, i.e., emphasizing the interest over other interests, is necessary to keep the specific will and urge in mind. These phases can easily blur, insofar as the drawing of boundaries are individual developments. Finally, within the framework of the taxonomy model, the awareness and recognition of the increased interest in computer science is crucial to individually confirm the statements, “I like this”, “I want this”, “I want to study this”.

- Initial and initiated interest
- Maintenance of interest
- Highlighting - Identification, Specification, Differentiation

During the interviews, the female students described their personal interest development process according to their personal influencing factors, inferring both positive and negative effects. In addition to the direction of computer science, participants tracked various interests, their developmental contribution, and outlined why these were not pursued or were simply not suitable for them personally for a career from their perspective. Due to the individuality of the development of interests, the personal stories should not be dissected by individual categories or identified phases, but clarified in their entirety. Because it is the only way to visibly and transparently present the entire process per participant in order to describe the conceptualized factor.

Individual Processes

The initial phases start the first encounter with the object of interest. In general, an object of interest can be both tangible and intangible. Thus, from the interviews, numerous interest potentials could be identified from music and art to sports and technology, especially computer science. Since this is only an initiated interest and the definition of computer science or software technology only becomes tangible for adolescents later in life, the term computer science must first be explained in the broadest sense. Thus, a high school student understands something different by the term computer science than a computer science student and an elementary school student far less than a high school student. Due to these gradations, the objects of interest are not always obvious and can be abstracted according to the respective age.

To investigate how, when, where, and why the initial or awakened interest in computer science starts, it may be useful to start by researching in its infancy at the toddler age. A favorite toy at such an age may indicate innate abilities, an inclination, or an initial interest that can be deepened later in life.

Starting with student 1, she remembered particularly well playing with Lego bricks, with which she built buildings or bridges, for example. In contrast, she rather rejected playing with dolls in phases, but this was not so much due to her lack of interest, but because of fearful images. A first unconscious inclination or interest in building could be associated with the help of assembling Lego bricks.

> “[...] with all kinds of toys when I was little, and mostly there were a lot of Legos in them, Lego bricks, I have a lot. I have dolls, so I had a lot of dolls, but I have, I have, at some point I didn’t like dolls so much because I saw so many horror movies on TV that I shouldn’t see, especially where doll tries to murder you like that and somewhere there was a little bit, I didn’t like them so much anymore.” – *Student 1*

> "I always built a lot of buildings, I always wanted to play in the buildings and wanted to build buildings later. In the future. Hm, I think mostly that was, but also bridges, but I don't know if the bridge works." – *Student 1*

She also first discovered an interest in drawing, as well as a later preference for mathematics, at school. The initial inclination in conjunction with mathematical skills deepened her initial interest in the STEM field. The concept of computer science was not entirely known at that time.

> "I would say I like drawing and things like that. Drawing like painting, as far as man-made stuff like that. But back in school, I also realized that I really liked math." – *Student 1*

As her school career progressed, her interest in math intensified, leading her to pursue more of a technical direction by attending a technical school. She also programmed for the first time and although it didn't go very well, her interest didn't ebb but intensified even more. The "impulse" as she says, encouraged her to learn more, to invest more time in the area she particularly enjoys. The initial interest in building Lego bricks is reflected in building software through components. Conversely, her initiated interest builds on her first favorite toy.

> "[...] there was from me the decision whether to go to technical school or to high school and so I actually got into the technical field. So already in high school. And at that time, I had the possibility that I could go in the direction of electronics, computer science and [...] communications engineering. [...] I did have communications engineering, [...] but my interests were actually in all three areas. And at some point, I [started] programming a little bit in school. I was pretty bad at it. But [...] algorithms and for was so okay, but that's also, you had this impulse, okay something is bad, but that's in the deepest you know maybe if you learn a little bit more, then you could do it. I liked that too." – *Student 1*

> "I already had contact, a little bit, with that in school and so I found it. So this building, so you build with software, what also sees results, and that has always been fun for me [...]." – *Student 1*

On the occasion of her strong interest in STEM, especially in the computer science field, her inclinations differentiated from her other friends, who moved in the social science field. Which never really captivated her. At this point, her penchant for drawing came out again, which also drove her in the direction of architecture. During her school years, however, the idea of being an architect never gained a foothold, as she did not consider her skills to be sufficient and preferred to continue to pursue it as a hobby. From the point of view of individual self-efficacy as another central factor of the taxonomy model, which describes the conviction in one's own ability, in one's own skills, the inner self-confidence obviously turns out to be higher for computer science than for drawing.

> "And then my friends were always like that, they wanted to become teachers, or something in the social field. For me [...] these areas were never of interest, because I only ever drew, I first wanted to go in the direction of architect [...]." – *Student 1*

> "It doesn't have to be like that, but some professions, direction of art, that's more, you need a lot of talent. I think if you have the talent, you can risk something like that. I have, I see more so that I would not have the right talent for it, but more as a hobby [...]." – *Student 1*

Through the interplay of STEM ability, self-efficacy, and interest, she finally decided to pursue her first degree in computer engineering after high school. Meanwhile, however, it turned out that her interests were more oriented to the software direction instead of the hardware direction. Due to the constant maintenance and purposeful pursuit of her interests, she finally realized a degree in computer science.

> “As it was with me that I knew it early on what I was going to do in the direction, at the time I had to decide, okay what do I want to study, that was a very very easy decision for me.” – *Student 1*

> “And I think that is the influence of the school. My option was as far as I can remember that I considered electronics, civil engineering so architecture and electronics. And there was a new course, so computer science I never took, computer science there was also, I’m not going to do that in life because its actually very software loaded, but I also wanted something with hardware and there was a new course the technical computer science, computing engineering. They sold it to me that it was a mixture of electronics and computer science. And I thought yeah okay well if I can’t really decide anyway then I can make a compromise, have of both worlds in the course.” – *Student 1*

> “I think in the third year, I noticed, so okay, actually software, direction software, that, that’s more fun for me than components, component to plug and measure some things. It’s already [...] it’s okay, but just that [...] was a bit for me, I don’t know, I was more limited than [...] than with software development and [...] programming.” – *Student 1*

During her school years and also during her first studies, her interests were combined with positive emotions in the form of fun. Among other things, this accelerating factor ensured that her preferences quickly focused on computer science and differentiated to software engineering. Knowing her interests, her will to study computer science which she really likes, she therefore always had as a gut feeling, in her opinion.

> “It’s also, with me it’s actually interest. I only had math, the lecture with electrical engineering, I always enjoyed it. I would say it’s been this interest, in it [in me], always.” – *Student 1*

> “I didn’t think that I would end up, a few years ago, that I would actually study software engineering [...] at the time, just before I make this decision, I want to study and if so, what subject. I think the field, the bigger field I always had so in my gut feeling, but I didn’t know exactly if it was computer science or software engineering, I didn’t analyze and decide exactly until, I think 6 months before, okay, so rather before applying [laugh].” – *Student 1*

Her development process started in childhood when she started forming buildings with Legos. Later she discovered mathematics for herself, which she liked to further deepen by attending a technical school. Under the influence of the school, her inclination towards computer science differentiated, which she focused on from a technical point of view with the help of her first degree. Based on experience, her interests specialized in the direction of software engineering, the study of which made her satisfied in the end.

> “But still I am satisfied with my course and choice.” – *Student 1*

In contrast to Student 1, the visible development of interest for Student 2 does not begin until high school. Thus, a first initial interest does not necessarily have to be initiated at toddler or elementary school age. Lack of equipment to personally unfold, such as student 2, led to her not being able to try out until she was in school.

> “We didn’t have that much money. [...] I didn’t have any toys before, unfortunately. [...] I didn’t have anything special at all when I was little.” *– Student 2*

Due to this restrictive situation, her interests initially developed in different directions. Thus, she first focused on her musical school education, which is oriented to study later in the conservatory.

> “[...] so in school, I attended music school there. So, I liked to play instruments. [...] And right, I think I was 5 or 6 year[s] in music school and so I occupied all my free time, right, at that time. And at first, I actually wanted to go to the conservatory, so to continue studying music, but then I changed my mind, right.” *– Student 2*

During her school career, she encountered various fields of study, almost all of which seemed to interest her. In addition to her interests in music, her fondness for mathematics and computer science was also awakened by her school lessons, so she pursued both her artistic side and mathematical subjects. At the same time, she was also open to many other subjects, the degree of interest in which she could not clearly assess even today.

> “That was in school, we had lessons.” *– Student 2*

> “That’s also called computer science and that’s more like operating computers, we do a little bit of everything. Worked with simple programs, or how internet works or stuff like that. Operating, a little bit of construction, a little bit of this and that a little bit, the basics, Pascal I think we programmed back then.” *– Student 2*

> “[...] so I was good in everything, but also without any special preferences. But what I liked was math, geometry, things like that, I also liked computer science, I liked history. So more like mathematical direction, right” *– Student 1*

Although her interests were oriented in different directions in her younger years, she favored rather the mathematical direction. A concrete focus of her preferences arrived much later, which were shaped by further points of contact with computer science. Around her first encounter with a computer, she immersed herself in the world of online computer games, which she followed very closely.

> “[...] where I had my first computer. Where I went on the internet with it, so first time myself and that’s when I saw all the cool stuff and started online games and stuff like that. I liked it so much. I thought *Oh that would be so great, if I could do something like that and work with it too.*” *– Student 2*

> “I was just playing, not programming” *– Student 2*

> “I played a lot, so overly much. Fully addicted.” *– Student 2*

Knowing her field of interest, mathematics, but not knowing herself at the age of 16 exactly where her particular preferences lay, she initially chose an engineering major after graduation, but it didn’t seem to suit her.

> “I majored in engineering.” *– Student 2*

"I chose something stupid, I wasn't happy there, but I had no idea. I was 16 where I started. I was 16 after all, I had no idea at all. And then I finished that and with no particular preference to that area. Right. And then I thought, I want to try this. Right, so with math and computer science." *– Student 2*

"There was prerequisite good math degree that I had and then they took me. [...] I could still study math, but math was a bit unattractive to me, that is, real pure mathematics [...] and then I chose that, because it just sounded better. And there was also a lot, so in [...] so right math subjects, physics, math and so on, because that was faculty of mathematics also and then I thought, yes that's probably not so bad, but it was bad in the end." *– Student 2*

It was only during her first degree that she realized what she should have been studying. Her personal interest development was slowed down by, among other things, weaker differentiation, what she particularly like, and initial specialization in music. Despite all this, she was finally able to develop a sufficient level of interest to identify what she was actually interested in and pursue to study.

Student 3 underwent a different interest development. While her toys varied, her early affirmations focused more on reading and puzzles, with which she was completely happy and content. What was unusual, however, was an interest that she pursued as a hobby, and by maintaining it during the developmental process, it also propagated into her studies. For example, she stated her special interest in data collection, in which she collected stacks of children's magazines with informational material.

"I did puzzles, I read [...] That made me totally fulfilled and happy." *– Student 3*

"[...] I like to collect data [Laugh]. [...] I've always done that. I don't know, do you know flea magazines. [R: No] Those are children's magazines, there are just such info articles at children's level, there are handicraft instructions, puzzles and whatnot. I already did that back then. I started scanning them. [...] I had several stacks like that and they were a thorn in my side because they were lying around. And then I just started scanning them, because I thought the information was important. [...]" *– Student 3*

During her school years, she finally discovered her interest in STEM and her abilities. She was particularly drawn to mathematics, for which she also repeatedly stated her good ability. Her later attendance at a computer science class initiated her interest regarding computer science, which she would have liked to continue. According to her narrations, she enjoyed the course thematically very much, that a positive emotional connection to computer science was built. In addition to school, she has also turned to various other extracurricular activities to either pursue her interests or find new ones. In the longer term, this did not result in any other interests besides mathematics that offered competitive potential.

"School-wise I was always good in science, in the other stuff rather so eh [tone]. Um, history, geography didn't go well. Also, politics was not my favorite. I took a chemistry course at the same time, a club like that. I was in the choir. I played the piano. Yeah. I didn't do any sports. [...] Oh, I was in the Boy Scouts and I was an altar boy." *– Student 3*

"Bio, chemistry, math, that kind of thing had interested me more." *– Student 3*

> “Because I enjoyed math and all that kind of stuff [...]. But like I said, science was fun for me, so why not. And I was good, again I was good, so even if all the guys at that time came up to me before the math exam and asked me how to do this or that [...]” *– Student 3*

> “I did at school, I liked science. [...] And then we had computer science in school for half a year and that was great. I understood a lot of stuff, we had sorting and stuff like that, where nobody got through it, but I had no problem with that. [...] I would have liked to have added another year or half a year to it.” *– Student 3*

Why she did not decide for other potential training or study course possibilities such as music or mathematics, she justified with the fact that on the one hand her ability in approximately music was not sufficient for a career and on the other hand the study of pure mathematics was made unattractive by her parents. For this reason, she lost her desire and interest in such studies. This has further differentiated her interests.

> “I was never that good in music and I think, you have to somehow, you have to reached a certain level by the time, so that you can do something with it.” *– Student 3*

> “I was still considering math, but my parents, my dad has some cousin who is a professor of math somewhere in England and he was like, *yeah if I want to study math then I should read this list [Shows imaginary list] of books before*. So that I am prepared, then I thought to myself, *oh no*.” *– Student 3*

With her first computer, she showed increased interest in theoretical elements of computer science such as algorithms. In particular it was not the technology or the implementation that convinced her, but solving problems are in her interests. The differentiation of interests is thus also part of the interest development, which are shaped by individual factors.

> “Somewhere along the way I had my own really really bad computer. And then at some point I played a little bit more computer games, but then not that much.” *– Student 3*

> “The technology doesn’t interest me at all. So now, also in retrospect, as I said, I like data sets itself. But it was more, I also don’t like implementing, I think it’s great to solve problems, and to understand something like algorithms. That’s why [...] What’s important is typing. I think that comes from playing the piano. So, if you can type like that, I think that’s really, really great. [...] Was quite interesting.” *– Student 3*

According to her ability in mathematics, towards the end of her school career she was considering which interests she would like to continue with. In the end, according to her interests and inclinations, she applied an exclusion procedure, with which she decided on a study of computer science. About the same time, she already informed herself at the University of Stuttgart and sat herself in a math lecture from computer science curricula, where her decision was once again reinforced.

> “At that time I had also thought about doing something with finance, because I liked numbers or tax accountant. I found somehow something funny, meanwhile I think that’s nothing for me.” *– Student 3*

> “Exclusion? At school, I liked science [...] and I knew I didn’t want to do biology and chemistry, because it would be too practical for me, too much in the lab. I dropped physics, I always didn’t understand physics or it wasn’t so intuitive anymore. And then we had computer science in school for half a year and that was great. [...]” *– Student 3*

> "[...] sat me down in a lecture. And that was [...] in math the topic was Taylor polynomials, that just came up and that was kind of smallest common distributor algorithm or something in the technical. Which was totally simple and I just thought *hohohoho, I can do that too*, studying will be easy, I'll do that and then I just tried that out." *– Student 3*

> "I tried it out. And thought, if it doesn't work out, then I'll just do something else." *– Student 3*

Her early inclination toward data management and data engineering were also reflected in her favorite courses, and she continued to maintain them, especially during college. But even despite her strong interest in computer science, her studies did not entirely reflect her preferences, leaving her with doubts about whether she should pursue a change.

> "The database stuff, so modeling, [...] data engineering and information degration, but [...] just data warehousing, and OLAP [online analytical processing]." *– Student 3*

> "I have to say, I kept doubting whether I shouldn't switch, simply, it wasn't that much fun in between. Like I said, it's not a hundred percent mine, it's more this, I'm more interested in this kind of meta-thingy, understanding stuff and solving stuff and understanding algorithms and complex relationships and, and stuff like that and collecting data." *– Student 3*

Regarding student 3, the development of interest was broad at the beginning. She tried many things but became more oriented toward interests in mathematics and computer science as she performed well and enjoyed STEM subjects. By means of any individual factors, her will to follow inclinations finally steered her toward a computer science curricula.

The development of interests for student 4 was similarly straightforward. Starting at a young age, she played with her first toy, a parking garage. The connection to a rather unusual toy in the STEM field, form the first harbingers of an inclination.

> "[...] my first great toy was a parking garage." *– Student 4*

As her childhood progressed, she continued to try things out, emphasizing in them especially her penchant for reading. Other activities, such as playing instruments or practicing sports, are also components of her development of interests, although she did not specialize further at the beginning.

> "I had a stuffed sheep that I loved dearly, [...] classical dolls rather less, but this stuffed sheep with baby carriage and clothes and everything. [...] I read a lot, had read many many books, [...] puzzled, tinkered. [...] already in elementary school I read much more than the school library offered. [...] We are relatively musically in my family. I play two instruments. Um [...] tried various sports once, but nothing captured me a longer time." *– Student 4*

Her STEM skills started to emerge, and her related interests also became more nuanced when she came to school. Her preferences for technical and natural sciences were reflected in the direction of her career aspirations. For this, she took her father's example in which she wanted to become an engineer without knowing what that meant exactly.

> "[...] so I had already rather the inclination to natural sciences than to languages." *– Student 4*

> "I've always been more interested in the technical stuff." *– Student 4*

> “so career-wise my dad, who was just an engineer, I kind of always thought that was great without having any idea now what that meant.” *– Student 4*

> “I always wanted to become an astronaut or a space architect. That then dissolved when it really came to the choice of study.” *– Student 4*

Especially her mathematical abilities became more prominent towards the end of her school years. In line with the interests, she had developed so far in the STEM field, she pursued them by majoring in math and physics.

> “What I also have to say is that, for example, mathematically, I didn’t really understand it until middle school. Elementary school was okay, at some point the functions came in, I found them quite [laughs] for a while [...] weren’t my friends and then at some point it clicked and from then on it also went very well in math [...].” *– Student 4*

> “My main subjects in high school were math, English, German, physics and Reli[gion]” *– Student 4*

The conscious awakening to computer science initially came during this time by attending a programming class, a voluntary club. This, as she says, awakened her interest in computer science to continue and develop on her own initiative. The initiation of her interest generated the fun in the subject, a positive emotion. As a result, she chose computer science as an orchid subject. An orchid subject is a voluntary additional elective course for high school students in upper grades eleven and twelve, in addition to their majors and minors. She took this step on her own after her friend’s interest was not piqued. Decisive for her final choice of studies was based on these two visits of her school career.

> “In high school, there was first a programming course and then there was um computer science as an orchid subject, which I took. And that kind of got me a little bit interested in computer science and stuff like that.” *– Student 4*

> “The idea of choosing the programming course was like ”Just try it out”. That was actually quite cool, and that was one of the deciding factors that I said, okay, I’ll choose that [computer science] as an orchid subject, because I just enjoyed it.” *– Student 4*

> “The programming club was definitely crucial for the course and the course was definitely crucial afterwards for the choice of studies.” *– Student 4*

> “So said friend who was in the same club, it was clear that the club was nice but that she definitely didn’t want to continue. It was nice between girlfriends but her interest was piqued” *– Student 4*

She was able to exclude her interests by an in-service internship, which is an offer for high school students in 10th grade. Also, physics was no longer her main interest. The idea of studying mathematics for a teaching degree, since she was good at both the emotional and mathematical elements, did not convince her enough to study it.

> “There’s a kind of dual university for chemical, technical assistants, where you could let off steam in a relatively large in the chemical field [...]. And after that it was clear that it wasn’t going to study chemistry. Because I simply read off too inaccurately, with the measuring units.” *– Student 4*

> “Yeah, there was a point. Physics was [...] strongly represented, but in the upper class [...] but somehow fit no longer to my mind, too much formula and math was discussed, just as math computer science as [...] as [...] teaching degree was actually the first variant. Um and then I thought to myself, being a teacher is too much the same, always-at-this-school, teaching the same [...] then after the study information day [...] computer science remained.” *– Student 4*

By differentiating and specifying her interests, she was able to raise and maintain the inclination level for computer science, especially software engineering to the point that the will was sufficient for such a study.

> “So I am quite clear about what my interests are and what I like to do.” *– Student 4*

Throughout the interest development process, her parents supported her unconditionally.

> “So everything I wanted to do was actually always supported.” *– Student 4*

Thus, Student 4 started her development of interests with a simple first toy, through school, in which her STEM skills were characterized along with preferences. Due to all events and experiences, such as interest differentiation or support from her parents, which had a positive impact on her development, a sufficient level of interest was finally provided that led her saying she wanted to study software engineering.

The development of interests was significantly more complex and difficult for student 5, also from her perspective, to achieve enough interest and will to study computer science. For this purpose, it is important to understand her thought process and all the contexts she has dealt with. Furthermore, the other key factors of the taxonomy model intertwine strongly in her development process, so these will be referred briefly.

Computer science curricula was not the first choice for student 5. Previously, she was eager to become a veterinarian and thus study veterinary medicine. Her preference for animals was already awakened in young years, since the family owns some horses. She even kept this thought in her mind shortly before her high school graduation, which meant that her interests in computer science did not stand out as clearly as it did among the previous female students.

> “[...] so I actually always wanted to study. And um at first, I didn’t know what to study for a relatively long time” *– Student 5*

> “So at the beginning I actually wanted to study veterinary medicine, and um at some point it occurred to me that I probably wouldn’t be able to put an animal to sleep, because that also happens at some point. And then I just thought about what else I’m interested in.” *– Student 5*

> “[...] we actually had always own horses and that is actually a bit of a hobby of mine. That’s why, that’s probably where the first interest came from, saying ”I want to study veterinary medicine.”” *– Student 5*

Because of loving horses, she spent a lot of time with them, plied this as a hobby and hence got her first idea of studying veterinary medicine. All other toys such as experiments and growing crystals were mentioned, but more superficially. Due to the fact that these occupations were mentioned after a long thought expressed by breaks in her story, but were also narrated less enthusiastically. This suggests that she associates fewer positive emotions and, on that core, got less interests.

> "So I kind of played with everything. So, I mostly [...] well, since that we have horses, I mostly played with horses a lot. So that was pretty much that, but I've also kind of experimented with stuff like that. So, I have um had somehow crystal wax [...] so that can somehow make them grow or yeah. With chemistry sets like that [laughs]. I always found that interesting. I had, I think relatively much so classical Schleich and Playmobil horses." – *Student 5*

According to her early passion of constantly logging even before she was able to write has no counterpart which could be drawn to the STEM field. In spite of that, she tried a lot of things besides her passion for horses, which all never went further than an initial interest. Till now, possible conclusions about an interest in computer science could not be identified either.

> "Somehow I always had the urge to log everything [laughs loudly]. That was full of fun, I found 500 um like um [...] little blocks where I [...] at some point where I [...] then learned to write a little bit. I wrote something down, but it was completely illegible because I couldn't really write." – *Student 5*

> "Once, I started playing the piano [...] I [...] was in the [...] like in the wind class [...]. I also played the clarinet. [...] I used to read a lot. [...] I actually started painting relatively early, that was also always a hobby. And photography. So [...] somehow, I have quite a few hobbies. Um and jogging I started then also sometime." – *Student 5*

Inferred from the last quote, she was not sure yet about her favorite hobby in her earlier years. So, she tried many activities, but each of them misses the passion that she shared with horses.

In particular, when she started school, self-doubt arose in her, which will be discussed later in Section 6.1.4. Due to the low confidence in her own abilities, her interests specified and differentiated slowly. In addition to that, the process was more difficult because she could not cope with the school system. Although she was obviously very good in math in the last years of school, she did not recognize her ability and interest herself and continued to doubt herself. Based on this condition, after the middle school she chose a social science high school chasing her friends not knowing what she wanted or what she was able to.

> "Somehow I don't have any favorite subjects. I thought school was kind of stupid. [...] I think it was more because of bad experiences with the system or something. [...] Actually I always found math boring. [...] So I was definitely not bad in math. Because somehow it was always that I thought, yeah, I don't know, I don't trust myself. [...] I just always understood it, I think that was a bit of an advantage for me. I always, somehow explained it to half of the class. [...] I was very bad at math in elementary school." – *Student 5*

> "[...] went to high school after that, but um not to technical, but rather to social science, um, because at that time I actually rather thought that I didn't trust myself with the technical." – *Student 5*

During her time on the social science high school, she had to absolved a social internship when she realized that the social direction did not match with her interests. She said she needed this experience to find and understand herself, what she likes and dislike.

> "we had a social internship. Um and there we have [...] then tried to find so that less bad and somehow went to so a youth farm. Um we thought, we don't have quite so many people. Which is totally smart if you're on a social mission. Uh, I took it [...] actually rather, because

> rather [...] a bit, something in [...] because I actually rather [...] what needed to understand myself better, to classify, if you can understand that. So that has actually helped me in the direction [...]" – *Student 5*

Finally, her interest in computer science was initiated by a computer science class at school, but the subject was not designed to be continued because she was not in a technical high school. Realizing that she didn't like the social field, she decided to major in physics. For student 5, this choice was her crucial point which initiated her preference, but also encouraged her to teach herself more in private.

> "So I had computer science in school. [...] by not being on the technical, computer science was just more casual." – *Student 5*

> "At some point I started to teach myself a little bit. Just because [...] because it interested me." – *Student 5*

> "I think what was [...] really decisive was [...] in school, we had the possibilities to [...] at least choose physics, and at least [...] graduate in physics [...] because it was the only point where I really started to do what interested me the most and not to do what everybody else was doing. My girlfriends and stuff. And then I'm there [...] the first time I dared to go in a different direction than yeah girlfriends and everyone. So, in this case really everyone else. [laughs] Um, yes. And then [...] that encouraged me a little bit that I [...] that it is the right direction after all and that I should just try it out." – *Student 5*

Despite progress about recognizing her inclination and affinity, she regularly fretted about her ability, which was related to uncertainty about her interests, which she had not yet been able to differentiate.

> "[...] was a little bit the hard part with me because I was just interested in [...] I was interested in STEM on the one hand, but on the other hand, of course, I was also interested in psychology and stuff, and languages and stuff, basically also [...]." – *Student 5*

The interlocking of the development of interests and self-confidence, the inner conviction of one's own ability is essential for the decision to studying computer science. Both factors are interconnected to other factors such as the process of self-determination. At this point the whole process comes to a standstill, because the interests were too unclear, the confidence in oneself too weak and the courage for self-realization not yet sufficient. Student 5 experienced such a standstill when visiting a university on Open House.

> "So we had actually like rather [...] what we could do [...] to the universities [...] there was a Open House at the universities and we could look [...] we could took a look [...] asked questions [...]. And yes, we were in Tübingen and [...] I have actually already dealt with, because that was actually a bit later. Um and yeah. But because of that [...] I was still not really at the point where I say, I'll do it, because I still thought, yes [...] so I can really do it or do I really trust myself to do it." – *Student 5*

To break out of this stasis, she tried to become aware of her inclinations, what does she really want. With application of this thought process, her interest development, as well as all other factors in the taxonomy model, moved forward like the wheels in a movement. She became aware of which of her interests would really fulfill her if she were to pursue it as a profession and dealt with it for the first time. With the help of these considerations, she ended up weighing the interest in computer science against the others and deciding to choose a computer science curricula.

> "I think, I just thought about what if I do this all day [...], what would [...] satisfy me the most, and what would fulfill me the most if I do this all day. And what would fulfill me the most [...] And I can probably imagine that then actually as a profession to do, like [...] and then somehow it turned out for me that this [computer science] fits best and I can do the most likely, the whole day. That was kind of my thought process. Somehow for the fact that I actually take that and not the other and because it interested me nevertheless again a little more." – *Student 5*

She reflected herself in the interview and also describes her interest finding as a development, but also of self-discovery.

> "I think somehow that it has started rather bit by bit [...] just a bit. So [...] which means initiated is a bit wrong, the wrong word, but um developed, because I've always somehow [...] so I've just found it interesting for a long time and then again and again I've thought, yes, I could study that and that and then at some point it turned out that it's so that, that's what interests me the most." – *Student 5*

The development of interests is present for all female students in computer science, but have individual paces which can be influence by other factors such as self-doubts as a slowdown factor or self-confident as speed up factor. With identifying, specifying and differentiating computer science as the most interesting subject, the choice studying computer science will be facilitate for female students.

6.1.3 Convergence

The first contact points with computer science are essential for the final decision to study computer science. However, according to findings from the interviews, a single point of contact is not enough. Rather, it requires constant contact combined with relations to other central factors of the taxonomy model, such as the development of interest. This will be initiate by introducing women to computer science. Both parties, computer science and female students, approach each other discretely or even continuously. This continuous approach will be described by the concept of convergence, as one of the central factors of the taxonomy model. This means an early initial contact with computer science in the broadest sense, which initially means the approach with toys from the STEM field. Also, by the bringing near of a first computer and later the concretization during the school time are possibilities of building a first bridge. The focus is not on the student's interest and its development, but on continuous contact from both sides.

The importance of first points of interaction for the interviewed female students became apparent in the interviews. The concept is not intended to represent a general secret recipe for which acts of connection are necessary, especially during the growing-up phase. Rather, it is an individual interaction and reaction to potential contacts. It is substantial that the contact is actively pursued, for the time being independent of when the approaches occur. How this factor is developed will be discussed below.

First Toy

Intensive play with the first toy is an initial familiarization with the associated area. However, the focus must be on actual play, since a toy does not generate the needed contact until it is voluntarily interacted with. An existing toy, but is rarely or rarely picked up over other toys, will not result in sufficient stimulation. Thus, there were differently used toys between the female students. For this purpose, especially those toys are interesting, which were played with particularly often and which show a relation to STEM. This resulted in two female students who played with such a toy.

> "[...] with all kinds of toys [...], mostly there were [many] Legos in it. Lego bricks, [I had] a lot. I always built a lot of buildings, I always wanted to play in the buildings and wanted to build buildings later." *– Student 1*

> "My first great toy was a parking garage [...]." *– Student 4*

First Hobbies & Passions

Hobbies and passions can be used to pursue interests more intensively. In addition, aspects of hobbies can also interconnect female students with the computer science world.

During the interview of student 2, it crystallized that she was excessively involved with computers and played an extraordinary number of computer games, even describing herself as an addict.

> "I actually spend all my time with my computer. [...] Either I'm reading something or gambling." *– Student 2*

> "[...] Very much, so overly much. Fully addicted." *– Student 2*

The hobbies from student 3 were quite different, as she also played computer games, but was not heavily attached to them. She was more oriented to collecting data or intensified reading.

> "[...] among other things, what do I enjoy, and that's when I realized, I like collecting data [Laughs]. And then I realized, I've always done that. [...]" *– Student 3*

> "I read a lot, I like to read. I also prefer to sit inside and read than go outside and play. [...] Reading, doing puzzles, [laugh], don't need much more. That made me totally fulfilled and happy. So, at some point there was also a bit of playing computer games, when [...] my computer. [...] we were only allowed to use the computer a little at that time, because that was something special. We had one when I was 10 or 12, and the Internet was something you weren't allowed to use, because it was expensive and until [...] until a certain age and time-wise, of course, somehow my parents wanted to use the computer, and you had to divide it up. And at some point, I had my own really bad computer. And then at some point I played little more computer games, but not that much." *– Student 3*

First Computer

The first computer is usually the first real-world connection to computer science. At this point, each student was able to share her own individual experience in the interview.

Student 1 had her first exposure to a computer in high school. Later, she got a computer at home, which she used to do her first homework.

> "My first contact with a computer was at school because we had a lab there. And in the first, I think in the second year [...] we bought a computer. So I've done my first homework [...] with looking up books and doing it by hand. Yeah, there were those days." – *Student 1*

In contrast, student 2 got her first computer during her teenage years. Thereupon she became especially interested in online computer games less in programming.

> "I had my first computer, I even know that, I have to think briefly, 15, 16, but not earlier." – *Student 2*

> "When I got my first computer, I went on the internet with it [...] and started online games and stuff, I liked that so much, I thought *Oh that would be so great! if I could do something like that and work with it.* [...] I was just playing, but not programming. I have already tried to look at the files, so how it's all together, but not [...] not understood at the time, exactly. So rather I was using my computer and not programming." – *Student 2*

Somewhat earlier, student 3 received her first computer at age 10 or 12. At first it was more like a family computer with which she could only play offline games. Later, she got one of her own, but it was not a good one.

> "[...] we were only allowed to use the computer a little at that time, because that was something special. We only had it when I was 10 or 12, and the Internet was something you weren't allowed to use, because it was expensive and until [...] a certain age and time-wise, of course, somehow my parents wanted to use the computer, and you had to divide it up. And at some point, I had my own, very bad computer. And then at some point I played a little bit more computer games, but not that much." – *Student 3*

At a similar age, student 4 also started out with a family computer that she had to share with the other family members. The use was preferably limited for homework or school exercises. Later, she used her own computer for chatting with friends.

> "I bought my first computer with my confirmation money, so when I was 14 [...] uh floppy disk, so my first Power Point presentation didn't go on the floppy disk anymore because the pictures were too big, but [laughs]. Um, yeah, so that's when it started, or just research, for presentation and all that stuff. I, I had a few computer games, such as science learning adventure games. [...] but I have to say that in beforehand [...] we had a family computer, my father had a computer, and we played [...] with him from time to time. [...] yes family games. [...] So computer was present, always there, that my father was allowed to use the computer much longer than I was, of course, yeah, he was working [laughs]. Um [...] yes exactly. And then chatting formats such as ICQ came in [...] quickly at 15, 16 around. Where of course you had to be on in the evening to [...] yes [laughs] chat." – *Student 4*

First programming

A further contact point can find as first programming attempts. These can be held at school, inspired by school courses or by own initiative at home. Thus, the female students have had different experiences in this regard.

Student 1 tried her first programming attempt at high school in a computer science programming course.

> "[...] at some point I [started] programming a little bit in school." – *Student 1*

In contrast, while Student 2 played around with her first computer such as computer games, her first programming experience took place when she was in a computer science class at school. She was also able to learn some programming skills during her first study, which was not a computer science curricula.

> "16, 17, I've already made attempts. [...] That's when I started playing around a little bit." – *Student 2*

> "[...] that's more like operating computers, we do a little bit of everything. Worked with simple programs, or how internet works or things like that. Operating, a little bit of construction, a little bit of this and that, the basics, Pascal I think we programmed back then." – *Student 2*

> "So engineering applications, for calculations. We rehearsed those and a little bit of programming." – *Student 2*

On the contrary, student 3 avoided implementing for quite some time, accordingly told of no attempts at home. Also in the computer science course, which she took voluntarily at high school, there were rather less programming attempts. She differed her interests not in programming, but in theoretical artifacts of computer science such as solving problems or comprehending algorithm.

> "The technology doesn't interest me at all. In retrospect, as I said, I like data in itself. But it was more. Also, I don't like implementing, I think it's great to solve problems, and to understand such as like algorithms. That's why [...] What's important is typing." – *Student 3*

> "[...] our computer science teacher just went through a book [shows imaginary book] with us where Delphie was explained and then piece by piece you could click here and open there and then he could give us tasks [...]." – *Student 3*

Much more obvious is the experience of student 4, whose first programming skills initially came from a voluntary club she attended in high school, which she later deepened in an additional computer science course. Although she says she was naïve in her initial approach, but participation was crucial for her subsequent choice of studies.

> "the programming course that was just a "We'll try it out." That was actually quite cool, and it was one of the deciding factors that made me say, okay, I'll choose this as an orchid subject, because I simply enjoyed it. Before that, I had nothing to do with programming or anything else. Before, I had never somehow disassembled a computer, so my classmates were quite a bit ahead of me [...] I really went into the whole thing completely naive [...] um [...] but it didn't go badly at all [laughs]. Right, the course was definitely, so the club was definitely decisive for the course and the course was definitely decisive afterwards for the choice of computer science curricula." – *Student 4*

> "At the beginning in the computer science course, we programmed a bit of Delphie, um [...] that worked more or less well, we were also relatively many students. Also, there was a friend of mine, we always had fortnightly, because otherwise it wouldn't have worked out in the computer room. Um, it was a little bit yeah, draw a [...] Yes on the canvas was [...] painting a line with coordinates, but also nicely with loops. So, a garden fence or something to paint. So very basic at all times write something down and execute. [...] yeah not really compiler, but just so, yes, yes machine code level a bit binary, a bit ASCII, a bit programming. Um [...] but that only worked moderately, because my teacher assumed that we had all learned programming well in this course before and we just had this garden fence level. [...] But it helped at least to get to know a little bit, if-else-loops and to know in principle that loops never compile before they start and at least a little bit, so this expressing, on assembler level, so to think a little bit in code. After that course, such aspects were there." *– Student 4*

However, the interest of her accompanying friend could not be aroused, so that she continued the additional subject afterwards without a friend. In retrospect, she still admits that without accompaniment, she would have been unsure about her participation in the club.

> "[...] said friend, who was in the club, knows that the club was nice but she definitely does not continue computer science. Between friends, it was just nice but not that her interests was aroused." *– Student 4*

> "[...] I would not have attended the club at that time and also at that time a friend was there, I don't know if I would have done it all by myself, um [...] we just had a hollow hour and then we just did it. I don't know if I would have gone in that direction at all, it's certainly difficult to get into it without any previous experience and to say, now I'm going to study that." *– Student 4*

In summary, attending a club and afterwards a computer science class greatly helped in her choice of a computer science major.

Also student 5 achieved her first programming skills in school and later, maintained as well as deepen her interests for herself at home by teaching herself.

> "So, we just had a little bit of Java, program [...] so programming, but not really [laugh]. Then I started to teach myself a little bit at some point. 15? 16? At some point I got the hang of it. Simply because it [...] because it interested me. Um [...] yes but also not that [...] so not that [...] I wouldn't say, I was an expert, but I've just just occupied myself with it. Um [...] at the end of high school I started to teach myself a bit more and so I programmed some small things a bit. [...] there I taught myself a little bit in C#." *– Student 5*

By following her interests by self-programming her development of interests got ahead. Specifically, her computer science interest has been highlighted against other inclinations thus, her wish of wanting to study computer science and do be a computer scientist as a profession was formed.

> "Where I taught myself a bit of self-programming, I noticed that I was actually more interested in it. And I can probably imagine doing it as a profession. A profession is not just something you do as a hobby once a month, you have to really, really like it." *– Student 5*

School Activities

All female students explained approaching points during their school career, which were already partly mentioned in connection with computer science in the previous section on the topic such as first programming experiences. Either they joined mandatory or voluntary clubs, programming or computer science courses.

> "Right, so to summarize. I already had contact, a little bit, with it in school and so I found it. So, this building, so you build with software, which you also see results, and that has always been fun for me and so I got into software track. At school, we had lessons. That was a subject, I had to do it." – *Student 1*

> "In school, so we had had lessons. [...] That's also called computer science and that's more like operating computers, we do a little bit of everything. Worked with simple programs, or how Internet works or such things simply. Operating, a bit of construction, a bit of this and a bit of that, the basics, Pascal I think we programmed back then." – *Student 2*

> "And then, we had computer science in school for half a year and that was great." – *Student 3*

> "[...] I had in high school, there was first a programming course and then there was um computer science as an orchid subject, which I then took. And that kind of aroused my interest in computer science and the like [...] and then I discovered software engineering." – *Student 4*

In addition to the aforementioned connecting points, female students were also offered basic courses or courses that were geared towards teaching Excel, Word, and Power-Point.

> "[...] so at that time we still had such a basic course, I don't know what it was called, but so a bit Word and Power-Point and Excel [...]." – *Student 4*

For student 4, the points of contact with computer science are an essential part of her decision-making process, because without them she doubts herself whether she would even decide to pursue such a course of study.

> "I don't know if I would have gone [to the club] at all, so in that direction at all, so completely without touch points." – *Student 4*

> "I had computer science in school, but rather [...] rather so [...] not really computer science [laugh]. So well, we did something like Word and Power-Point and briefly we also had um thing um a little bit of HTML in high school, but not really so really very superficial." – *Student 5*

Other potential touch points included possible internships during and after school that were queried. However these narratives had nothing to do with computer science, but to exclude potential study interests in other topic fields.

Other points of contact

Further points of contact are connections that cannot be assigned to any of the previous categories. Among them, a possible first contact is via their parents, i.e., at least one of the parents has an affinity to the STEM field, for example through an apprenticeship or a study. However, this condition is not found for all female students. Only three female students indicated technical professions or STEM affinity in one of their parents, so count as additional convergence points.

> "My dad is a merchant, I think it's called, he did an apprenticeship. I claim that if he have had access to a high graduation, then, he would also have studied, and would have made something in the direction of computer science. Because I think he is well in thinking rationally." – *Student 3*

> "My father studied mechanical engineering, so he first did an apprenticeship and then studied afterwards. That's why he studied relatively long. [...] Interest-wise, I was more on his side. [...] he once explained physics to me." – *Student 4*

> "[...] my father is also doing something in that direction, [...] but I didn't want to do anything that he was doing. So somehow [...] that was definitely not the reason. [...] My dad did study, but at a university of applied sciences. [...] something like computer science, but a technical direction." – *Student 5*

> "Early, we had [...] I got such an assembled computer, from all sorts of old computers. My dad put it together." – *Student 5*

Besides the three female students, only two of them indicated a consideration of having their parents as role models.

> "Not so consciously. [...] so career-wish-technically my dad, who was just an engineer, I somehow always thought that was great without having any idea at that time what that meant. Um [...] but not somehow individual persons." – *Student 4*

> "Parents are always role models when you are little, I think. That's also quite normal, um but not really role models like that." – *Student 5*

However, it must be noted that none of the female students provides concrete role models or decisive formative persons for themselves in computer science. Neither teachers nor female teachers, nor celebrities or more famous names.

> "So not that I can really remember." – *Student 1*

> "I don't have any real role models, after all." – *Student 2*

> "I think my mom and my grandma have always influenced me quite a bit, insofar as that, they never put up with anything [...] but otherwise, I don't really have a role model that I, that I now aspire to or something." – *Student 3*

Even if parents do not act directly as role models, they can encourage interest formation by approaching computer science. To this end, student 3 mentioned that her father gave her a lot of confidence at a very early age and taught her more responsibility in using computers. As a result, she lost her fear of using computers.

> "[...] my father had a family computer back then and he gave me quite a lot of credit for it, for example, that I could install games myself or something like that [...]. And I remember that he had two hard drives at that time and you had to reboot and select the other one to be able to play and he also wrote that down for me in the correct order and I did that at the age of, I don't know, 10 or so, so I was able to do that. Because he just said, do this and this and that, and it worked, so it did, that touch fear of breaking something was totally not there" – *Student 4*

> "Technical support, um [...] that kind of always depended on me at home, [...] that is, if somehow there were problems with the Internet or otherwise, I was always the one who was allowed slash to call the hotline, slash had to. [...] But also a lot was done by googling. Googling the usual error messages and seeing what came up. And accordingly, simply little fear of contact, simply times made, already nothing he will go hopefully." – *Student 4*

As a final point of contact just before graduation, three female students indicated other individual contacts. Student 3 stated that she had sat in on the mathematics lecture of the computer science program at the University of Stuttgart prior to her studies.

> "[...] sat me in on a lecture. And that was, don't know if you remember it, in math it was Taylor polynomials, that just came up and that was kind of least common multiple algorithm or something in the technical. Which was totally simple and I just thought *hohoho I can do that too, studying will be easy*, I'll do that and then I just tried that out." – *Student 3*

The other two students 1 and 4 used the presentation and application of the study program on the information website of the University of Stuttgart and this perceived as a convincing argument.

> "[...] because I had liked the software engineering curricula or how it was presented. So, the software engineering subjects that you have as a specialization line, I don't know if it's still like that, but it's changed since I started. But there was a specialization line that was specific software, software qualities and requirements engineering and so on. And there was [the possibility] choosing subjects as a specialization line from the computer science lecture, then I thought okay, I see I still have a look into the subjects of computer science, then I can get this extra software engineering." – *Student 1*

> "[...] then also just this description that you also have these projects where you then really work in a team, that then convinced me so far." – *Student 4*

6.1.4 Self-Efficacy Process

Self-efficacy is the confidence in oneself and the ability to recognize one's own competencies, abilities, and possibilities. Thus, the wearer has the inner conviction of being able to master difficult and complex challenges with sufficient confidence. However, self-efficacy is not a characteristic or a state whose expression exists naturally and universally at birth and is identical in everyone. Likewise, such a conviction does not set in overnight. Rather, it must be learned in a developmental process. This is also the case with the interviewed participants, whose self-efficacy process is reflected in the narratives of their growing up. The process is accelerated or slowed down by individual factors such as their environment, they differ in their extent and are partly still in the initial stages. Thus, the degree to which the process begins varies, as does the degree of cognition needed to apply self-efficacy. The decisive factor is not the current stage, but the degree of maturity to be able to confirm the statement, "I can do computer science".

Hence, the self-efficacy process is another central factor, as part of personality development. Only if the female student's own conviction and confidence are sufficient, she will not see studying as an insurmountable hurdle. To present how the factor comes about, the two core categories of self-doubt and self-confidence are presented below, supported by quotes from the interview candidates.

Self-Doubt

Here, self-doubt refers to doubt and uncertainty about one's own abilities, possibilities, and competencies. The way to deal with this and to overcome this hurdle depends on the personality, but also on other individual factors. In particular, the degree of expression is decisive in determining whether there is a potential for breaking free. Despite this, self-doubt is not an obstacle to taking up a computer science degree program. Rather, dealing with it and acting on it is an essential part of the self-efficacy process.

In two out of five interviews, self-doubt could be identified in various forms and stages. These were particularly pronounced in two female students. The self-efficacy level of both women was primarily low during their school years. As the interviews progressed, the different characteristics of self-doubt crystallized. Where Student 2 used her self-doubt through the repeated use of expressive words such as ßtupid,SStudent 5 reflected on her situation and emotional state through long narratives.

> "I've always wanted to do that. So, this is actually my dream job and I really thought for a long time whether I should do this or not, whether I'm too stupid or not." – *Student 2*

In the process, she dealt with her self-doubt only briefly and was not dissuaded. She was, after all, aware of her abilities and interests in math and computer science, partly because of her good degree.

> "[...] so I was good at everything, but also without any particular preferences. But what I liked was math, geometry, things like that, computer science I also liked [...]." "[...] And then I thought, but I'll try [it] at least. So [it] is what I want to do." – *Student 2*

However, going through the self-doubt phase of the self-efficacy process does not simultaneously mean release from it. Self-doubt can still occur during studies, but due to completely different reasons as student 2 further emphasizes in the interview.

> "[...] already failed a few exams, so I thought, I'm too stupid, what am I doing, I'm just losing my time. Because everyone else is better, so you always see the statistics, right, in the exam you always see, for example, the statistics that there are always so many good grades or so many have passed and I'm the stupid one. [...] That I am not good enough." "Although I am not bad at all, so I prepare myself and I do not solve worse task." – *Student 2*

In contrast, self-doubt and, to some extent, anxiety about her own competencies affected Student 5 much more strongly. As a result, she went through a prolonged and partially unfounded self-doubt phase from which she tried to break out during her school years. She expressed her self-doubt with words such as her own confidence in technology or even fear of trial and error.

> "[...] I was definitely not bad at math now. Because somehow it was always the case that I thought, well, I don't know, I don't think I can do it [...] I just always understood it, I think that was a bit of an advantage for me, I always somehow explained it to half the class [...] so I was very bad at math in elementary school."

> "[...] then I went to a grammar school, but I didn't go to a technical school, but rather to a social science school, because at that time I thought that I didn't trust myself with the technical part [...]."
> "I don't want to say fear now, but already a bit [...] yes, I don't know, maybe [...] I didn't have enough confidence in myself."
> "I am always somehow too much afraid that I will ruin everything."
> "Sometimes, I don't have enough confidence in myself." *– Student 5*

Her confidence in herself fluctuated particularly strongly during her adolescence. Thus, at times, she even assumed she was incapable of doing anything at all.

> "I kind of dabbled in that way. In any case, for a relatively long time I wasn't interested at all [...] well, puberty is always difficult. I think that was the time when I really started to doubt all that stuff because of that. Or so. I sometimes have the feeling. That was a bit of a time when I actually thought that I wouldn't be able to do it all and so on. That actually got better at some point. But I think that's actually a big part that just resonates a bit [...] somehow always a bit, that no one really means and no one formulates like that, but somehow always resonates." *– Student 5*

During the interview, it was obviously that she could not accurately describe the cause of her self-doubt. She justifies it by her adolescence, which she describes as difficult or shifted the reason on some unconsciously situations that she have to oppose in her childhood.

From chasing her friends she recognized the wrong way, that the social science did not match with her interests so, she had to face the self-doubt. Through these independent decisions, self-reflection, she revised her self-doubt, slowly developing self-confidence in her own abilities and interests.

> "[...] what was really crucial was really that in school, we had the opportunities to at least choose physics there, and at least to do graduation in there. Because it was the only point where I really started to do what interested me the most and not to do what everybody else was doing. My girlfriends and stuff. And then I'm there, the first time, I dared to go in a different direction than yeah girlfriends and everyone. In this case, really everyone else. Um, yes. And that encouraged me a little bit, that I [...] that it is the right direction and that I should just try it out. Yes."
> "[...] then it turned out that maybe I do trust myself and that maybe it's smarter to just give it a try than to say you don't trust yourself". *– Student 5*

As a reason for her early and low self-confidence was lying on unconscious stereotype insinuations for example by the mediation in the media or by teachers in the kindergarten or elementary school times, in which only boys are addressed to dislocated tables.

> "So just with what is just conveyed in kindergarten or in elementary school or in the media. And I think that's a big point [...] so that's what stuck with me a little bit is um [...] when somehow even in kindergarten, where it actually still doesn't make any difference whether you have [...] what gender you have, when you're physically just still so similar and that hasn't developed at all yet. Even then, it was said that we need three strong boys or so to move the tables back-and-forth. And even then, it was somehow already conveyed a bit, or the workbench is for boys or so. That was never said, but there were boys at the workbench and girls in the kitchen. And I have the feeling that it was also [...] so definitely subconsciously, even if it was perhaps never said, but subconsciously" *– Student 5*

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The previous explaining reflects only two different childhood experiences, but both intersect in dealing with self-doubts. Therefore, self-doubt itself is not a positive factor but pertain to the self-efficacy process as a positive factor. In order to gain an inner conviction about one's possibilities and abilities, the stage of self-doubt is not an obligation step.

Self-Confidence & Self-Assurance

Here, self-confidence and self-assurance refers to the belief and conviction in one's own ability, that is, the degree of self-efficacy to also act and react in a self-effective manner. Self-confidence is synonymous with the definition of self-efficacy. Self-confidence is initially a characteristic or a state that can develop or regress as a result of external influences. In the context of the self-efficacy process, reaching a certain level of self-confidence is crucial to facilitate the step for women to study computer science in the context of the taxonomy model.

Interpreted differently, self-confidence can also be defined as a personality trait, i.e. the way people interact with their external world, for example in the form of introversion or extroversion. Thus, the two definitions differ in terms of directed belief. The one that is directed inside the person, closing off to the outside world, and the one that is demonstrated outside, regardless of the extent to which inner self-confidence develops. Both must be treated separately. Essential for the self-efficacy process is exclusively the own belief in the personal abilities. The external effect is of secondary importance. Therefore, the two perspectives revealed by the interviews will be treated separately in the following. For both figures, processes of change could be identified.

A development of self-confidence as part of the self-efficacy process accompanied each interviewed participant. However, the manifestation was individual. Thus, the self-confidence of two female students developed from a previously manifested self-doubt, which they were able to overcome with self-confidence, by trying out and confirming their abilities, to such an extent that their conviction in their abilities was sufficient to study computer science. In contrast, the basis of the other three female students' self-confidence was built on a largely neutral self-belief that developed into relevant self-assurance during their school years. Their developmental process is repeatedly individually, which will be presented for each interviewee below.

At latest, initial proficiency becomes noticeable in school, when the first tasks have been solved and evaluated. This was also the case for student 1, who failed miserably with her programming attempts at school, but tried to reflect on the experience in order to use her will and what she calls ïmpulse"to learn, because she believed in her ability. She did not transform the negative experience into negative emotions, such a self-doubt and thus aversion, but used this low blow to become better from it. From this situation, her natural self-confidence manifested itself as an impulse. The self-confidence saying ”I can do it", even if others do not believe in it, she uses as motivation and for self-determination.

> "At some point I [started] programming a little bit in school. I was pretty bad at it. [...] you had this impulse, okay something is bad, but [...] deep down maybe you know if you learn a little bit more, you could do it." – *Student 1*

> "From before I always think like this, when I heard, okay, women can't study anything and only men study, I think, it rings a bell with me and I want to do it differently. It is also, with me it is actually interest [...]." – *Student 1*

However, the self-confidence achieved by her own drive got a beating during her studies. Due to situations that were not specifically mentioned, she got the impression that she could not make it, especially as a woman. Due to this negative perception, her self-efficacy reached a crack, characterized by slight self-doubt in short anecdotes.

> "I never had the impression that I thought I would not be able to do something because I am a woman. During the studies I already have such impressions." – *Student 1*

> "Already, I see, I get here [...] I have the feeling I get more, I do not know, not reproach, but strained moments [...] prejudices." – *Student 1*

In particular, student 3 possessed a high degree of self-confidence about her ability. Looking back on her school years, she went through a very easy and lighthearted self-efficacy process. She clearly showed which weaknesses and strengths she had, which school subjects she particularly liked, and repeatedly cited her good performance, also confirmed by classmates. Furthermore, she mentioned her math skills and her experimentation in the natural sciences by taking part in clubs with regular consistency and conviction.

> "Yes, and I was also somehow, so school-technically, I was always good in the sciences, in other subjects rather so eh [tone]. Um, history, geography didn't go at all. Politics wasn't mine either. I took a chemistry course at the same time, a club like that. I was in the choir. I played the piano." – *Student 3*

> "But like I said, science was fun for me, so why not. And I was good, again I was good, so even though all the guys at that time came up to me before the math exam and asked me how to do this or that. I didn't feel like they [classmates] were superior to me in the subjects, like I wasn't enough to do something like that." – *Student 3*

> "But I was good, it's not like that." – *Student 3*

> "I think I'm loud enough, I'm confident enough that I just push through it. I'm good enough. Part of it. So you can't label me either, [...] I'm a big contradiction, in myself. I'm also insanely insecure, but you don't notice that." – *Student 3*

So, her self-confident started at a high level which results in an accurate differentiation between her interests, what she likes and her abilities, what she can. This behavior about self-confidence and the appropriate self-assurance was strongly influenced by women in her family, whom she knew to use as self-efficacy role models.

> "I think my mom and my grandma have always been pretty influential on me, in that, they never put up with anything and they still don't." – *Student 3*

> "My mom also got into it with the people at school because there was almost no chemistry class, no 4-hour one, and threatened them that I was going to change schools, if they didn't get it right and stuff. Um, that worked out in the end, it wasn't like that, but um, she fought for me, so you see this strong female personality in me. And my grandmother is the same way, you know [banging her fist], she also bangs on the table sometimes when she doesn't like it, I think you can see that." – *Student 3*

However, her self-efficacy and her outwardly directed self-confidence overlap very strongly. About herself she judges more as an insecure, introverted person, but at the same time she shows a self-confident personality to the outside. In this respect, self-efficacy is constantly developed and shaped, accelerated or slowed down by factors such as family or, more specifically, the environment during the study period.

> "I have always had such a helper syndrome. So I want to help people, and that's what I enjoy massively. [...] I actually have a hard time with people sometimes. I'm more of an introvert and [...] it costs me a lot of energy to be with people, which is kind of a shame. That's why I need a lot of time for myself and [...] But I like to be with people [smirk]. I'm just complicated sometimes." – *Student 3*

> "I'm a big contradiction, in myself. I'm also insanely insecure, but you can't tell. So that's why. It's a bit of an advantage, this [...] I can be loud and then there are moments where I'm very quiet. But um. I think maybe I've also been shaped there in this male environment." – *Student 3*

> "So I have to say, I had since I've been at university, I'm a new person, I'm very different than I used to be. I was much much quieter then. And since I've been here too, back then I only had [...] before university I only had female friends, now here I have mostly friends, male friends. And I have [...] so here I have become more self-confident. Much more committed, much more I don't know. So that can already be that being has shaped me the time here." – *Student 3*

From the quotes, it is very easy to see how the current self-confidence of the female students differ. Student2 and 5 are a bit more shy in their statements, need many pauses, and are less able to express their inner conviction. In contrast, students 1 and 3 are more expressive, can state their strengths directly without needing many pauses or restarts. What is seen that this self-efficacy process develops beyond the beginning of the study and is influenced by external factors.

In the case of student 4, who was also not plagued by any overt self-doubt about her ability while growing up, self-efficacy was high without representing this strongly to the outside world. She was able to visibly recognize her strengths as well as her weaknesses and, with the help of this knowledge, decided to pursue a school career in the natural sciences. This insight was reinforced by the good marks she received for mathematics as a school subject, even though this was not consistently the case throughout her schooling.

> "[...] after I had decided not for the third foreign language, but for the [...] eh, the natural science branch, we were then only 9, so me and 8 boys." – *Student 4*

> "So my main subjects in high school afterwards were math, English, German, physics and religion. [...] So I was more inclined towards natural sciences than languages. [...] although I also have to say that now, for example, mathematics, so rather from the middle school has really cracked. So elementary school was okay, at some point the functions came in, I found them quite [laughs] for a while [...] were not my friends and then at some point it clicked and from then on it went very well in math or so too." – *Student 4*

> "So I was in elementary school very good in math, in between okay, never really bad, and at some point then just so 11th grade has done it then again such a jerk and then I was very very good. [...] This has then continued until the graduation." – *Student 4*

The reasons for this break are not known, but this short valley did not have a formative effect on her conviction in herself. Nevertheless, for a computer science club and later in the upper school for the orchid subject computer science decided.

> “[...] the programming course that was just a "We'll try it out". That was actually quite cool, and it was one of the deciding factors that made me say, okay, I'll choose this [computer science] as an orchid subject [...] I really went into the whole thing completely naive [...] um [...] but it didn't go badly at all. [...] the club was definitely decisive for the course and the course was definitely decisive afterwards for the choice of studies.” – *Student 4*

> “I remember doing relatively well in computer science.” – *Student 4*

> “And I think that certainly had a positive effect on [...] yeah [...] just doing what you're comfortable with.” – *Student 4*

The entire process of self-efficacy was shaped throughout by her parents, especially her father, who gave her both confidence and a sense of responsibility regarding computers. As a result, certain fears of contact fell away.

> “Parents have actually always gone out of their way and made it clear to us that everyone is allowed to do everything, can do everything, should do everything. [...] it was never the case that I wasn't allowed to do something because I was a girl or something. So actually everything I wanted to do was always supported.” – *Student 4*

> “[...] my parents or my relatives were always proud if you were great and especially if you were good in math or something, EVEN though you were just a girl, in general, that was just always a reason to be happy [...].” – *Student 4*

> “[...] my father had at that time a family computer and he trusted me at that time already relatively much with it, so for example that I install games myself or something, um, yes because he was not [...] not there during the week. And I remember, he had two hard drives back then and you had to reboot and select the other one to be able to play and he also wrote that down for me with/in the right order and I did that at the age of, I don't know, 10 or so, so [laughs] I could do that. Because he just said, do this and this and that, and it worked, so it did, that fear of touching something broken, was totally not there.” – *Student 4*

> “So computer science in the very broadest sense, from, I say help desk [laughs], tech support, [...] that kind of always hung on me at home. [...] if somehow there were problems with the Internet or something else, I was always the one who was allowed to call the hotline, slash had to.” – *Student 4*

In contrast to a firm self-confidence in her skills, there is a self-confident woman behind it, but not a person who strongly conveys her skills to the outside world. Thus, she describes herself as more of a loner type, more of an introverted personality.

> “More of a loner type with rather less close friends.” – *Student 4*

> “Definitely introverted.” – *Student 4*

That is, within this self-efficacy process, it is secondary whether the students represent their self-confidence to the outside world. What is decisive is the conviction of one's own abilities without having to convince others. Thus, it is not always the case that students doubt their own ability, but it is essential to reach an individual level of self-efficacy in which one reflects on one's own ability and possesses this knowledge and the belief that one can do it. This process is shaped, accelerated and slowed down by individual factors. For example, parents can have a positive, negative or as well no influence. However, these potential influences are individual from student to student which can not be conceptualize by an connecting category. Thus, developing a sufficient confidence in one's own competencies is an essential component of the taxonomy model in order to be able to affirm the statement, ”I can do this”.

6.1.5 Autonomy Process

The second component of personality development and fourth factor of the Taxonomy Model is the autonomy process. Autonomy itself describes a person's self-determination, freedom of decision-making action, and self-governance. Like self-efficacy, autonomy is not a trait or state that exists naturally and universally. Rather, it is a process that must be learned individually from childhood and is thus in constant flux. Obvious trigger factors or influencing potentials can facilitate or complicate this process. Where the desire for autonomy is taken for granted, others need a trigger for an an autonomy.

However, the concept of autonomy needs to be more sharply defined. For example, an autonomy can be only temporary in nature, i.e., short-term, such as for a single decision, but infer long-term goals and effects, such as for the desire of an autonomous life. Any forms of autonomous action are to be accommodated under the concept of autonomy. In particular, autonomy centers on three identified phases of the process. The first phase describes the desire for autonomy, triggered by personal factors. That phase is not self-evident, but it is also not consciously perceived by everyone. Rather, this unconscious desire can be a part of personality development, usually around puberty. The second phase deals with the recognition of self-determination, being allowed and able to decide for oneself. Within the framework of the taxonomy model, the third phase aims at the actual realization and implementation of a study of computer science. Within the sub-process, the courage is mustered to finally take this step of Ï'm going to do this".

Due to the individuality of the growing up, the made decisions, actions and experiences, the single stories and processes of the female students can only be confronted over a conceptualized perspective. For this purpose, on the one hand, the processes gained per female student will be presented, i.e., not shaped by categories, in order to describe a coherent process. On the other hand, the personal developments will be roughly ordered according to their process starting point, that is, in which phase the autonomy process starts.

Desire of Autonomy

The autonomy process often begins in connection with the desire for independence and is triggered, for example, by incoming situations. Such a desire was evident in the case of two female students who were trying to break out of what they considered to be a hopeless circumstance. Although the approaches of both students are different, the background idea of leading an autonomous and self-determined life is similar. This goal is specifically linked to degree programs and the associated professions that can support such a life.

For student 1, the desire for autonomy was born out of her parents' example. Due to her mother's dependence on her father, her desire to, in her words, "absolutely" achieve independence awakened. From this desire of needing a foundation such as a career that would allow her to finance everything without needing anyone to do it. However, she also emphasizes that she does not want to pursue a career, but only wants to earn money to the extent that she can support her life according to her imagination.

> "Because my mother was a housewife, that means she was totally dependent on my father, financially dependent. And one thing where I thought about it especially early on was I really want to have my independence. I need to have a career or something or learn so that later on, at some point in my life, I can finance everything without being dependent on anybody." – *Student 1*

> "[...] it's the area that I already knew I was going to do something technical that would give me enough money." – *Student 1*

> "I personally, I never plan to have family [...] I also don't want to make career [...] I just want to work normally stop, live my life." – *Student 1*

> "[...] for me it is important to be independent. That I get enough money to live my life the way I want. But, that I don't become a bit breadless." – *Student 1*

Thus, she also associates an independence with no needing anyone else to finance her. This is the point, at which she turns consciously to the independence goal and would like to strive for this in combination to her interests in form of a technical course of studies. To get closer to this goal, she used her conscious freedom of self-determination for the first time and chose to attend a technical school.

> "And there, from me was the decision whether to go to technical school and that's actually how I got into the technical field." – *Student 1*

All of her autonomous decisions, such as choosing a technical school and computer science experiences, led her to her individual, sufficient level of autonomy to ultimately choose a computer science or software engineering degree and realize her desire. In the context of the taxonomy model, other factors such as interest development continuously impact her autonomy process, which accompanied her to this "I'll do it"-step. Since she was interested in a technical field at a very early age, the final decision was easier than choosing between computer science and software engineering.

> "My options, as far as I can remember, that I considered were electronics, civil engineering so architecture and electronics. And there was a new course, so computer science I never did. There was also computer science but I thought, I'm not going to do that in life because it's actually very software loaded, but I also wanted something with hardware and there was a new course the technical computer science, computing engineering. They sold it to me that it was a mixture of electronics and computer science. And I thought yeah okay well if I can't really decide anyway then I can make a compromise, have of both worlds in the course." – *Student 1*

> “[...] I didn’t think that I would end up [...] actually studying software engineering [...] the time just before I make this decision, do I want to study and if so what subject. I think the area, the grater area I had always a gut feeling, but I did not know exactly whether computer science or software engineering. I have only, I think 6 months before exactly analyzed and decided, okay, so rather before the application.” – *Student 1*

> “[...] early on I knew what I was going to do in that direction, in the time where I had to decide, okay what do I want to study, that was a very very easy decision for me.” – *Student 1*

Supportive process factors from her immediate environment, such as from her family, were not identified, which allowed her to drive the process herself.

> “[...] from my family, it’s no one that anything, they don’t know what I’m doing so far [...].” – *Student 1*

By starting her studies, she has reached her individual level of autonomy for self-realization of her desires, but this does not mean the end of the autonomy process. Moreover, during the interview she told about the beginning of her studies and the difficulties she encountered. Thus, it turned out that her independent drive and personality development in terms of autonomy, pursuit of interests, and self-efficacy is developing to the extent that she significantly follows through with what she sets out to do until the end.

> “The first semester was already very difficult [Laughs]. I have to say that. But I am of the opinion that if you are sure to a certain extent that you want something like that, then you should go all the way [...].” – *Student 1*

The progressive development of autonomy is as much a constant companion of personality development as the self-efficacy process. After her realization of the concern to lead an autonomous life and the fusion with her development of interests, she has chosen the technical way. Through self-determined actions and the conviction of her ability, she achieved her autonomy level to actually apply for a software engineering degree.

Similar to the case before, the desire of independence was born out of the childhood experience that student 2 went through. Here, for privacy protection this thesis will only refer to the difficult situation from which her desire arose with the goal of wanting to achieve a better life than she had at the time.

> “I have such a difficult situation in the family [...] That was rather difficult in childhood. [...] they also didn’t care at all.” – *Student 2*

Associated with this was a particularly pronounced transmission of stereotype thinking, which was reinforced by her close environment. The demands of society on her as a woman, the contrasts to the man, and her dissatisfaction on this gender gap became exceedingly clear during the interview. Just a small excerpt of her thoughts is shown in the following quote:

> “[...] so as a man, you have everything easier anyway in finding job finds or side jobs. And men can do much more, because they are simply stronger, no idea. So, because of looking for side job for example, you can do something hard, which women can’t do. And then women also get married earlier. They also don’t have time for. If men can study until, I don’t know, until all eternity and do what they want. Women marry at the age of 25, I don’t know, so as a rule and after that they don’t have time to study anymore and I understand that. And then the children come and then it was already over with all the dreams anyway.” – *Student 2*

> “Yes, I always wanted to achieve something and my family was so poor after all and then I said to myself, I want, so have something better in life. And that’s why I set myself goals and try, so I [...] as I try to be better [than I was then] in any case. Yeah, and that I’m not going to live the way my parents live.” *– Student 2*

> “I would rather like to work and my husband [takes care of] the children at home. I do not want to stay at home.” *– Student 2*

To this day, the demands of her environment do not match her ideas and desires about life. For this reason she demands for herself an independence, a better life according to her ideas, in which she can also create and achieve something.

With this goal in mind, she first studied a technical engineering course at a mathematical faculty, which had a lot to do with mathematics, but less with computer science. Although her level of autonomy was high enough to muster the courage to study something. In particular, at that time she was still struggling with her direction of interest. In spite of this, the choice was one of her self-determined actions, with which she tried to break out of the mediated social thinking. All those choices are part of her process.

> “I chose something stupid, there I was not satisfied, but no idea, I was 16 where I started, I was 16 after all, I had no idea at all.” *– Student 2*

Due to her difficult childhood, also from a financial point of view, and the escape from her former situation, she was left on her own after her first studies. By which she had to finance herself an autonomous life. In harmony of her interests, she gathered the courage to try computer science in the end.

> “[...] first worked in a retirement home because I was on my own. So I had no financial support at all. [...] And where I saved a little bit and [...] thought that I may study now, [...] I applied.” *– Student 2*

> “And then I thought, but I’ll try [computer science] at least. So this is what I want to do.” *– Student 2*

However, for her the notion of autonomy was not limited to life, but rather included freedom in the pursued profession. This factor also played a role for her, which she experienced in her everyday professional life.

> “After my work in the nursing home, where everything is always the same and routine. And you are always subordinated, yes, you always have your bosses and every home resident, no idea, then I thought that would be so great if I had so more freedom and could develop something.” *– Student 2*

> “[...] if I could, I would just study computer science from the beginning, I would choose that already.” *– Student 2*

The juxtaposition of student 1 and 2 shows the commonality of an expressed desire for independence that extends to both life and the profession itself, with computer science for student 2 corresponding to her imagination, a certain freedom, of a positive image.

> "In computer science professions you are rather so free and you could work from home or like you see that everywhere that they have whole recreational rooms in their offices with Playstation and so on. So that they look informally and they don't talk to each other formally and stuff like that. And that's when I thought, oh that's so great. I've got not that image of sitting in the office boringly." *– Student 2*

Both students grew up completely different, yet both pursued the desire to be independent and study either computer science or software engineering. Through a wide variety of experiences and self-determined decisions, both paved the way to achieving an individual but sufficient level of autonomy to ultimately decide to try out computer science curricula.

Self-determination & Self-realization

A conscious desire for independence emerged in only two of the five female students. The other three interview participants never questioned the freedom of their decisions and actions. For them, the process toward autonomy is something natural that develops automatically as they grow up. Here too, individual factors can be found that influence this process in a negative, positive or neutral sense. In the context of the taxonomy model, self-determination and thus, self-realization, namely the realization of one's own desires and goals, is decisive for taking up such a study of computer science. Besides the will and interest, the actual urge of self-realization is essential.

For student 3, the freedom of her decisions and actions has been a natural circumstance from an early age and its givenness she never doubted. In terms of the autonomy process, she never experienced a conscious triggering situation that caused the urge for freedom, rather her childhood took place in a secure environment, including financially secure, where she never had to worry about what would happen tomorrow. Because of this background, she was free to explore.

> "I tried out. And thought, if it doesn't work out, I'll just do something else. I have a pretty secure home, so I would have been financially [...] so I was also always secured, that had never been the problem. After a year, if I have said, I want to do something else. I wouldn't have had to say because of the money, and quickly and Bafög [supporting credit for students] and here and here. That's why I actually had the freedom to try things out. Yeah, that makes it easier." *– Student 3*

> "[...] I always had child support, I didn't have to worry so much about that." *– Student 3*

The safe environment gave her the opportunity to freely pursue her interests, so she considered several paths here as well. In contrast, student 2 is limited in her freedom of self-realization, because of her financial situation. While this aspect is important, financial security will not be an issue for every female student. In their narratives, the other participants did not mention any financial difficulties or motivations for why they were studying computer science or how the issue had impacted their path. Due to this, the financial point is an influencing factor on the existing factors of the taxonomy model such as the autonomy process.

The autonomy process for Student 4 was oriented toward independence from her environment, her friends. This is also part of the process, the urge to pursue one's own interests, self-determination, must be stronger than the urge not to be alone.

> “I am someone who has learned a bit, a bit probably also by himself, um [...] does what me enjoys, [...] even if no one else does it. I would never have done the third foreign language just because everyone else was doing it, simply because it wasn’t for me.[...] that’s why I studied software engineering, simply because it was the right thing for me [...] without looking at whether a friend or something else was studying something else. [...] so at least from my schoolmates this [...] this group effect was already clearly higher.” *– Student 4*

> “I am quite willing to participate or try things that I don’t know or where I am rather averse [...].” *– Student 4*

The accumulated experience and also the background of a safe environment, tempted her to try the course of study, even if it turned out to be bad later. The step to the actual implementation is based on the previous experiences and experiences, with which she found her individual, sufficient degree of autonomy.

> “I thought, I want to try it in any case. In the worst case I reorient myself. So the possibility was open in principle to say, if it’s just nothing at all and I’ve made a complete mistake, then it has to be something else, but now I’ll give it a try. [...] And because I had at least a little bit of programming experience, I thought, yes, I know at least a little bit what I’m getting myself into.” *– Student 4*

Also as with Student 3, facilitating factors, such as the support of her parents, impacted the autonomy process.

> “[...] my parents have actually always made an effort and made it clear to us that everyone is allowed to do everything, can do everything, should do everything. [...] So actually everything I wanted was always supported.” *– Student 4*

> “[...] my father had a family computer at that time and he already trusted me relatively much with it, so for example that I install games myself [...] and I did that at the age of, I don’t know, 10 or so.” *– Student 4*

> “[...] my mother certainly also influenced me, because she was simply also employed early on[...].” *– Student 4*

Her process of becoming independent changed over her school career. Also, by learning to make own decisions without waiting for someone is partly responsible for her being able to fully focus on computer science while in school and software engineering as a degree. With the help of the influences of the other key factors of the taxonomy model, she has taken the step of pursuing such studies independently.

The difficulty of chasing others was especially evident during Student 5’s self-determination process. On the one hand, she struggled with the complex of interest orientation and related self-efficacy, as she turned to many interests but did not believe in her ability. As a result, she initially chased after her friends’ interests, which, conversely, did not match her own interests. So she accepted the school’s offer to do her high school diploma in a STEM subject, which she enjoyed much more. She calls this turning point the “single” point in which she first did what interested her. Encouraged in her choice, her level of autonomy to break away from others increased, along with her confidence in her own abilities. Having the courage to try something new had thus been essential for her to finally turn to the technical field. However, the uncertainty still remained shortly before graduating from high school.

> “[...] to the grammar school, but um also not to the technical, but rather to the social science, um, because I thought at that time actually rather that I do not have the technical confidence.” – *Student 5*

> “I don’t want to say fear now, but already a bit [...] yeah, I don’t know, maybe [...] I didn’t have enough confidence in myself.” – *Student 5*

> “That was a strange time, but I think that was also due to puberty.” – *Student 5*

> “[...] then it sort of turned out that maybe I did have confidence in myself and that maybe it was smarter to just give it a try.” – *Student 5*

> “I think what was really decisive was really that in school, we had the possibilities to at least choose physics there, and at least to do graduation there, because it was the only point where I really started to do what interested me the most and not to do what everybody else was doing. My girlfriends and stuff. This was the first time, I dared to go in a different direction than yes girlfriends and everyone. So in this case really everyone else. [laughs] Um, yes. And then that encouraged me a little bit that I [...] that it is the right direction after all and that I should just try it out. Yes.” – *Student 5*

> “So we had actually so rather what that we can to the university and then that there the day of Open House [...] we could look there halt times the courses of studies so a little bit, but rather ask questions [...]. And yes, we were in Tübingen and there I have actually already dealt with, because that was actually a bit later. Um and yeah. But because of that [...] I still wasn’t really at the point where I said, I’ll do it, because I still thought, yes [...] so I can really do it or do I really trust myself to do it. But then I decided to do it after all.” – *Student 5*

> “Then, I just decided to do it because I was just totally interested in it and then I just thought I’ll just give it [computer science] a try.” – *Student 5*

One problem of her interest development for which study course she should decide, built on the search for the fulfillment and satisfaction in the later occupation. With the help of her freedom of choice she has come to the point that she wants to do what she likes, what fulfills her the most. The conclusion of this thought process is the self-realization of taking up a study of computer science, of having the courage to apply for it.

> “I think I just thought about what if I do this all day now, what would [...] satisfy me the most, or the most, and what would fulfill me the most if I do this all day. And what would fulfill me the most [...] so [...] and then somehow it turned out for me that this fits best and I can do the most, the whole day. That was a bit of my thought process.” – *Student 5*

Comparing studying to the school system, she noticed the lack of self-determination element, which she never really got along with. The restriction by having to go to school, even negatively influenced her autonomy process in this case, if not slowed down in her personality development.

> “In school it was always, you have to do this and you have to do that, and woe is me, you do that, and that has to go there and there, and in college it’s more like, you do it all for yourself, less for someone else, and you do it because it interests you, and less because you just have to. That was rather what I found different and better. Because you do something interesting for the first time, because you are really interested in it, and not because it is on the curriculum and you just need that subject” – *Student 5*

She was able to achieve the necessary degree of autonomy only very late, among other things because of the restrictive school system and also the low self-confidence in her own abilities. However, the turning point of self-determined action was essential for the development of her independence.

6.1.6 STEM Skills

Computer science, with mathematics, informatics, natural science, and technology, by name forms the summary German term MINT. In the acronym of the English designation STEM, computer science is not mentioned as an independent term, but is considered as an overlapping product also to the STEM courses. The sense of STEM is also composed of science, technology, engineering and mathematics. This implies a high level of mathematical thinking, a high level of mathematical-technical skills and also interests to the same extent.

In the context of the taxonomy model used to represent the factors that facilitate women's entry into computer science majors, affinity or ability in at least one of the STEM fields is one of the essential and central components of the model. Specifically, computer science-related subject sectors that are directly related to computer science are meant. Foremost among these is an affinity for the art of mathematics, not forgetting some understanding of electrical engineering. Certainly, the study of computer science has contemporary changed and adapted over the years, and the courses offered by universities and colleges also differ so that, as a result, further affinities are required en detail. Likewise, lines of specialization in computer science require additional skills. Moreover, not only talents in STEM are required, different skills such as an analytical and logical thinking help to better understand and fit into the computer science world. Generally, STEM aptitude is defined here as an exceptional disposition or affinity, even inclination, in one of the STEM fields. It is equivalent to having an innate aptitude without having fully lived it out beforehand. More precisely, it means concrete ability, even in the absence of previous practice.

At this point, the level of ability is crucial. As different as the talents of individual personalities are, their expressions can also differ. Important is the potential to deal with mathematical problems and to be able to solve them. For this purpose, the person in question may have above-average algebraic talents, but bilateral influences by the other factors also play a role here, which go hand in hand. In the end, the factor to the interest developments overlaps, since the tendency to computer science is to be interpreted also as interest. More details can be found later in chapter discussion 7, where among other things the intersectional aspects and the internal relations between the factors are discussed.

That STEM ability is an essential taxonomy factor could be conceptualized thanks to the interviews with the participating female students. According to the definition of an ability to be an innate aptitude or affinity for the STEM subject area, an affinity can show itself in early years by favoring or disfavoring certain toys. The toys or preoccupations in early years ranged from playing with dolls, Barbies to stuffed animals to Lego blocks to parking garages, as for Student 1 and 4:

> "[...] mostly there were a lot of Legos in it, Lego bricks, I have a lot. Dolls I have, so I had a lot of dolls, but I have, I have, at some point I didn't like dolls so much because I saw so many horror movies on TV that I shouldn't see, especially where doll tries to murder you like that [...]." – *Student 1*

> "I've always been more into the technical stuff. Um [...] my first great toy was a parking garage." *– Student 4*

However, first pursuits and favorite toys do not always guarantee that computer science-related or mathematical skills will already be evident. For example, the toys for Student 5 were varied, with a focus on playing with horses evident during the interview. No specific STEM skills were initially identified for this case.

> "So I kind of played with everything. So I mostly [...] well, since that we have horses, I mostly played with horses a lot. So that was pretty much that, but I've also kind of always kind of [...] experimented with stuff like that. So I have um had somehow so crystal wax [...] so that can somehow make them grow or something. With the chemistry set moderately." *– Student 5*

Later in life, around the time of the school career, abilities crystallize recognizably through good grades. This process played out individually for each student.Early on, for Student 1, it was clear that she did well easily with mathematics and was able to discover her abilities.

> "[...] back in school I also realized that I really liked math and could also handle it well." – *Student 1*

She also sees logical thinking, which is important for studying computer science, as intuitive for herself, which was not learned or acquired, but recognized as naturally innate.

> "And I think for programming, many people say "Ah, that's a bit hard with logical thinking", but I find it has a lot of, I don't know, for me it's intuitive." *– Student 1*

A situation quite as simple and clear as it was for Student 1 did not exist for Student 2. The problem lay in the fact that she preferred a broad repertoire of interests. Thus, she first acted out her aptitude for music before devoting herself more and more to the mathematical direction.

> "And right, I think I was 5 or 6 year in a music school and so I occupied all my free time right, at that time. And at first I actually wanted to go to the conservatory, so continue to study music, but then I changed my mind, right. Then I thought, I'd rather do like math." *– Student 2*

> "[...] so I was good at everything, but also without any special preferences. But what I liked was math, geometry, things like that, computer science I also liked, history I liked. So more like mathematical direction, right." *– Student 2*

> "Chemistry I hate, but physics I think is quite great. So physics I like." *– Student 2*

In terms of her STEM ability, she specifically showed a very good degree in mathematics, which she used to get taken for her first intended study.

> "So, there was prerequisite good math degree that I had and then they took me. [...] I could still study math, but math was to me, so real pure math, was a bit unattractive [...]." *– Student 2*

More clearly, student 3 differentiated her STEM skills, which moved in different directions during her school career. For example, unlike Student 2, she was more averse to physics, as it was no longer intuitively understood by her in a higher grade. Instead, she turned to computer science, which she had no difficulty with, even showing a higher affinity to her classmates. Especially mathematics always suited her, which was also reflected in her very good grades during her school years.

> "I deselected physics. I always did not understand physics or it was no longer so intuitive. And then we had computer science in school for half a year and that was great [laughs]. I understood a lot of stuff, we had sorting and stuff like that, where nobody got through anymore and I had no problem with that." – *Student 3*

> "Yeah, and I was also kind of, so school-wise I always was good in science, in the other stuff more so eh [sound]. Um, history, geography didn't go at all. Politics wasn't mine either. I did a chemistry course on the side, it was an extra club." – *Student 3*

> "Physics I can do to a certain extent, but as soon as it comes to electrical engineering or something, it doesn't fit in my head from the idea. And from then on I [...] don't feel like it anymore, I don't really understand it anymore, or yes. Especially electrical engineering, the electrical engineering part was what put me off computer science, where I then didn't consider whether I shouldn't switch to software engineering." – *Student 3*

> "Because I enjoyed math and all that kind of stuff or maybe I still needed points, I don't remember. But like I said, science was fun for me so why not. And I was good, again I was good, so even if all the guys at that time came to me before the math exam and asked me how to do this or that [...]." – *Student 3*

However, innate talents need not be permanently reflected in grade levels, as student 4's school years show. According to her, she has always cultivated a certain affinity for natural sciences than for languages, for example. The aptitude first emerged during elementary school. Reasons can be in the change on the high school, the knowledge transfer, mathematical reasons or other imponderables, which led to the fact that she showed very good achievements particularly in her upper classes.

> "Somehow I had a certain affinity from the beginning [...] I had already rather the inclination to natural sciences than to languages. Whereby I also have to say that now, for example, mathematically, so rather from middle school has really cracked. So elementary school was okay, at some point the functions came in, I found them quite [laughs] for a while [...] were not my friends and then at some point it clicked and from then on it also went very well in math or so." – *Student 4*

> "So I was in elementary school very good in math, in between okay, never really bad, and then at some point just so 11th grade has done it then again such a jerk and then I was very very good. [...] Which means very very good, but [...] very good. Then, that continued until graduation." – *Student 4*

Especially in the upper school, she took a course for the area of computer science, in which her ability also showed, also strengthened by her interests. However, the affinity for physics was not enough, so she was less clear in this subject.

> "I remember that I was relatively good in the orchid subject and that I quite enjoyed it [computer science] except for being a bit [...] so being the only girl has also [laughs] [...] has also had something." – *Student 4*

> "Because also, mostly physics 4-hour class has led to not wanting to study this. Before, yes, there came at some point the point, so physics was already strongly represented, but that has somehow the 4-hour class then nevertheless no longer fit, that I then became too formula and math was also in the discussion [...]." – *Student 4*

In addition, she emphasized the necessary logical affinity for a computer science degree.

> “[...] this certain logical affinity just has to be there and if it’s not there, then it doesn’t work.” *– Student 4*

Unlike all the other female students interviewed, student 5’s STEM abilities crystallize later in her school career, due to the influences of the other factors such as her interest development. The discussion about the relations between these central factors are discussed in Chapter 7. While she was aware of her technical interests, perceived STEM talents were not initially reflected in her grades. At this point in particular, difficulty with the school system also played a role for her.

> “[...] actually, I’ve always been interested in technical stuff like that, and I was actually always [...] in math, [...] most of the time I didn’t really enjoy it that much, but I think it was more because of the teachers [chuckle] than the material. [...] but I just thought school was stupid. I think it was more because of bad experiences with the system or something.” *– Student 5*

> “So I was in elementary school I was very bad at math.” *– Student 5*

Later, her mathematics grades were towards A-levels that her ability showed through good grades, for which as she puts it she has ”an affinity more towards math”, even completing a physics A-level.

> “Yeah, actually I always found math boring [...] But I was still actually always rather in the above-average range. [...] I always understood it, I think that was a little bit my advantage, I always explained it somehow to half the class. So [laughs] I was definitely not bad at math now” *– Student 5*

> “I did physics A-level” *– Student 5*

> “But then I actually found the classical computer science more interesting, because I always also [...] so that goes yes [...] partly [..] yes, I [...] because I have on maybe an affinity more towards math, and [...] I don’t know either.” *– Student 5*

In summary, each student interviewed has math skills or additional STEM skills. Due to this circumstance, the STEM skills factor developed.

7 Discussion

The underrepresentation of women in STEM majors, especially computer science, is a great discussed problem both in the scientific framework and in society. Negative reasons that lead women not to choose such curricula are addressed in various scientific works. Based on the researched causes, countermeasures are taken, which only trigger a very slow increase in the percentage of women. Instead of explaining the phenomenon of the lack of women on negative grounds, the research of this thesis aims at explaining the phenomenon from the opposite perspective.

To explore this research gab, the thesis is based on the inductive research method Grounded Theory, which aims to answer the central research question "What are the factors that enhance female participation in German Computer Science Curricula?".

For the selection of a suitable Grounded Theory methodology the methods of Glaser, Strauss & Corbin and Kathy Charmaz were discussed. Decisive for the decision was, besides the treatment of an initial research question and the use of a previous use of literature, the philosophical research paradigm of the Constructivist Grounded Theory by Charmaz. This reconstructs the real world through the idea of construction via the collective of all individual realities. Included in this are not only the participants of the study but also the researcher, the author of this paper, as a co-constructor. Due to the diversity of motivations and histories of the female computer science students, the entire research is based on Kathy Charmaz's Grounded Theory.

Two potential data collection methods were used for data genesis. One is a literature review, which is however limited due to the narrow range of available and valuable material focusing mainly on negative factors. Next, the thesis focuses in particular on the data genesis of a total of 5 interviews of female computer science and software engineering students at the University of Stuttgart, among whom were also former students who are currently employed as staff members at the same university. In accordance with the grounded theory strategy, data analysis and theory building started at the same time as the interviews. A detailed description of the design of the study is given in chapter 5. After evaluating all results, it was finally possible to create a taxonomy model, the research results were presented in Chapter 6.

The focus of this chapter is now to explain the individual concepts of the taxonomy model in more detail, their interconnections and coherence to each other. This includes answering how the factors are related or how the theoretical model should answer the initial research question and what the model can answer beyond that. Other points raised are aspects from which new research questions can be derived and what limitations the model reveals both visibly and invisibly. In addition, any problems encountered during the research are reported and how they affect the model directly and indirectly. In particular, potential uses are important to enhance female participation in computer science curricula in the future. Also, possible adaption of the model to other STEM fields is a point that falls in connection with the taxonomy and is discussed. At the end of the discussion chapter, the research will be evaluated under the four evaluation criteria suggested from Charmaz's Constructivist GT.

7.1 Taxonomy

The data basis of the taxonomy model is grounded on the 5 interviews, which represent 5 different stories and personalities. In order to generalize the individual narratives into a taxonomy, coding analysis had to be used to summarize the essential and most common codes, conceptualized through categories, core categories and concepts. From this on, the 5 characteristic factors emerged to answer the research question of why women study computer science or what are the factors that enhance female participation in German computer science curricula. In particular, 3 factors from the whole taxonomy represent the focus of the model, describing the personality development of female students. These three factors can be compactly clarified as the achievement of the individual, sufficient degree to agree personally with the following statements:

1. I want that
2. I can do that
3. I do that

Here, the will or urge refers not only to the study itself, but to the interest in computer science and the confirmation of wanting to do it later as a profession. Interest also refers to the inclination or preference for an object of interest, which can be both material, for example, a toy, and immaterial, such as a complex of topics. Over the course of life, the interests of personalities evolve. Thus, the toys and hobbies from very young years change in comparison with those in adulthood. For example, object of interests develop in their intensity of execution, in their form or in their simple interest. Under this concept, development of interest was identified as a factor to that extent, since all interviewed female students underwent such a process according to their personality development.

Above all, it is important to note the need of abstraction of computer science according to age. For example, female students understand the term computer science to mean more than just pure programming compared to high school students. High school students associate computer science with far more than just working with computers than elementary school students would. So the younger the age, the less the term computer science is understood to mean exactly. It is the same with toys, hobbies and certain interests, such as inclinations towards a certain field. Later, the identification, specification and differentiation proceeds means highlighting the own computer science interest occurs during the school time.

Such development can be divided into different phases, the boundaries of which are not sharp but blurred. The initial phase is either shaped by innate preferences or triggered as an initiated interest. The former turns out to be the case when young children are provided with a large selection of toys from which they independently choose one to occupy themselves, as in the obvious case of Student 1. Out of the many toys available to her, she engaged with Lego blocks most of the time. The intensity of her occupation distinguished her love for building to such an extent that she continued to specify her preference in later life. From the work with Lego bricks, to attending a technical school, further to specify her career aspiration in civil engineer or architect and finally wanting to build software. Her good mathematical skills and inclinations also stood out to her during her school years. The constant interest pervades an interest specification and differentiation with itself, which led her finally to a software engineering study. The various stages and decisions of her school career were shaped by her interest in the STEM field, which continued to deepen toward computer science.

Student 4 also started early with a first given technical toy, a parking garage. A concrete pendant to her love of toys was not found directly in her adolescence, as student 1 pursued with the inclination to build. At first, the leisure activities ran in different directions, she tried different activities, but of all of them she intensively pursued reading as a hobby. Then, during her school years, she realized for the first time her very good mathematical skills. Compared to Student 1, both of them had a special liking for mathematics and were characterized by good grades. Student 4 has a wavy mathematical career which was characterized by two peaks in elementary and high school and a valley in middle school. Despite this, she never lost completely her interest in mathematics. Her interest in computer science was initiated through the programming club, which she attended voluntarily. The connection measured with positive factors such as fun, made her follow her interest on her own and sign up for a voluntary computer science course at school. This additional subject sustained and help her to highlight her interest in computer science, also because of independent perception of success concretized as good grades. According to her, taking the course has been the reason to decide to study software engineering.

Comparing both female students, an initial innate interest and a situational initiated interest in the STEM field can be identified. Due to the independent continuation of the inclination, an initial interest develops into an intensification, which leads to a sufficient individual interest level. This was important for both of them to build up the will to study computer science and software engineering.

A similar developmental trajectory as the student before, was shown by participant 3. In her preschool years, she engaged in various hobbies and pursued different interests, in particular collecting booklets with information material. Based on this initial interest in data and meta-level, a common thread can be identified. Like student 4, she especially loved reading and discovered her aptitude for STEM, especially math in school. In this, she continuously performed well, but tried not to limit herself too much to it and continued to pursue various preferences, such as to music. Later in her schooling, she had her first real contact with a computer science as a subject course, which aroused her interest, especially in algorithms, such as sorting algorithms, or goal-directed problem solving. Her initial interests in high meta-aspects is reflected in her favor to algorithm. Due to the coincidence of her natural preferences and the topics covered in the computer science course, a connection was made. On the one hand through the positive factor of fun, but on the other hand also through the understanding of a meaning behind computer science, how she can use the discipline to understand and solve problems according to her interests. Using the process of exclusion, the differentiation of her interests, for her the inclination towards computer science exceeded that towards other STEM subjects, so she was able to identify her individual level of interest.

The comparison of student 3 and the developmental processes from the previous students shows that both a natural and an initiated interest are part of the initial phase. However, unlike student 1 and 4, the phase of a maintenance of interest for student 3 is not essential because her strength of the inclination initiated in the computer science subject was significantly greater than to other interests. This means for the development of interest that an initial or initiated phase is essential, but the sustain phase dependent on the development of interest from the first phase. Thus, the degree of inclination reached is decisive, but is individual high. Hence, some students need significantly more points of connection than others.

In contrast to the three developments discussed so far, there are two further processes in which the relationships and influences of the other two central factors, the self-efficacy process and the autonomy process, of the taxonomy model are particularly apparent.

The course of interest development for students 2 and 5 was less straightforward than for the other interviewed participants. The difficulty lay in the external influence on the process, especially self-doubt in one's own ability and other individual factors. Due to a difficult childhood of student 2, it was hardly possible to pursue the interests, lack of toys, little support of her close environment and mediated values slowed down their development. According to the inclination to music, therefore, she attended a special music school with the aim of studying in the conservatory. She discovered her interest in STEM, more precisely in mathematics, during her school years, and was also told about attending a compulsory computer science course at the music school. Especially the first contact with her computer, with which she played online computer games intensively in her free time, aroused her interest in being able to create something as well. However, all her preferences developed into unguided paths, so that although she performed very well in many subjects, she could not classify any particular preferences for herself at that time. An initial interest was aroused for computer science, but nevertheless the initiation was not as strong as for the female students 1, 3 and 4. Because of this assessment issue, she was unable to assess what her exact interests were and how her interests would develop, especially because she had previously focused on studying at the conservatory. The only classification, was her inclination towards mathematics. Based on this conclusion, before studying computer science at the University of Stuttgart, she first studied another engineering course at the faculty of mathematics, the choice of which she seemed to regret. Only after its completion did she finally decide to continue her studies in the field of computer science. As short as the process description was, the actual process dragged on. Her development of interest was accompanied by strong self-doubt, such as whether her skills were not good enough for a computer science degree. The low assessment of her abilities, and thus the low self-efficacy, caused, among other things, a delay in taking up her studies. The process was also influenced by her self-determination, autonomy, as she wanted to break out of her difficult childhood. But could not determine her exact interests herself, which first, caused her to decide on a different curricula. As a result, her decision to study computer science also stalled.

Compared to the other interest trends, the mathematical affinities and natural or initiated interest in computer science of all four female students overlap. Student 2's difference is that her interest in computer science developed late due to individual factors, but she was still able to specify and differentiate them. Mapped to the development of interest, this means that in an initial phase the first interest towards STEM is recognized or initiated, especially the mathematical affinity. Later, the more differentiated computer science is introduced, in which an initialization also takes place. Depending on the strength of interest, this phase is sufficient or must be further maintained or strengthened. Consciously by the female students the interest to computer science must be specified and differentiated however even opposite other specialized sectors. By the recognizing interest differentiation of the subject area from other fields, computer science emerges clearly in the consciousness of the students, so that the will or the urge to study can occur.

The opposite of student 2 was the interest development of student 5, who was attracted by an extraordinary number of interests from which she was initially unable to highlight. Her initial interest was already limited to working and playing with horses since her early childhood. Toys and hobbies were mostly related to said animals, from which her first desire crystallized to become a veterinarian. During her school years she spent her free time with various passions, which she would not have wanted to continue in the form of a course of study or profession. Mathematics was one of her affinities, but her consciousness was strongly marked by self-doubt and low confidence. The lack of confidence in her own abilities has led her to chase after her friends only to discover that the interests of her friends do not coincide with hers. Driven by this, her first turning point occurred, when she first detached herself from the interests of her environment, becoming independent and turning to the technical. Furthermore, she recognized her passions, which strengthened her confidence in herself. With regard to computer science, she participate a computer science course and, due to the turning point, gained the knowledge to intensify this awakened interest independently in her free time. However, the low self-efficacy still hindered her from deciding on a specific curricula even shortly before graduating from high school, since she saw herself surrounded by far too many interests. Thus, clear identification, specificity and differentiation occurred very late. For this process, she used the train of thought of what really interested her the most, herself and not others. Which study course and the career options would fulfill her the most are one of the questions she asked herself. With the help of this highlighting, specifying, and identifying, she ended up realizing what interest she was most wanted to pursue, which led her to computer science curricula.

Compared to student 5, the development of interest in the last steps can be clearly seen in her thought process, but also in her breaking out of self-doubt, achieving independence, and how in the end she manages to emphasize the computer science interest over other interests. Although, the lives of the students are completely different, an overlap in the complexity of interest identification and differentiation can be visibly seen. Compared to the previous developmental processes regarding interest, the last two participants set their focus primarily in the identification, specification, and differentiation of interest. Which means that they discovered their interest very late. Whereas the interest of the first three female students was mainly aroused in the initialization and remained so.

Mapped onto the development of interest, this is characterized by the initial phase, in which a natural interest must be innate and discovered, or a situational interest presents itself through initiation. Depending on how strongly the inclination has been shaped, it requires further connecting points that must maintain or further promote this interest until an independent drive occurs. The third phase deals with the conscious identification, specification and differentiation of the interest in computer science. Finally, an individual level of interest must occur for the will to study computer science. In this framework, identification refers to the recognition of interest, specification describes the more specific field of study, for example, from STEM to computer science, and differentiation exhibits the highlighting of computer science over other fields. An overview of all phases is shown Figure 7.1.

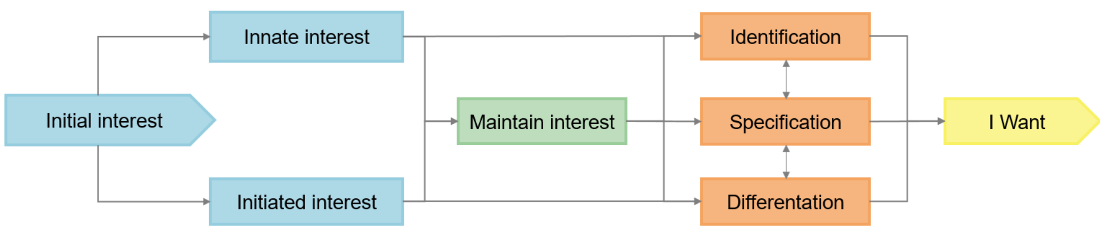

Figure 7.1: Development of interests derived from the interviews

Due to the different life histories of the female students, the development of interests is highly individualized and is also influenced by individual factors, both positive and negative. Thus, life circumstances in childhood, especially contacts at school or even one's own character can accelerate or slowdown the process. Towards all interviewed female students it must be mentioned that interest does not resemble the intensity of an obsession. The inclination that plays a role in the taxonomy model refers only to the course of study, not the one pursued during free time. All female students also pursued other preferences, which they very much enjoyed doing during their free time. The main difference is that their affinity and interest in computer science is significantly higher compared to their classmates. In the case of student 4, she clearly separates study and leisure.

> "[...] of course I am interested in computer science. More than most other people I know in my circle of friends. But not extremely. I also program extremely rarely in my free time, for example, that is [...] with me there is already a pretty clear separation between studies [...] and free time. That blurs relatively little." – *Student 4*

Whereas student 2 prefers to spend her free time with her computer, even describing herself as addicted to computer games.

> "I actually spend all my time with my computer. [...] Very much, so excessively much. Fully addicted." – *Student 2*

The identified interest development derived from the interviews of the 5 female students only maps the developments from birth to study enrollment. However, this does not mean that the development of interests has ended by this time. Even beyond this time, inclinations and preferences may change, adjust, subside, or emerge anew. For this reason, it can happen that interests no longer fit the course or program of study because the interests changed. On the other hand, it can also happen that the study or course of study no longer fits one's interests, for example, if one's ideas and inclinations do not match the subjects taught. Such a case even occurred for student 3, who had doubts during her studies, whether she should change the curricula, because the study did not quite suit her. Nevertheless, she kept the study program.

> "Nevertheless, I must say, I doubted again and again whether I should switch [the course study], simply, it wasn't as much fun in between. As I said, it's not a hundred percent mine, it's more this, I'm more interested in a meta-thingy like that, understanding and solving stuff and algorithms and understanding complex relationships. And, and stuff like that and collecting data is kind of part of, but as I said, that I could have had in other disciplines. That's why there was always enough stuff that somehow bothered me, where I thought, I should have done something else." – *Student 3*

This gives rise to the research possibility of observing the development of interests more closely over the period of study. The problem that a course of study no longer matches one's expectations or interests can be reflected in the high dropout rates of female students in computer science courses. Even if women decide to study computer science, it does not guarantee that all women will also follow through the entire study course and graduate [13]. From this problem, the issue continues into industry where it exacerbates the gender imbalance. Regarding this perspective, it is a necessary knowledge to explore why women stay and continue in computer science studies. This point will be addressed in more detail in Section 7.3.

The concept of interest development in terms of the taxonomy model as a positive factor is new, but in the context of pedagogy already known as an object of research [Ben18]. In this pedagogy context, interest is referred to as a wanting-to-know-more, being characterized by emotional or emotional valence and value-related or value-related valence). Thus, personal importance and connection through positive feelings. In general, the development of interest of students in the classroom is decomposed into four phases.

The first phase arouses, releases, or evokes situational interest. Typically, this is referred to as the "catch" component, which triggers an initial interest. Compared to the interest development of the taxonomy model, both phases are similar and are intended to trigger an inclination toward the object of interest. However, the concept of the taxonomy model differentiates the phase in that an interest can also already be innate. Thus, the slightest contact can indicate a visible preference. Within the second phase, according to the four-phase model, situational interest is constant or maintained and is characteristically referred to as the "hold" component. This phase also corresponds to the second phase of the developmental model of taxonomy. However, the difference is that the phase can also be skipped, since the initially generated interest is so strong that hardly any points of contact are needed.

Phase three and four of the pedagogical model deals with the emergence of individual interest in the classroom, especially in STEM, which is entirely detached compared to the process of the identified taxonomy model. In the four-phase-model, the emergence of positive feelings and the independent, permanent curiosity is referred to, which in the concept of taxonomy already takes place in the initial phase. It should be noted that the goals of both models differ. The pedagogical approach aims at stimulating the interest of students in the classroom, regardless of whether the students have an affinity for the topic, for example. In contrast, the goal of interest development of the taxonomy model aims at tracing and representing the inclination processes from birth to study. This factors in grounded in the qualitative data of the interviewed female students. With the help of the identified model, the general public is to be inferred from the few female students interviewed on a conceptual level. Because of this difference, only the first two phases look very similar, since many more individual factors play a role, so that the pedagogical concept is seen only as a rough adaptation to the factor of the taxonomy with the same ulterior motive of the development of interest.

However, it is interesting to note that this process is equally influenced by the central factors of self-efficacy and autonomy. In pedagogy this is described within the self-determination theory and says among other things that an interest is developed if the own competence is perceived and the freedom of decisions is satisfied [Ben18]. Similarly, the three central factors of the taxonomy model.

The second central factor in personality development describes the self-efficacy process. Self-efficacy refers to the inner conviction, self-confidence and belief in one's own abilities, skills, competencies and possibilities for action that enable one to master a difficult and complex challenge. Based on the research results, self-efficacy is not only a state, but a developmental process that is accelerated or slowed down by various individual factors. Thus, however, there are differences between inward self-efficacy and outward self-efficacy. The former describes self-efficacy, inner conviction. An outwardly visible self-confidence does not automatically have to do with self-efficacy, since the student wants to convince others through this behavior, and not herself.

Such a self-efficacy process can be seen in the curriculum vitae of all female students interviewed, which can be subdivided according to the respective starting point. Thus, there are two possibilities. The first starting point begins with negative self-efficacy, known as self-doubt. When and how exactly this low self-assessment comes about is individual and cannot be precisely identified and specified. In concrete terms, the low confidence in one's own abilities became apparent during the school years. This was not due to poor grades or bad experiences, but to the hesitant pursuit, even identification, specification and differentiation of actual interests. Here, we can see a direct link between interest development and the self-efficacy process.

These have an effect in two directions. The first direction describes the influence of self-efficacy on the development of interests, i.e., a high awareness of the own ability strongly drives the development of interests, whereas a low self-assessment leads to being unclear about the own interests for a longer time. Conversely, there is the influence of interest development on the self-efficacy process. A strong interest can lead to a stronger engagement with the topic, which drives the process of one's own self-evaluation, first regardless of whether it is positive or negative. In contrast, the low preference to an object of interest triggers a neglect of the occupation, with which also the inner conviction sinks. Such a conclusion will be discussed below on the basis of the female students.

Overall, two of the five participants struggled with difficulties in the self-efficacy process, evidenced by self-doubt, low confidence in themselves, and weak self-assessment. The form of hindrance to the process ensured that the awareness of computer science interest linked to one's own abilities were so doubted, causing the self-efficacy process to be greatly protracted. Student 2, who was struggling with self-doubt, initially chose an engineering curricula because, as she says, she was too young to know, so she didn't yet know herself what she wanted and what she was capable of. Through the experience of her first degree course her interest in computer science consciously stood out for her. Student 5 first broke out of the circle of self-doubt during high school, the level of which stabilized concurrently with the level of interest development at the end of high school and reached a relevant level sufficient to choose a degree in computer science.

Thus, the childhood from student 2 was characterized by simple circumstances without or with negative support from her environment. In contrast, student 5 experienced a childhood full of freedom in her choices, through much trial and error and pursuing the interests of the time.

While student 2's schooling was primarily accompanied by the pursuit of her music interests at the beginning, student 5 focused on her interest in animals. Both recognized their good performance in mathematics, but did not identify, specify, or differentiate it from other skills. Then, toward the end of their school careers, both encountered computer science for the first time. Initial interest was aroused, but interest did not yet develop into a sufficiently strong argument against meaningful identification, specification, and differentiation. This resulted in statements such as "I was good at everything, but also without any particular preferences" by student 2 or "I actually find way too much interesting" by student 5. Two opposite poles can be seen here. The one side that shows no particular interest and the other side that has too many interests to be able to decide.

The self-doubt that plagued both students was shown by statements such as "I really thought for a long time whether I should do this or not, whether I was too stupid or not" by student 2 and "then I didn't know what to study for a relatively long time [...] that I didn't trust myself to do the technical stuff". Because of this weak inner conviction, the decision process towards studying computer science prolonged.

Self-Efficacy Process → Interest Development

The relationship between interest development and self-efficacy process can be discussed from the following point of view. Both are aware of their ability, yet assess themselves as too poor, making it difficult to differentiate their interests. Self-doubt causes a slowdown in the development of interests due to the influence on identification, specification and differentiation. Because of this delay, the duration of the decision process is prolonged. That is, the long decision process was dependent on both the delayed interest development and the delayed self-efficacy process due to self-doubt. A causal relationship of self-efficacy on interest development emerges, which is illustrated in Figure 7.2.

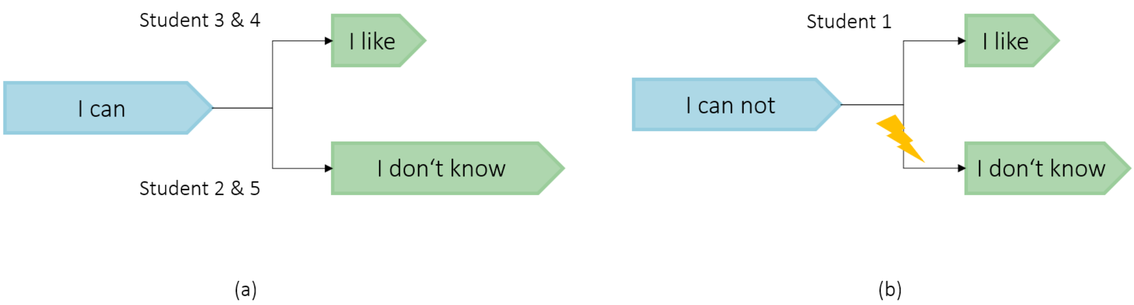

Figure 7.2: Influence of self-efficacy on the development of interests

Pictured are two possibilities with four cases. Either, female students are aware of their ability agreeing the statement ”I can”, which supports or encourages their knowledge of their interest by agreeing the statement ”I like”. This case occurs with student 3 and 4. Or, the students are aware of their ability, but their level of self-efficacy is not mature enough, which means they cannot cannot sufficiently define and emphasize their interests. This case occurs with student 2 and 5. In short, this means that they initially lack sufficient internal self-confidence to apply the courage of assessment to their interests. That is, on the part of female students, both their interests and their own abilities and competencies must be identified, specified, and differentiated.

Then, there is the case of female students who, based on their experience find out that they cannot do computer science such as programming, but raise the will, to be able to do it. This also promotes their interest, through the perception that they will finally be able to program, such as student 1.

> “At some point I [started] programming a little bit at school. I was pretty bad at it. But [...] algorithms and for was [...] okay, but that's also, you had this impulse, okay something is bad, but that's in the deepest you know maybe if you learn a little bit more, then you could. I liked that as well.” – *Student 1*

The fourth case, in which the realization of not being able to do computer science or computer science relevant subjects has an impact on interest development could not be identified. This case may occur for female students who have not decided to study computer science.

Interest Development → Self-Efficacy Process

On the other hand, a causal influence of interest development on self-evaluation can also be identified. Such a case visibly occurred for student 1. Since her interest was already in the technical field at a young age, she attended a technical school where a first computer science course was held. However, there it turned out that she did not have very good programming skills, was even very bad at it.

> "At some point I [started] programming a little bit at school. I was pretty bad at it. [...] but that's also, you had this impulse, okay something is bad, but that's in the deepest you know maybe if you learn a little bit more, then you could. I liked that too" – *Student 1*

However, her level of interest in it was strong enough so, that she was able to transform the impulse into the form of self-efficacy, in which she used as an action solution, further learning. Thus, the causal relationship of interest on self-evaluation can positively influence the decision-making process as an accelerating factor. Such direction of influence is depicted in Figure 7.3.

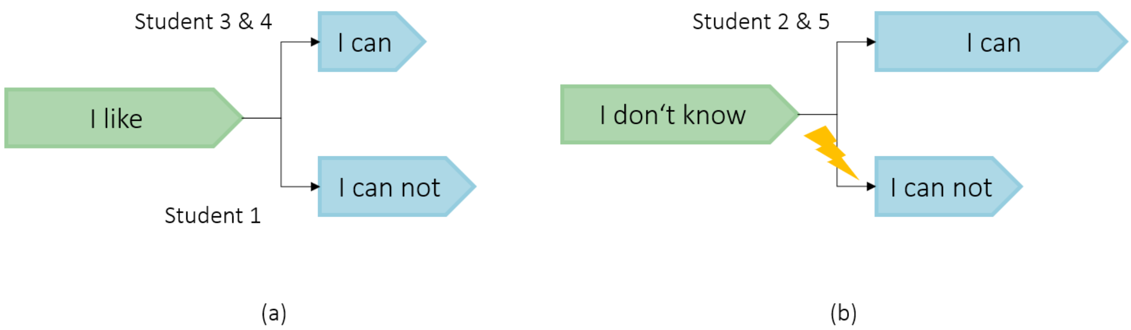

Figure 7.3: Influence of development of interests on self-efficacy

Like student 1, student 3 and 4 also underwent the process of inner persuasion. Whose starting point was not self-doubt, but a neutral view of their own abilities and competencies. Both were good at mathematics and were also aware of it. The initial arousal of interest of computer science courses at school and the simple understanding of knowledge transfer led to the fact that interest development and self-efficacy process supported each other at the same time. For this reason, the decision to study computer science or software engineering was very easy and the underlying process took less time than for female students 2 and 5. Thus, the concurrent support is described at the same level in both Figure 7.2 and Figure 7.3.

Here, the only case that was not mapped is when the inner conviction about the ability and the knowledge about one's own interest are simultaneously absent or weak. As an inference, this means that at least one of the two factors must have reached a sufficiently relevant level to support and promote the other factor.

However, it must also be noted that the coherence and self-efficacy factor takes into account the time between birth and the beginning of the study. Anything beyond that is no longer included in the described representation. Furthermore, all other external influences from the self-efficacy process that are not ready in the taxonomy model fall under the rubric of individual factors that cannot be conceptualized.

The third and crucial factor for a college application or admission is described by the autonomy process. By autonomy is meant the independence of the person towards his self-determination, self-management and freedom of his actions and decisions. In this process, autonomy is learned through growing up and follows a process. As a part of personality development, autonomy can be described as a natural and necessary good. The interviews showed that the desire for autonomy can be consciously triggered by means of trigger factors or accelerated respectively slowed down with the help of influence potentials. Where the desire for autonomy is taken for granted, others need a trigger, for example a childhood situation. To this end, interviews can be divided by autonomy starting point. Those who take it for granted as a natural and self-evident good, and those who want to choose a conscious path of independence through formative situations. Such a subdivision is presented in chapter 6, as well as all independence processes.

In the context of the taxonomy model, the process describes not only the independence of the personality, but also the courage to want to swim independently against the tide. In order to crystallize essential overlaps and finally the influences and relationships to the interest development and self-efficacy process, the important situations and turning points regarding the autonomy processes of the female students will be briefly discussed. For example, the female students recounted growing up in which situations arose from which such autonomy developed.

Student 1 showed a strong inclination towards technology early on, which led her to attend a technical school, although none of her previously known friends accompanied her.

> "My girlfriends were always like that then, they wanted to be teachers, or something in the social field." – *Student 1*

This situational detachment moment describes her first self-determined activity toward computer science.

Student 2 also made several independent decisions that initially led her into another major that she did not like. Only afterwards she dared to take the step of studying computer science.

> "I chose something stupid, there I was not satisfied, but no idea, I was 16 where I started, I was 16 after all. I had no idea at all. And then I finished that and with no particular preference to that area. Right. And then I thought, I want to try that. Right, so with math and computer science." – *Student 2*

Despite the initial difficulty, she described taking up the second degree as an attempt.

Student 3 took freedom in her actions for granted and did not question it. As a result, she always did what she wanted and liked.

> "My mom and my grandma have always shaped me quite a bit, insofar as that, they never put up with anything[...] I have my own head and want to enforce what I like anyway." – *Student 3*

Because of this imprint of her mother, she already had a very high level of independence when she was in school, which she also used such as choosing a computer science subject.

For student 4, the self-determined path was important to pursue her own interests and not have to worry about having a friend accompany her.

> "Because it was [...] the right thing for me to do without looking at whether some girlfriend or something was studying something else. I already [...] so at least from my schoolmates this [...] this group effect was significantly higher." – *Student 4*

The detachment process from female friends is a key turning point in the autonomy process for student 5.

> "At least to choose physics, and at least to do graduation there, because it was the only point where I then really started to do what I was most interested in and not to do what everybody else was doing. My girlfriends and stuff. And then I'm there sort of, the first time I dared to go in a different direction than yes girlfriends." – *Student 5*

The first time to do what interests oneself and not the others also strengthened them in their confidence in themselves and their development of interests.

The development to freedom of choice, as well as learning through mistakes, is an essential element of the taxonomy model. This is because, even if interest and a positive self-assessment are sufficiently present, female students must actually decide to study. How the factor may correlate with the other two key items will be discussed below.

Autonomy Process → Interest Development

Part of the development of interest is to pursue one's own inclinations and preferences. If this does not take place, it can be difficult to find the path to computer science. Therefore, it is necessary to be able to decide for oneself which interest gives the most pleasure according to one's own judgment. Autonomy supports and encourages thinking and development in terms of trial and error, maintenance, and identification, specification, and differentiation. This case is present in all the female students interviewed. They all independently decided to study computer science or software engineering according to their interests. Student 1 went to a technical school according to her interests and student 2 decided to study engineering in a mathematics department after music school because she was particularly interested in mathematics. Student 3 tried engineering because she did well with computer science in school and had a lot of fun, as did student 4. Student 5, on the other hand, first encountered her interests by detaching from her friends while in school. All of the female students, in one way or another, achieved their interest development with the help of independence.

Autonomy Process → Self-Efficacy Process

The inner conviction in one's own ability and its differentiation is influenced by the self-determined recognition of one's own strengths and weaknesses. The higher the level of autonomy and freedom over one's own actions, the more likely it is that experiences can be gathered and evaluated. Based on these experiences, interests can be developed or rejected. The same happens with the discovery of one's own abilities. A strong example is given by the experience of student 5, who followed her classmates due to insecurities about her ability and thus, had to learn that the topics did not appeal to her. As a result, she had to stand up for her interests on her own and hence, achieves her confidence in herself.

Interest Development → Autonomy Process

When an interest is aroused to the point of wanting more knowledge, the female student must independently pursue the interest. Through the urge of interest development, it automatically promotes self-directed learning as part of the autonomy process. Such a case occurred, for example, with student 5, who only very briefly touched on computer science as a course during her school years. From this initial interest, she taught herself programming at home, furthering her knowledge and the intention of independent further education. Similar has been the situation for student 4, who enjoyed the programming club she attended with a friend so much and sparked her interest that she decides to take an additional computer science course, even though said friend no longer wanted to accompany her.

Self-Efficacy Process → Autonomy Process

Finally, the self-efficacy process influences the autonomy process, in which inner confidence in one's abilities entices one to press forward and make independent decisions. Again, some examples can be given here. For example, student 1 attended her first computer science class and found that her programming skills were quite poor. However, knowing she could do it if she just learned enough prompted her to practice and learn from herself, from her mistakes. The direct link between self-efficacy and autonomy was demonstrated by student 3, who acted on the mentality, ”I can do it, so I do it”.

The autonomy process can further be influenced by individual factors. Delegation of responsibility and confidence can promote autonomy, which happened to student 3.

> “[...] my father had family computers at that time and he trusted me quite a lot [...] if there were any problems with the Internet or otherwise, I was always the one who was allowed to call the hotline slash had to.” – *Student 4*

The importance of all three factors is mentioned in the pedagogical four-phase-model of interest development. This theory is also called self-determination theory and describes the development of an individual interest if, among other things, the need for perception of one's own competence, i.e., the feeling of having successfully mastered something and the perception of having voluntarily chosen something, is satisfied [Ben18]. The need for efficacy or the perception of competence corresponds to the result of self-efficacy, that is, the application of the inner conviction and then to recognize this conviction. Whereas the autonomy experience, describes just that self-determination or autonomy, which is implemented with the autonomy process, the conscious independent action. These elements are called innate psychological needs. Compared to the taxonomy model, at least two differences exist. Besides the subject of application, namely pedagogical teaching, and the phase differences of interest development, an individual interest occurs only with satisfaction of the other factors. The influence of self-determination and self-efficacy can only take place on the interest process, but not vice versa. Therefore, both concept of development of interests are not the same and the self-determination theory can only be adapted as an idea.

The connection between the three central factors are held together by personality development. All three are factors grounded in the data of the 5 female students' decision to pursue a computer science or software engineering degree. Because of this coherence, the three factors form the center of the taxonomy model presented in Figure 7.4.

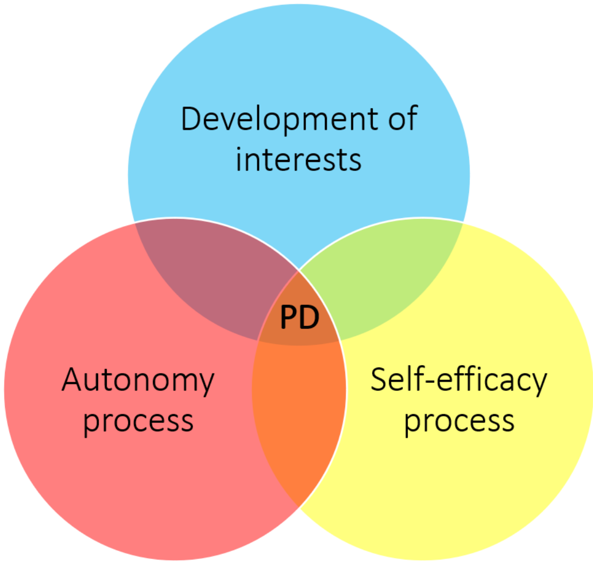

Figure 7.4: Development of the personality

All three factors strongly influence each other and must always occur in trio. A pure interest development, needs the support by the internal self-confidence of the competences. These again are reached by means of independently, which carries out the last step to a computer science study. However, around the three focal factors act two more factors that are essential to achieve interest, self-efficacy and independence. These are STEM skills and convergence to computer science, which are presented below.

STEM Skills

All interviewed female students have a clearly visible commonality, which is an affinity or ability for at least one STEM subject, specifically centered on mathematics and computer science. Ability is used to describe an innate or acquired competence, affinity, or opportunity to deliver exceptional performance. An acquiration based on a basic innate ability. The ability to do mathematics is one of the crucial aspects that promotes logical thinking, being able to grasp and solve problems analytically. Thus, all female students are united by their mathematical understanding and potential good grades during their school years. The exact research results and all extracted data on this can be found in chapter 6.1.6.

As part of the taxonomy model, it influences the three key personality developments - interest development, self-efficacy and autonomy processes. Innate skills on STEM, especially on mathematics, facilitate access to the subject matter and owners often find it easier to cope with. This is also true in the case of interest development. Looking at student 1 and 4, one can see a natural interest as early as preschool age. Playing with Lego bricks or with a parking garage condenses the assumption of a natural interest in technical things, which is excelled during their school career in the technical, STEM subjects. Math skills enhance the interest process by supporting a simple and easy understanding. The ease of access connects more quickly with a positive emotion, such as enjoyment, recognition of competencies, and the will to continue. Because of their mathematical ability, they connect less difficulty in relation to computer science. The same image continues for the other female students 2, 3 and 5. None of the interviewed female candidates had insurmountable difficulties with mathematics or computer science. Student 3 and 5 even performed well enough in math to be able to explain it to all of their classmates. Thus, the presence of a STEM skill supports the development of interest, the self-efficacy and autonomy process, and therefore, facilitates access to computer science.

Convergence

Convergence refers to the set of connection points, an approach between the students and computer science in the time between birth and college enrollment. Here, convergence does not describe individual points of contact, but rather the total time and total quantity of these contacts that converge steadily over time. Exactly defined, how these contacts look like and when or where they occur is individual, because the effects on interest differ. However, these are necessary to drive interest developments, expand aspirations for independence over interest, and strengthen proficiency in computer science, including mathematics. The detailed research results can be found in chapter 6. According to this, all the interviewed female students have one thing in common, which is their first contacts through school. First to mathematics and finally sooner or later with computer science. Here, the concept of computer science has to be expanded, since a definition of computer science only emerges in the later school career. Thus, the first computer, the first programming attempts, first hobbies and toys before middle school are also included as points of contact.

The idea that the higher the contact rate, the stronger the connection to computer science was not reinforced for all female students. For student 3, six months of computer science classes at school were enough to strengthen her innate interest in data management and problem solving. In total, enough to highlight her interest to computer science over other fields of study. Also, student 5 had little computer science instruction according to her, but it sparked her interest enough to continue it at home, which finally led to differentiation.

> "[...] I do think that it is also a lot due to the lessons, maybe it is also because I had relatively few computer science lessons [...]." *– Student 5*

However, the convergence factor has been an essential aspect for student 4's decision. Attending the programming club sparked her interest in computer science, which then led to her decision to take an additional computer science course in high school. This, in turn, was the reason why she chose a software engineering major.

> "[...] the club was definitely crucial for the course and the course was definitely crucial afterwards for the choice of studies." *– Student 4*

During her development of interest, which changed from convergence point to convergence point, she perceived her ability in addition to interest, which she then pursued independently by means of study. Thus, convergence affects the three focal factors both indirectly and directly. Conversely, they also have an effect on the convergence process. Through the urge, even independently, to learn more, the students seek further points of convergence, the culmination of which defines the study of computer science.

7.1.1 Taxonomy Model

The totality of all identified factors forms the taxonomy model as shown in Figure 7.5. Central are the three factors of personality development for the development of interests, self-efficacy and autonomy process. The focus is on the female student and her personality development, which accompanies her from birth to the beginning of her studies. These factors, are crucial for the choice of study program. From the outside, the three factors are shaped by their STEM abilities or affinities and the points of convergence. Due to strengths of expression, they affect the other factors and function only in the interaction of coherence. All of the above factors are present in all female students to varying degrees prior to their studies, which influenced and facilitated their choices.

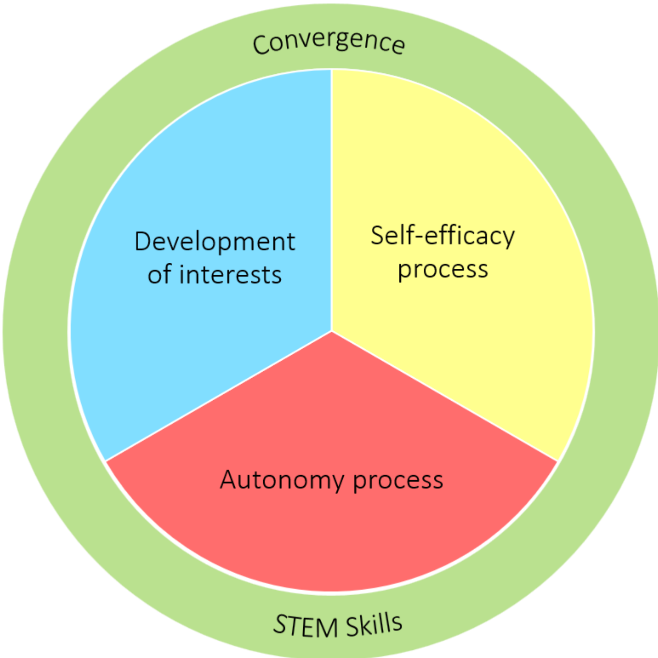

Figure 7.5: Taxonomy-Model: 5 central factors that enhance female participation in German computer science curricula

In addition, there are many other factors that impinge on the taxonomy model and push female students in either one direction or another. However, the so-called individual factors do not have a direct degree of influence on the decisions and motivations of female computer science students, thus, indirectly influence only the factors of the taxonomy model. As the name suggests, these are individual and can only be combined as such. They can influence convergence, interest development, and the self-efficacy and autonomy process, but not innate STEM abilities. Nevertheless, these innate abilities are always dependent on their bearer, emerge differently, can be hidden but never get lost. A first initial hypothesis derived from the taxonomy model can be defined as follows.

The five positive factors-interest development, self-efficacy process, autonomy process, convergence, and STEM skills-, promote the uptake of computer science studies for women in Germany.

Within a continuing deductive research method, the hypothesis must be proven or disproven in further iterations. With the help of further iterations the initial taxonomy can be refined.

Individual Factors

Individual factors refer to those items that have a potential impact on the taxonomy factors on women's readiness to pursue a computer science degree, but do not qualify as part of the taxonomy model due to situational uniqueness or low impact. Therefore, these factors are referred to as individual factors, which describes the outer shell of the model. So, these factors speed up or slowdown the decision-making processes. Consequently, the following will present those categories that made it to the shortlist during the Initial and Focused Coding of Grounded Theory, but did not prevail due to the reasons mentioned above.

One of the individual factors was the so-called sense of belonging. The sense of belonging is called according to the self-determination theory as innate psychological need of the third and last component [Ben18]. This sense of belonging is understood as the social integration, the belonging of a group with similar interests and goals. Such a feeling is mentioned concretely by two female students, whereby they refer in their statement to the current study, whereby it flies out of the framework of the taxonomy model. This temporally constrains only the time from birth to the beginning of studies.

For example, student 2 had rather fewer friends at school, as her interests differed significantly. In contrast, she finds more friends with whom she understands and can exchange ideas in her current university life.

> "In school I had rather fewer friends. So and in university, where we already had all the interests, [...] I already found a few. Right, so, rather in the university times, or now for example I also have friends [...]. So, rather like-minded people. So, because everyone loves math and computer science [...]." – *Student 2*

The University of Stuttgart serves different profile focuses. The technical-scientific courses of studies, which also include computer science and software engineering, are located in Stuttgart Vaihingen. The campus in Stadtmitte mainly houses the disciplines related to humanities or social sciences. Based on this separation, student 3 noticed the differences between the two campuses, because of which she feels a sense of belonging to computer sciences. Because this feeling only settled in during the study, it was excluded from the taxonomy model.

> "Have you ever been to the Stadtmitte campus? [...] I used to take some continuing education classes [...] a few years ago. I feel so strange there [shocked look]. The women are [...] so once there are almost only women walking around and relatively, well compared to what happens here, relatively few men, and I'm not used to that anymore. And [...] they are all dressed so differently. So much fancier and with make-up and styled up and [...] I also feel more comfortable here, among the people who [...] sit more on the natural sciences, scientific campuses. Maybe it's also that. Why I feel more belonging here." – *Student 3*

Possibilities for inclusion in the model were also shown by the process of self-confidence, which is directed outward. The conviction that is visibly radiated outward. However, as in the factor before, the problem occurred that strong developments were only visible at the end of school with the beginning of studies. Thus, the entire self-confidence was taken together as one, with a stronger focus on the inner conviction. In addition, this process effect occurred very strongly only in isolated instances, so that too little circumstantial evidence led to the factor being applicable to all female students. An example is offered by student 3, who describes herself as an introvert, but at the same time became more outwardly confident during her time in college.

> “I have to say, I had changed since I’ve been in college, I’m a new person, I’m very different than I used to be. I was much much quieter then. And since I’ve been here too [...] before university I only had female friends, now here I have mostly friends, male friends. And I’ve become [...] so here I’ve become more self-confident. Much more committed.” – *Student 3*

Another individual factor, was the category ”role model” preferably the focus is put on parents, because during all interviews it turned out that teacher did not leave a pragmatic background with any female student.

Three of five interviewed female students were found to have at least one parent who was either educated or studying in a STEM field. The parents of the other two female students had nothing to do with STEM, which meant that instead of the STEM role model category, only the parents served as role models. Despite this change, it became clear that the influence of parents is highly individual for each student, depending on the age at which parents can still exert influence. The younger the student, the higher the influence. However, when it goes towards the actual course of study, the effect is minimal. Some of the quotes that were consulted on this topic are shown below.

> “They don’t know what I’m doing or what I’ve done so far because I think by now, they say I’m an electrical engineer because it’s from the subject matter, that’s been very different from my whole family.” – *Student 1*

> “That I never want to be like that.” – *Student 2*

> “Vocationally my dad, who was just an engineer, I somehow always thought that was great without having any idea now at that time what that meant.” – *Student 3*

> “My father is sort of doing something in that direction too, but I haven’t said now that I want to do anything he’s doing.” – *Student 5*

From this point of view, the last individual factor was the aspect of support for the female students, under which the support of the parents was also included. For example, the support category should be united the responsibility handing over, the confidence of the parents and beside the emotional also the financial support. As can be seen from the name of the category, the factor supported the female students, but not specifically in the direction of studying computer science. Had the participants chosen a different course of study, the support would have been exactly the same. To this end, the support was not directly related to the taxonomy model, but indirectly contributed to building personality development. Such as to encourage different interests, the encouragement of self-efficacy, or self-determined behavior.

> “[...] my parents actually always made an effort and made it clear to us that everyone is allowed to do everything, can do everything, should do everything.” – *Student 2*

> “[...] my mom and my grandma have always shaped me quite a bit, insofar as that, they never put up with anything.” – *Student 3*

> “[...] my parents are actually, so [...] they have always supported me and actually they tend to be the ones who say you can do it.” – *Student 5*

The support from parents or other possible help either did not have any effect at all or even had a negative effect on female students. Therefore, the category did not qualify as a generalized factor such as other presented categories. However, individual factors may have still influence the taxonomy model, but as external factors.

7.2 Research Question

The phenomenon of underrepresentation is an often discussed problem that can be described from two perspectives. One perspective addresses all the factors why women choose not to study computer science, i.e., the negative factors. The other perspective describes all factors that address why women choose to study computer science, the positive factors.

The initial, central research question in the context of this thesis aims in answering the second perspective. More precisely, the research question is defined as follows.

What are the factors that enhance female participation in German computer science curricula?

To answer this question, the revealed taxonomy model is consulted, which describes the positive factors of the second view. As discussed in the subsections before, the model is composed of the five factors of interest development, self-efficacy process, autonomy process, convergence, and STEM skills. These factors are particularly interrelated and only answer the research question through their totality and interplay.

In summary, female students study computer science or software engineering because they have a sufficiently high level of self-confidence in their innate STEM abilities. They portray an exceptionally high level of interest toward computer science, which they have developed through various and individual points of contact, the Convergence factor. They put their independence and self-determination in their confidence and interest towards computer science for choosing to study computer science. These immediate factors are promoted or slowed down by means of individual factors from the outside and only indirectly influence the central 5 factors. In addition, it must be noted that no order of importance was determined between the factors. For the further, future research processes an initial hypothesis can be given, which is as follows.

H: The five positive factors-development of interest, self-efficacy process, autonomy process, convergence, and STEM skills-encourage women in Germany to take up computer science studies.

Within outstanding deductive research methods, the hypothesis serves as a thematic testing framework in which the initial theory is tested and corroborated or refuted in further iterations.

To relate to the beginning, the related work presented an Israeli study that identified some factors that motivate Israeli women to study computer science. In this research work, the factors, self-realization, self-efficacy or affinity, and economic well-being were mentioned. The subdivision of women based on their religious status, which was set up in the paper, is omitted here. Self-realization refers to personal fulfilment, that is, the realization of desires and demands. Mapped on the taxonomy model the self-realization corresponds to the factor autonomy process, which aims to reach a sufficient measure for the self-realizations thus the self-realization. Similarly, self-efficacy is found in the factor self-efficacy process, which differently describes a process to achieve inner conviction. This is important because the constant recognition of the abilities, shaped by independent experiences and perceptions, build the inner conviction. This process also includes overcoming of self-doubt. Instead of putting affinity respectively the ability as a separate factor as in the taxonomy model, the Israeli research merge the affinity to self-efficacy. However, self-efficacy and affinity describe two different facts. The former focuses on the conviction in one's own competencies, independent of abilities and interests, thus acting on a psychological level. Affinity, on the other hand, is associated with either STEM skills or interests. As an inclination, it corresponds to the factor development of interests, but affinity can also associated with actual ability, it corresponds to the factor STEM ability. A classification corresponds to the respective definition. Exclusively the factor of economic well-being, contradicts the initial taxonomy. This is because the grounding base of the model observed such a circumstance only in two cases of student 1 and 2, which triggered the desire of independence. Though, this factor was not tied to the specific computer science course, but to the general desire to lead an independent, financially self-sufficient life. On account of this, the factor of economic well-being cannot serve as an essential reason for deciding to study computer science. It is more a factor that can accelerate the process of autonomy from the outside. Other factors that were mentioned in the Israeli work but are prominent in the countries like Mauritius are a high prestige level or a strong pressure and influence from parents or family. These must also be contradicted by the taxonomy model, as the former did not play a role at all and for the second factor, parental influence was minimal to nonexistent. Parents can support their children in both positive and negative ways. It can be concluded from this that the autonomy process factor has a much higher significance than in Mauritius, for example. Therefore, female computer science students are not looking for a prestige level, but the point of their own self-realization. This difference can be seen in Maslow's hierarchy of needs in Figure 7.6 [McL07].

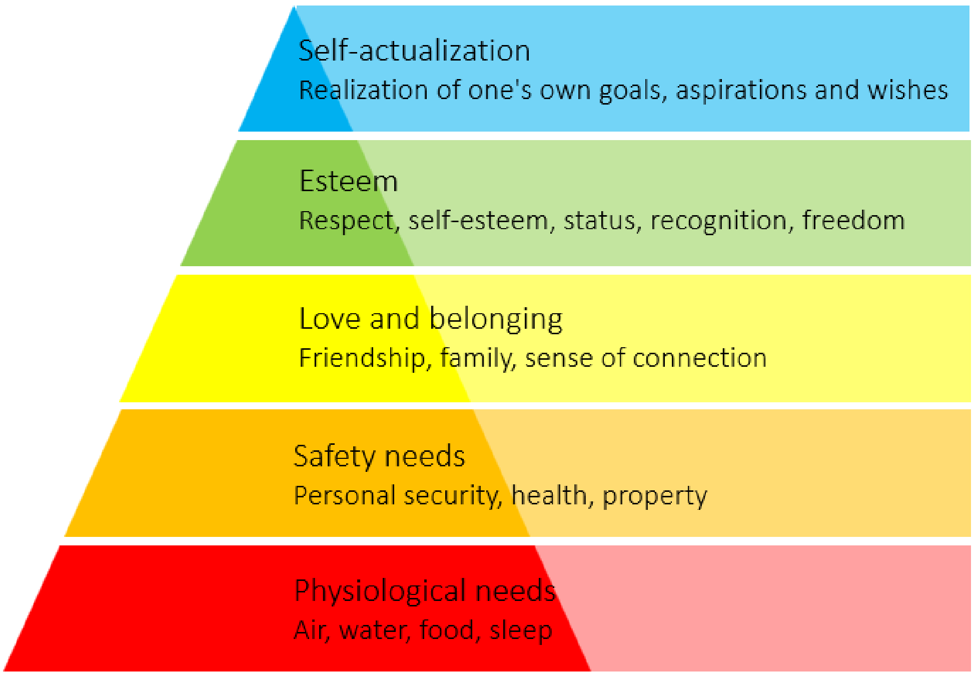

Figure 7.6: Comparison of student needs with Maslow's hierarchy of needs. Based on [McL07]

The pyramid consists of five levels, which are stacked according to the importance. Fundamental are the physiological needs, such as food, followed by the need for security, belonging, and the need for esteem. Once the lower levels are secured, the others can follow. At the top of the hierarchy of needs is self-actualization, the same factor which female computer science students especially strive for in Germany. In contrast, female students in other countries, such as Malaysia, strive for status and prestige, also economy well-being i.e. not at the top of the pyramid. Derived from this, the factors differ not only in terms of aspiration, but also in terms of their aspired needs.

In summary, this means that the initial research question can be answered using the taxonomy model, but the factors that are crucial in other countries outside Germany do not fully match those of the model.

7.3 Development of Research Questions

During the research process, thematic research interstices developed whose exploration would not be conclusively covered by answering the initial research question. From this discovery, additional valuable research questions identified that immediately expanded the primary research question. Depending on when such a research question developed, they could either be addressed through systematic extensions of data genesis and analysis or had to be released for future research. In total, this allowed for two additional research questions to be identified, one of them can be answered directly.

Extended Research Question RQ2 & RQ3

The initial research question aims to uncover the positive factors that enhance female student to participate computer science curricula in Germany, or in other words, that motivate women to pursue such studies. However, the utilization question was at hand, namely how the findings and knowledge can be used in a continuing and profitable way. The easiest way is through the use of appropriate measures and improvement approaches. Though, since these are not dealt with in the foreground, a close and relevant connection of the thematic framework of this work to potential measures was sought. Here, in an initial concept, with the help of the initial theory or taxonomy, connecting points for existing or future measures should be created. At these identified interfaces, the required parameters and conceptual variables can be offered to which improvements can dock. For such an investigation, the research question developed as follows.

RQ2: Which factors can be promoted externally?

By means of answering this second research question (RQ2), the model can both offer potential uses and simultaneously achieve a contribution to the evaluation criterion of usability. Which factors can be influenced from the outside can be answered directly. For this purpose, the individual factors will be considered and evaluated.

The Convergence factor is the artifact of the model that can most easily show an authoritative outside influence. In short, convergence describes the approach of computer science with the potential computer science female student based on points of contact. As taken from the research results in chapter 6, contact points can range from first toys, hobbies, to first computer, to school and extracurricular activities, to first attempts at programming or also other possible experiences. In particular, computer science teaching at school can be an essential touchpoint of convergence.

However, the respective generated intensity, which expresses itself as interest, also belongs to the convergence. Therefore, not only the simple teaching is enough, but the awakening of interest to the extent that female students also want to continue computer science in future.

Furthermore, the factors of personality development can be considered. Here, the development of interest can be found, which is influenced by convergence points, for example. Within the initiation phase a connection can be created to the computer science, which is strengthened or intensified for instance by positive emotions such as fun. Grounded in the qualitative data from the interviews, all female students felt this positive sense of fun which can be read in Chapter 6. Likewise, there may be opportunities during the maintenance process to sustain and even intensify interest. Only the identification, specification, and differentiation phase has no obvious docking point for promotion. The reason is that female students need to emphasize and recognize the interest in computer science for themselves. The overview of one's own interests is kept by the person alone, so neither teachers nor parents or others have any knowledge about it. In addition to points of convergence, other aspects play a role that also draw a connection to the two factors of self-efficacy and autonomy process.

The self-efficacy process describes the student's development, according to how she achieves an inner conviction regarding her abilities and competencies, with the confidence to successfully overcome difficult challenges. Not every computer science female student starts with self-doubt, from which they gain a positive self-assessment. Thus, this process takes place internally, which does not have to show itself externally as self-confidence. Hence, the indication of possible parameters is not quite so obvious. However, the potential to promote and accelerate the process lies in, on the one hand, supporting the development of interest, for example through the perception of one's own abilities, and, on the other hand, taking into account the individual factors of personality development or the autonomy process as an important aspect.

During the autonomy process, the student's independence and self-determination are developed. This process already starts at birth and can continue to change even beyond the start of studies. As different as the female students are, the personal processes also differentiate with regard to their independence. Either this is done consciously or it is part of the natural process of growing up. As before, it is also shaped by individual experiences and cannot be fostered by any specific interventions. However, it can be influenced by the development of interest, in that a high level of interest supports independent pursuit. Furthermore, self-efficacy or convergence also has an impact on the self-determination process, as well as, conversely, the autonomy process also has an impact on interest development, convergence, and self-efficacy. This is due to the fact that successes through autonomous perception or actions increase inner conviction in abilities, promote interest, and as a result, more contact with computer science is sought out. Such interactions and influences are addressed in Section 7.1. Therefore, although the autonomy process factor can be easily accelerated or slowed down by external factors, it cannot be accelerated or slowed down by any fixed parameters.

The last factor is called STEM ability, but due to its grounding basis it does not provide for any possibilities to assume a decisive influence from the outside. This is because a basic level of STEM skills, especially mathematical reasoning, must be innate and can only be influenced to a certain degree. This is based on the fact that all female students interviewed felt very comfortable in STEM, especially in mathematics, which can be seen in Chapter 6.

In summary, the greatest potential for influence is found in the Convergence factor, followed by Interest Development, which, however, is also shaped by the factors Self-Efficacy and Autonomy Process, which can hardly be influenced. Bringing up the rear is STEM ability, which is difficult to impossible to influence.

Despite the limited degree of influence, some positive factors can be found that measures can dock onto in order to facilitate access for women to computer science studies. The design and implementation of appropriate undertakings, is therefore an important measure of this research chain. After uncovering and providing positive factors, the next step is to design or triage existing measures to finally measure higher female participation in computer science lecture halls. Thus for this step, further research should be focusing on factors that can positively influence the factors of the taxonomy model, which can be pursued with the help of this research question.

RQ3: What measures can be implemented to promote those factors?

The goal should be to find new and existing measures that can both positively and negatively influence those factors in the revealed taxonomy. Based on the differentiation, the positively emerging measures can be promoted where all others can be avoided.

Expanded Research Question RQ4

Based on the identified research gap of uncovering the positive factors as to why women choose to study computer science, there is subsequently an opportunity to apply measures to promote the uncovered motives. If this should bear fruit, in the form of a higher quota of women, it is not guaranteed that a higher quota of women in the lecture halls will also result in higher quotas of female computer scientists in industry and economy. High to very high dropout rates are still found in the first semesters of computer science studies. For example, the Gender and Women's Research Center of the Hessian Universities states for the year 2017 that the dropout rates in the bachelor computer science program are 9.7 percentage points [1]. This figure is indirectly determined by comparing first-year female students to graduating female students.

During the review of existing literature presented in chapter Chapter 2, the issue of high dropout rates was mentioned again and again. Not only in Germany, but also in Switzerland or Austria, many female students drop out of computer science studies in the first semesters, after which the imbalance of women and men is reinforced again afterwards [KGSK20; Pöp09].

Also, during the interviews, the topic of studying and dropping out came up, which slowly developed the research questions according to dropout rates. Some interview quotes highlight the doubts or situations that female students struggled with during their studies. For example, student 1 told of a feeling that occurred due to various incidents after which a negative feeling overtook her.

> "I get here, I have the feeling I get more, I don't know, not reproach [...] but strained moments [...]. So I [...] never had the impression that I thought I would not manage something because I am a woman. During the studies I already have the impression." – *Student 1*

[1] The data is available at https://www.gffz.de/gendermonitor/abbruchquoten

Likewise, student 2 recounted situations in which she continued to be plagued by self-doubt regarding her self-efficacy in not being good enough for computer science curricula and thus losing valuable time.

> "[...] there I thought, I'm too stupid, what am I doing, I'm just losing my time. [...] so there were already such moments. That I'm not good enough." *– Student 2*

In the case of student 3, she even admitted to having had doubts at times regarding her mismatched interests with computer science studies.

> "I have to say, I kept doubting whether I shouldn't change, simply, it wasn't that much fun in between. As I said, it's not one hundred percent mine [...] That's why there was always enough stuff that somehow bothered me now, where I then thought, I should have done something else after all." *– Student 3*

While student 4 did not tell of her own situational dropout desires, she did notice the high dropout rates herself, as she describes in the following quote.

> "So, in the beginning of study finding contacts was a bit difficult, respectively because all the female students have then clumped together and made the teams. Stupidly, most of them quit and then you are alone again. That was actually an effect, which I noticed strongly, that actually almost all other women dropped out in the first two semesters." *– Student 4*

Based on the analytic process, these interview fragments reached the issue of high dropout rates. However, the issue only became more prominent during the final interviews, which means that the problem cannot be answered in this research work and therefore spans the possible scope of a future research. For this purpose, only the space will be framed with the following fourth research question. This reads as follows

RQ4: Why do female computer science majors stay enrolled?

The fourth research question (RQ4) encompasses the conscious and unconscious reasons why female computer science majors stay enrolled, continue to study, and, in the best case scenario, successfully graduate. In addition to matriculated female students, the focus may also be on female graduates who showed perseverance and were not irritated by the high dropout rates. Then, the overarching goal is how to persuade female students to stay until graduation. Nonetheless, beyond this, two other interesting viewpoints can be found as to why the research question is a significant, as well as a complementary, contribution to this thesis. During the literature review, various texts were analyzed that depicted, among other things, the experiences of female students, describing both positive and negative situations. A brief introduction of the research can be found in chapter 2. However, the majority of the scientific work is concentrated within their country borders and thus, cannot be transferred to the institutions in Germany. The second reason why the continuation of the work is so interesting is to check how the positive factors of the revealed taxonomy model behave during the study. On the one hand, whether they have an effect and, if so, how they have an effect and what influences them. Because also beyond the beginning of the study, a further development of the female students could be identified from the interviews.

7.4 Benefits and Advantages

What benefits and advantages can be drawn from the findings and answers to the initial and extended research questions, respectively, will be discussed in the following.

The initial taxonomy model describes the 5 factors that improve the promotion of women to study computer science. Thereby, the factors of interest development, self-efficacy and autonomy process as well as convergence can be influenced by the outside world. Based on the findings of the taxonomy model and the influence potentials, various benefits can be derived. In addition to answering the initial research question and the extended research question, a better understanding can be achieved in the decision-making of all female computer science students. This knowledge can be used to better plan and design interventions for promotion or other supportive intentions. This is because the approaches to improvement to date have been based on what is known, i.e., predominantly the negative factors as to why women do not want to study computer science. As a result, the measures could not achieve the same effect as if they also took into account the positive factors. Sometimes, it can lead to the counter-direction of negative factors, for example, to transform them into positive factors. That is, for every positive factor, there must be a negative pendant to counteract with existing measures. In addition, it can be clarified whether the positive and negative factors complement each other like two pieces of a puzzle.

Starting with the factor of interest development, the pendant would have to deal with the lack of interest formation. In fact, such a pendant exists, described in several scientific reports, whether from an experiential narrative or sprung from stereotypical thinking [HB21; YP21]. The authors described that women either think that computer science is not interesting, or according to stereotypical thinking female students lack the natural ability and interest for it. Likewise, it is assumed that women are worse in mathematics and technology and therefore less talented than men [HB21]. This is also followed by the STEM ability factor. The emergence of this existing image is based on a traditional notion, which, however, has been refuted, as women are sometimes even better than their male counterparts [HB21].

Opposite to the self-efficacy process, the negative factor describes a lack of confidence in one's own competencies, especially in STEM or computer science. In fact, studies indicate that women generally struggle with low self-confidence or low self-efficacy, which is also known as impostor syndrome [HB21]. In the same study, the pendant to convergence is described as a component of frustration factors, including lack of access to adequate instruction, comprehensive support or encouragement, and to a computer.

Finally, a pendant to the autonomy process is sought, which is characterized, for example, as dependence on others. However for this no negative factor is found, which broaches such an aspect. From this perspective deriving with past search for the time being from the fact that the autonomy process is the only factor of the taxonomy model, which was identified neither as negative nor as positive form in existing scientific research.

Based on the brief comparison of positive and negative factors, it can be seen that firstly, the two perspectives do not fully complement each other, which means that with the help of this research result, new knowledge has been gained in the form of a new factor that cannot be derived from the negative factors. Secondly, because of the lack of a counterpart to the autonomy process, it is possible to offer appropriate measures at this point in order to be able to perceive one's own ability, for example, through independent trial and error, and to promote interest as a result.

7.5 Dealing with Problems

In the context of research, problems are unforeseen situations that may affect the research outcome. These results from the researcher's mistakes, which can then be further propagated. In order to reveal them as part of qualitative research and thus contribute to the evaluation criterion of credibility. Therefore, this section will explain any difficulties encountered and describe their degree of impact on the research findings. In addition, if possible, the countermeasures taken to avoid further complications will also be elucidated.

7.5.1 Literature Review

Regarding the data genesis, both a literature review and interviews with female students at the University of Stuttgart were to be conducted. In the course of the literature review, a total of 16 existing texts were found. In addition to academic publications, other texts were also examined such as blogs, internet forums, and websites. After the initial abstract analysis, only 6 of scientific publications remained, of which only one paper Chapter 2. All other research contributions focused on the motives why women decide not to study computer science. Despite changes in the search string, no further suitable texts could be found to complement the research results regarding positive factors. Therefore, the conceptualized taxonomy model is grounded entirely on the 5 interviewed female students.

7.5.2 Research Process & Methodological Awareness

Another problem area defines difficulties that occurred during or after the interviews. Therefore, the subsection is divided into two sections.

An interview is conducted between an interviewer, the researcher, and the interviewee, the female student. This is framed by a predetermined time frame that estimates interview time. During this time, the participant must give the researcher a glimpse into her own personal world. However, difficulties may always arise what makes it difficult for the researcher to gain sufficient insight. For example, the basis of such a problem can be built on a difficult foundation of trust, as two complete strangers see each other online for the first time only via a camera. Such a situation also occurred during the research process, where it was difficult to establish a trust connection with the participant in a short period of time. The openness on the part of the participant was therefore very limited at the beginning of the interview. This was evidenced by terse answers or by omission of certain periods of time filled in, for example, by the choice of words ”blah blah blah”, despite open-ended questions. Based on facial expressions and gestures, a decreased motivation of the participant could be seen compared to other female students interviewed. This was shown for example by pulled down corners of the mouth, weak to no gestures or a monotone voice pitch. In order to achieve better results, and also to improve the level of trust between the two parties, several measures were carefully introduced. First, the researcher increased and clarified his reactions to what was being said, through smiles, nods, and verbal approvals. The goal was to create a relaxed atmosphere in which the participant no longer saw herself as a subject, but rather a conversation, with the linguistic portion still on the student's side. In addition, on occasion, as with all female students, the answer to a question was summarized again and either formulated as a question as to whether this was correctly understood or simply formulated as a statement. On the one hand, this should ensure that the student felt understood and could possibly correct or add something, and on the other hand, the researcher could read his recorded view confirmed. In order to look in particular behind the filling out word choice ”bla bla bla” or ”and so on”, gradually the questions were led there without directly addressing the gaps. The reason lies in the fact that on the one hand no sufficient confidence basis was created and on the other hand that the student try to hide sensitive topics, which would have been possibly hidden by the directness. So, the questions to discover such tender topics have to be choose and adjusted carefully. In order to protect the privacy of this person, no example quotes can be included here, since a private story was actually hidden behind the hidden words.

Completely different problems arose with very enthusiastic female students, who were happy to talk at length about their experiences and let the researcher share their emotional world. Thus, from the beginning, the students were allowed to ramble, so that all facets of the participant could be recorded. However, gradually the personal answers to the open questions became philosophical answers, which on the one hand were general without mentioning an I-reference, and on the other hand became more and more diplomatic, so that the attempt to avoid ”wrong” answers in an interview was recognized. The female students tried to convey a positive image of themselves, which made the answers useless. As a countermeasure, either the question was flexibly readjusted, for example, asking if the answer was personally true or if it could be worded more precisely. Furthermore, the answer was summarized from the researcher’s point of view, to which the female student could again reflexively respond. Based on these changes, either the answer was revised or an appropriately personal answer was provided.

At the beginning of an interview, the student already knew about the framework and the goal of the research. The participants were informed once in the invitation email and again in more detail via a Consent Form. As a consequence the answers were pointedly directed at the topic, whereby much else was initially omitted. To avoid such excluding, at the beginning, the researcher was deliberately pointed out to be able to speak both openly, honestly and freely without thematic coercion. If the problem already occurred, additional adjustments to the questions had to be made here as well, for example, by additions such as ”What was beyond that?”.

Another issue that both the participant and the researcher could not respond to were the gaps in memory or the correct temporal classifications of various events of the female students. These were not only related to very early childhood, but also decision paths that they chose or chose not to take. Therefore, specifically reasons and causes could not always be identified. Regardless of how long the female students thought about it, some memory gaps could not be filled. To capture temporal classification, specific time periods were used rather than age, divided into infancy, elementary school, and middle and high school.

After the interviews, the transcripts were created, which involved transcribing the audio into written form. For this process, the recordings were briefly played, paused, and written down. However, every now and then the sound quality of the video was disturbed to the point that isolated words in the transcript were written down as what was heard, even if the meaning could not be reproduced or the grammar of the sentence was lost. Quotes with such an error, were corrected for the paper to establish meaning for understanding. In order to correct problems of this nature, students were asked at the end of the interview to be allowed to ask again about minor issues, although this offer was never resorted to.

Another difficulty, which only arose during the transcription, concerns the female students' answers. It seems perfectly natural that sentences are sometimes pronounced incompletely, repeated, or restarted. The transcript was intended to represent the interview as realistically as possible, this included filler words such as "um", pauses or repetitions. Tough, the transfer of the answers into the written elaboration of the thesis created a greater challenge, since certain text passages, which were only a few lines long in total, were twice or three times as long due to the realistic transcription. For this reason, major sentence repetitions were removed as they did not provide valuable evidence from either a thematic or emotional perspective.

Unexpected challenges also arose during the analysis conducted in parallel with the data genesis or initial theory building.

For the coding analysis, not only the data itself, but also the tacit data beyond are analyzed and evaluated. This includes gestures, facial expressions, accentuations, or even the invisible data that shows up, for example, through pauses or reflections. For example, in the case of interests or hobbies various scenarios can falsify the research results. Such a scenario was described above as the preceding problem, which is propagated here. Thus, the systematic focus on the topic of positive factors of women regarding computer science studies follows that the answers always come in contact with computer science. Thus only interests and hobbies are called in connection with the computer science, as well as educational paths or preferences on the topic field steered. By this approach, the computer science will always trump the other fields of interest in theory, although this does not represent the reality of that student. For this purpose it was necessary to look at the other interests, preferences or hobbies from different perspectives and to put them into the overall picture of the individual personality. Do the statements really correspond to the educational background or do discrepancies occur? This case was also observed on a subject when two statements contradicted each other shortly after each other during the same answer. However, the case could be resolved quickly after understanding the time periods under consideration in which the statements were embedded. The two statements concerned two at different points in time, on the basis of these findings the factor independence has developed to the autonomy process, since there was a obvious change between the time periods. The two statements are shown in the following quotes.

> "[...] I am someone who has learned a bit, a bit probably also by myself, um [...] does what he enjoys without [...] even if no one else does it." – *Student 4*

> "[...] so if I had not attended the club at that time and also at that time there was a friend, I don't know if I would have done it all by myself [...]." – *Student 4*

The second problem, which could change the research results, was not only the focus on the thematic framework, but the consideration to reflect the experience so completely. In general, when asked about toys or interest used in childhood, there may be a difference between those that were mentioned spontaneously and first and those that were mentioned only after a longer consideration. Those object of interest that are named quickly and spontaneously with a joyful voice may represent a much deeper emotional connection to the student because it was left deeper as a memory. All others that were commented on with a shrug of the shoulders, were only reproduced after a much longer time or with a less joyful voice compared to the first toy or hobby, are less prominent in the evaluation according to their importance. However, this must also be put in relation to the entire interview, which represents the social, individual reality of the student. An example of such a scenario is represented by the following two quotes. In the first quote, all kinds of toys the female student played with are described, but what remained most important to her were the first two play activities, which she later repeatedly focused on.

> "I did puzzles, I read, I had [...] no idea [ponders] also played some kind of things in my head, I don't remember, I played Harry Potter School or something, but eh [...] listened to cassettes like that, listened to the radio [shrugs] or [...] do I still have a favorite toy? We still had a bunch of board games, they were great." – *Student 3*

> "Reading, doing puzzles, [laughs], there wasn't much else. That made me totally fulfilled and happy." – *Student 3*

Same situation can be seen for student 5 as she told about horses several times, but all other hobbies took more of a back seat because they were only mentioned once or less passionately.

Because of these multi-faceted challenges, a constant methodological awareness regarding Grounded Theory has been necessary to collect, analyze, and utilize qualitatively valuable data and form it into a theory.

7.6 Adaption to other STEM-Fields

The taxonomy model emerged from the interviews of 5 female students and former female students of the computer science and software engineering programs at the University of Stuttgart. By conceptualizing, the model can be generalize to all female computer science students and answer the research question about the factors that enhance the participation of female students in Germany's computer science curricula. However, the fundamental problem of underrepresentation of women is not unique to computer science curricula. Likewise, other STEM majors are known to be less attended by women. According to the OECD report [OEC21] and Figure A.2, there are also few women in the engineering sector. Based on this line of thought, the idea is to adapt the model to other STEM fields or to discuss the potential of such an application. From a bird's eye view, the model is composed of interest development, self-efficacy and autonomy process, STEM ability, and convergence. These five factors in combination describe the factors why women choose to study computer science. For possible adaptation, the model can now be decomposed and discussed individually.

Starting with the external factors, these are STEM ability, and convergence. The former, specifically for computer science, requires not only computer science itself, but also very good and high mathematical knowledge. Correspondingly for other STEM fields, this knowledge must be adapted in each case to the corresponding prerequisites of the study program. For example, for physics course, physics itself and perhaps high mathematical skills are wanted. Therefore, similar to computer science, there needs to be enough contact points between the future student and the respective subject. For example, a civil engineer degree program may require internships, and a chemistry degree program may require contact with laboratories.

From the perspective of the three personality processes, the development of interests is found first. As before, interests must match innate or acquired abilities. An interest is initiated by toys, hobbies or contacts in school. Continuing, other points of convergence serve to encourage and support the inclination. Above all, it is important to identify, specify, and differentiate the particular interest.

The self-efficacy and autonomy process is far less subject-bound due to the focus on personality. Thus, the building of the inner conviction, as well as the autonomy in the pursuit of the interests is also necessary to let the connection to the respective professional sector emerge.

However, it is explicitly noted here that the adaptation does not have to work sufficiently. This may be grounded on further aspects. For example, the competition of interest identification, specification, and differentiation are higher, since other majors have the same requirements and potential female students could otherwise be poached. Or the set of convergence points takes on a stronger valence. Besides, these conjectures are not evidence of actual occurrence, and therefore need to be investigated in a separate study. Thus, generalization to all STEM majors is not guaranteed.

7.7 Evaluation Criteria

To conclude the qualitative research, it is still necessary to consider the evaluation criteria, which are documented by Charmaz [Cha06]. Among them, the research process, as well as the research results are examined under the aspects of the four evaluation criteria credibility, originality, resonance and usability.

7.7.1 Credibility

Credibility refers to the openness and comprehensibility of the research results. So, the validation of the willingness to accept the qualitative research and its results. Here, Charmaz asks about the connection of the research to the overall topic, about the sufficient data genesis and sufficient evidence for an independent evaluation, the comparisons between the observations respectively categories, the coverage of the categories of a broad spectrum or the close connection of data, argumentation and analysis [Cha06].

This research operates thematically within the given framework and shows the limitations. How the research gap is formed, how the overall process is designed and implemented is well opened accessible in the previous Chapter 2 and Chapter 5. A list of all questions regarding each interview can be find in the appendix in Appendix A. Furthermore, all resulting factors are grounded and formed by the qualitative data given as citations which can be find in Chapter 6. According to the limitations the initial research questions was limited to the period from birth to the beginning of studies to computer science or software engineering. So, further research questions expands the initial inquiry by picking up the resulting research possibilities such as using the taxonomy model to design measurements or treating the high dropout rates, which is not addressed in this thesis however.

The revealed taxonomy model is exclusively grounded in the underlying data of the interviews, which can be taken from the accordingly research results. Hence, all mentioned assertions are based on the determined data and can be traced back, even to the respective student number, which was distributed at the beginning. For an independent evaluation only the given interview excerpts serve, since due to the data protection the complete interviews may not be indicated with. Another part of this thesis was the discussion of categories that were shortlisted but could not be included in the taxonomy as a core category or concept due to weak connections

In particular, comparisons between observations were made in the research results as part of the analysis. Category comparisons addressing relationships between categories due to strong coherence were also made.

As part of the criterion of credibility of the research findings, the entire research process from design to implementation can also be traced. Furthermore, the positive factors revealed versus the negative factors were concluded. In addition, all the problems as well as the constant methodological self-awareness during the research process were also revealed as a brief reflection.

7.7.2 Originality

Originality as an evaluation criterion refers to the novelty of the revealed concepts, as well as social and theoretical significance [Cha06].

Within the taxonomy model, 5 of different factors are found that collectively represent a new insight into the motivations and decisions of women who choose to study computer science. The concept of interest development is known as the four-phase model in psychological pedagogy, but there are some differences between the two concepts. First of all, they differ in their goals and purpose, namely, once a sufficient level of interest for the choice of the field of study, whereas the pedagogical approach prescribes the design of teaching in order to generate an independent and autonomous interest. Accordingly, both also differ in their implementation and phases, which are similar only in the beginning. The self-efficacy and autonomy process, on the other hand, are both new concepts with regard to the problem, since so far only the respective states have been considered, but not the generic process behind them, which have been uncovered with the help of Grounded Theory. Regarding convergence, it is already known that undergraduate experience can increase the likelihood of women entering computer science [Bey14]. However, the viewpoint was not described under the totality of all points of contact, their intensity and convergence. Such a concept was only uncovered through the application of Grounded Theory. The last factor, STEM skills especially mathematical thinking skills has been treated under the negative discussion point of stereotypical assumptions. Among them were classified as low STEM gifted, especially in relation to mathematics and technology [YP21].

Derived from the new findings of the initial taxonomy model, there are various potential uses, such as which factors can be promoted, especially external. There are also opportunities to guide the countermeasurement approaches, which have so far been oriented toward the negative factors, on the basis of the positive factors.

7.7.3 Resonance

If there is a close connection of the two criteria credibility and originality, the resonance and usability will increase [Cha06]. Besides, the resonance criteria is understood as the illumination of borderline or unstable aspects, also the resonance of the conceived theory towards the people, who are also described by the theory. It is examined whether the result also reflects the generality to which the theory refers.

Mapped to the thematic framework and in addition to the central factors, the individual factors that cannot be conceptualized into another factor are also highlighted. Additionally, categories are described that provide a high potential for a further factor, but could not be sufficiently substantiated from the set of female students interviewed, were even contradicted. The question of whether the taxonomy makes sense to the participants or female computer science and software engineering students beyond that cannot be meaningfully substantiated. However, for each factor, the personal lives of each female student were highlighted individually and the evidence presented as to what extent the factor is characterized and shaped by all female students. Because not all information could or was allowed to be presented due to privacy concerns. Also, regarding the request of the female students, certain fragments of evidence may be missing, but would not have had a considerable impact on the research results.

7.7.4 Utility

The criterion on utility or usefulness refers to the usability of the interpretations in the everyday world and how a better world can be achieved through qualitative research [Cha06].

First, the taxonomy model explains why women choose computer science as a field of study and why they begin their studies in this topic. In order to exploit this finding, the second research question was developed with the intention of identifying those factors that can be promoted externally through action. Thus, four of the five factors have such a potential. It is not possible to conceptualize exactly which ones, since individuality depends very much on personal situation and influence. For example, the interest for one student was aroused by half a year of computer science at school, but for another it took much longer and more contacts. Despite, there is the possibility of state institutions to intervene, for example, as an interestingly designed teaching.

The identified categories represent generic processes that are part of personality development and also affect female students who have not chosen computer science as a field of study. These include the development of interest and the self-efficacy and autonomy process. Because of this, it is possible to apply the taxonomy model to other STEM fields as well. However, essential is the underlying subject, in this case computer science. From the research results derived, it is known how the interest is built up, the hurdles of the self-efficacy process, and the importance of self-efficacy on personality development. In addition to convergence points, STEM skills are also significantly important. In computer science, particularly high mathematical knowledge and understanding are critical skills. Mapping to other STEM fields must be determined on an individual basis.

Therefore, the usability is not limited to computer science, but can be adapted to other fields as well.

8 Reflection

As a co-constructor, the researcher also forms a part of the research process and its results according to Charmaz's Constructivist Grounded Theory. In particular, as a researcher and at the same time as a female student of software engineering at the University of Stuttgart, the social reality of the researcher also complements the initially constructed taxonomy, which is formed by the collective of all female students of computer science and software engineering in Germany. Such an extension and generalization could be realized with the help of Grounded Theory from few considered cases. For this reason, a condensed reflection, which maps the results to the co-constructor, is to be carried out separately to the results. The individual factors of the taxonomy model should be compared with the world of the researcher and evaluate whether and how they apply. For this purpose, the first person form is used to illustrate personal reflection on the research findings, detached from the previous work.

STEM Skills

STEM skills are one of the central factors that facilitate the choice of computer science curricula for female students. Especially mathematics and computer science are important fields. Other skills beyond these are also possible.

Going through the self-assessment of one's own skills is a much more complex situation than conducting interviews on which to examine the skills of others. Because of this, I view self-assessment from two critical angles. The open disclosure of one's own skills assessment is not done under a privacy curtain, behind which the data of the female students were hidden. As a result, one's own assessment can be traced directly to the person behind the text. As a second point, such an assessment also simultaneously achieves an overlap point with the self-efficacy process. That is, the assessment of the former inner conviction compared to today. Two paths follow from this. One way leads through the possibility of underestimation, which as a negative factor hides behind the concept of low self-confidence, self-efficacy or also known as imposter syndrome [MJ19]. As a second path, the variant of downplaying can strike in an exaggerated opposite direction known as the Dunning-Kruger effect, namely overestimating one's own abilities [Dun11]. The first reaction describes itself as dismissive, because in the first moment I would neither consider myself highly gifted nor less gifted. Then a certain level of sensitivity is needed to insert a realistic assessment.

The word gifted is therefore a far too strong term to describe my STEM abilities. Measured in terms of academic performance, I was already far ahead of the required performance in kindergarten and elementary school, especially in mathematics, because I did not associate learning itself with any negative emotion until then. It was more like a game to me. Due to the subsequent school system change to a Gymnasium or high school, the grades were then in the mid to upper range, although the fun remained. When I took computer science as an additional subject in high school, my interest was confirmed with very good grades.

Overall, I see very few clues of a STEM talent for me, because for the concrete assessment I only have the grades from school. If I compare these with other subjects, I can observe a tendency towards STEM. But for the overall unified assessment, I would include more aspects than grades given by teachers. For example, mathematical skills can also be identified on the basis of non-obvious situations such as small everyday situations. For such a case I remember, for example, situations in driving school, when the braking distance was calculated in seconds, while everyone else was much slower. It is not possible to enumerate each situation individually, but when memories are searched for those situations, whether in or out of school, they add up to skills sufficient for studying computer science. Based on my memories and experiences, I can agree with the statement of having STEM skills, at least sufficient ones.

Convergence

The points of contact can be easily counted are decisive for convergence.

With regard to toys, I was encouraged by my parents in childhood in the direction of learning and brain development, which was more than fun for me. So learning was a game for myself, an immaterial one. Besides, there were also material toys, Lego bricks, technical building sets, puzzles or memory games. The access to a first computer was the family computer, which I rarely used, because there was little to do with it. During elementary school I got my first own computer, with which I created folders or learned to type. Then in school, subjects like mathematics and science were added. In addition, every student had to take a typing course during middle school. In this course, the positions of the letters on the keyboard had to be memorized and trained using a program. Because of my previous experience, I was very good at this and completed the course much earlier than my classmates. Every now and then we worked in the computer room during class, where we learned how to use Excel or had to do small exercises. It wasn't until the upper school that I took computer science as a subject, in which I had a lot of fun on the one hand and also achieved very good grades on the other.

Decisive for the choice of my course of studies was this subject, whereby a single day in the computer science lessons occurred, which particularly convinced me. On this day, we should implement an independent program in Java, which actually worked and this was something I was very proud of. The perception of success, the perception of having accomplished something on my own, was personally a big step.

Development of interests

The development of my interest in STEM was shaped and accompanied early on by the previously presented points of contact. The career aspiration to be an engineer occurred because my dad was an engineer and I wanted to be just like him. Then in school, mathematics was something easy that I had great fun with. The interest in computer science was consciously perceived during the computer science lessons, and differentiated itself from other courses of studies that were available. When an initialization took place, I cannot answer exactly, just that I was consciously aware of the interest for the first time. For the preparation of the computer science exams I researched far beyond the topic and discovered thereby computer science from a completely different point of view. This also motivated me to give presentations in this subject on my own. Comparatively short was the development of interest from initialization to sufficient interest.

Self-efficacy Process

Self-efficacy briefly describes one's inner belief in one's abilities, competencies, and possibilities to cope well with a complex challenge. The development of growing this inner belief is described as a process.

In reflection on my life, self-doubt has always been part of it. However, this is not primarily about computer science, but about smaller situations in which I have seen my inner conviction grow. For example climbing a big tree or an exam in school. Successes fostered my faith in myself, failures sometimes produced the opposite. Growing up also taught the inner reflection in me to not give up, not to doubt, and to work at challenges. Situations such as the typing course boosted my confidence to deal with keyboards, with computers. Because the computer science course was not offered until high school, by that time the development of my self-efficacy had matured to the point where failures no longer had such an impact, such as when a program didn't work or a topic wasn't understood. This, of course, also had to do with the various touch points at which I perceived my successes and my abilities.

Autonomy process

Also part of personality development is the autonomy process, which describes the development of self-determination and independence.

Remembering my growing up, I have to admit for myself that I was a very dependent person in my childhood. My parents shaped me with their choice of toys, learning with me as a game, which made me do exceptionally well in school. The successes I perceived I was associating with my parents and trusted them and their actions. It was only during high school that I formed my first independence, choosing natural sciences instead of a fourth foreign language, choosing the subjects I wanted to focus on in high school and also computer science as an additional subject. The majority of my points of contact were thus predetermined. But still, the strong connection to my parents, was part of the choice of the course of study. I steadily asked for their opinion and advice on my decision, which they were always completely supportive of, even beyond that, regardless of what I wanted or planned to become.

My own reflection of the research findings on my life, again shifted the view of the taxonomy model a bit. While I agree on the importance of each positive factor, there was no obvious order in the research results. However, for me reflection has revealed that the positive factors can be ranked according to my own hierarchy in terms of their importance and power on my decision. Most important to me was the fun factor, the interest, and the perception of success, shaped by the touch points. The STEM skills, autonomy, and self-efficacy processes lay hidden to me and tacitly had power on my decision making. Without the Grounded Theory research method, the essential, low-present and tacit positive factors, would still remain hidden.

9 Summary & Outlook

The underrepresentation of women in computer science programs at Germany's universities and colleges is a well-known problem that is also evident across borders in other countries around the world. In order to investigate this phenomenon, scientists from different countries around the world are working on finding reasons why women decide not to study computer science. From this perspective, the problem has already been explored in several scientific papers. Based on the negative factors, appropriate countermeasures should lead to improvements. However, the phenomenon can also be explored from the opposite side, namely the question of positive factors why women decide to study computer science. However, research from this point of view is lacking, resulting in the research framework of this thesis, the initial research question "What are the factors that enhance female participation in German computer science curricula?".

The task of this thesis was to investigate the initial research question using a Grounded Theory methodology and to extend it during the research. In more detail, a suitable GT methodology was to be selected with the help of which an initial taxonomy represented as a model was constructed.

After extensive research and comparison to the thematic framework of the thesis, this approach was chosen due to the philosophical research paradigm of Constructivist Grounded Theory by Kathy Charmaz. In this approach, female students who choose to pursue such a course of study construct their own needs and choices that enable them to do so. Mapped to Charmaz's underlying research paradigm, reality is constructed from a collective of all individual realities, which therefore lends itself to the prevailing research environment.

Both a literature review and interviews were selected for data collection. However, only negative factors emerged from the review, thus focusing the data genesis on conducting the interviews. For this purpose, 5 female students from the University of Stuttgart were invited to participate the designed interviews with whose qualitative data created an initial taxonomy. The interviews were all conducted voluntarily and online. The chosen form was a narrative interview, which leaves most of the flow of speech to the interviewee, who is encouraged by the interviewer through questions and prompts. The audio and visual track was converted into a written form using transcription. Simultaneously to the data collection, a data analysis took place, according to the methods and principles of the chosen Grounded Theory approach.

Such analysis takes place using Coding analysis, in which first the transcripts are broken down into data components, such as individual words, sentence structures, or paragraphs. Then, these are coded using active and summary words. Within Focused Coding, relevant and repetitive codes are identified, which in a further phase are held together by categories. Problems that occurred during the research process occurred both in relation to the participants of the interview and from the researcher's point of view. The cause of both directions could be solved with the help of constant methodological self-awareness. Overall, 5 unique factors could be conceptualized as a result - the development of interest, self-efficacy process, autonomy process, convergence and STEM skills.

The development of interest deals with the process beginning with an initiation to the adequate degree of interest that is sufficient to choose the recognizable computer science. In between, there are other possible stages such as the maintenance and conscious identification, specification, and differentiation of interest from other inclinations. Such a process is accelerated or slowed down by other individual factors. These include essential touch points, characterized by the concept of convergence, and STEM skills. All other components vary from student to student such as support, including emotional support, both positive and negative, is not present for all female students.

Related to the development of interest the self-efficacy process exists, the inner conviction about one's own abilities to master a complex challenge. The two factors go hand in hand and influence each other. The highlighting of an interest is influenced by the identification of the ability, just as the development of interest influences the identification of the ability. As just external influences can also accelerate or slow down the process, especially self-doubt leads to low self-confidence.

As a part of personality development, the third factor besides the two mentioned is the autonomy process, the way to independence. As a matter of course for some, as a trigger factor for others, the factor is strongly related to the development of interests and self-efficacy. Without own self-determination, interests are not pursued and self-confidence is not achieved. On the other hand, the will to pursue interests is followed simultaneously by independent action and inner conviction to the will of independent perception. Individual external factors accelerate or hinder the process. The factor trio is the focus of the taxonomy model from the point of view of personality development.

All three factors are influenced by the factor of convergence. Convergence describes the convergence of student with computer science by means of points of contact. Not the number, but the intensity plays a role. The higher the interest in computer science was aroused or strengthened, the higher is the urge to pursue the interest. Be it immediately through studies or for the first time through activities, for example. Because of this influence, convergence also affects the process of interest, self-efficacy, and autonomy.

The fifth and final factor cited is the student's STEM ability. In particular, the focus is on mathematical reasoning ability, which predates any specific interest in computer science. A high mathematical affinity favors interest in computer science, due to the strong connection. By its presence it strengthens the interest development and thus on all other factors of the personality development. STEM ability also has an influence on convergence, because it reinforces the urge to pursue the abilities through points of contact.

These 5 factors answer the initial research question of why women study computer science. Because they have the will, represented by the interest, the confidence in their ability, and the strength to take the final step to study. During the research process two further research questions were formed, one deals with the potentials for external influence and the other with the problem of the still high dropout rates. Potentials for external influence are found in development of interest, as well as in convergence. The self-efficacy process and the autonomy process can be influenced to a certain extent. Innate STEM skills cannot be conditionally influenced in this case. A second avenue for research extension is offered by exploring factors why women continue to study computer science.

The benefit to answering the initial research question lies in designing measures that also focus on promoting the positive factors. The assumption that conclusions can be drawn from negative factors to positive ones has not been fully confirmed. With the help of the taxonomy model, it is possible to understand why women study computer science and what they need to do so. Furthermore, the taxonomy model can be adapted beyond the boundaries of computer science to other STEM fields.

In which the object of interest is changed, self-reliance and independence is directed toward the object of interest. In which the STEM ability is adapted according to the course of study and the points of contact of the convergence factor are aligned. Problems that occur throughout the research process appear during the data elicitation and analyzing phase were explained. In addition to the problem of insufficient appropriate literature, severe problems arose during and after the interviews such as building up a satisfactory trust in a short period of time.

For the evaluation of the research results, the criteria of credibility, originality, resonance, and usability were reflected. Credibility describes to what extent the research is accepted as valid. For this purpose, the research results can be traced grounded in the results of the interview, and the entire research process was revealed in addition to the limitations. Originality is the degree of novelty of the revealed taxonomy, which was also achieved for all positive factors with the help of a comparison to existing concepts. A strong credibility as well as originality results in a strong resonance. For this, individual factors were considered, which could not prove to be a sufficient factor of the model. The usability of the model results from the potential to orient measures not only on negative factors, but also on positive factors, in order to attract more women to study computer science.

As a supplement, the researcher reflected his individual reality on the taxonomy model, comparing each factor with personal situations. This crystallized the possibility of an individual hierarchy of factors that can be ranked by influence and power toward the decision choice to study computer science.

The identified taxonomy model shows the positive factors why women study computer science in Germany. The next step is the obvious implementation of a deductive research method, which can be used to further refine the taxonomy model in further iterations. This can be done by either using the created initial hypothesis, which was presented below, or by further defining it to examine the individual factors.

The five positive factors - interest development, self-efficacy and autonomy process, convergence, and STEM skills-, promote the admission of computer science studies for women in Germany.

As a further objective, namely improvements through action, the thesis forms a complementary research question that generates the focus of a future research, which is:

RQ3: What measures can be implemented to promote those factors?

Furthermore, the problem of high dropout rates in computer science programs is still a well-known problem. Only generating introducing measures to attract more women to such studies is not sufficient. Especially in the industry and economy there is a lack of computer scientists. If the additionally gained female students are lost during their first semesters, all introduced measures serve neither the economy, nor the state. Because of this, a study forming a theory is necessary to expand the boundaries of this research, which is intended to answer the research question:

RQ4: Why do female computer science majors stay enrolled?

Central to this research is a search for reasons why female students continue to study computer science and, in the best case, graduate successfully.

A Appendix

This chapter summarizes all additional data and documents that serve as a supplement to the research work.

Figure A.1 describes the distribution of female entrants in STEM for all OECD countries. Here, Germany is at the top of the list of countries with the highest proportion of females in STEM. In addition, the overview in Figure A.2, shows all percentages of all first-year students in the tertiary sector, explicitly highlighting the female percentage in STEM. The figure served the basis for the world map in Figure 1.1 at the beginning of the introduction.

For the provision of the question catalogs, they are summarized in the tables Figure A.3, Figure A.4, Figure A.5, Figure A.6 and Figure A.7 for the interviews A to E.

In addition, the documents in Appendix A.3, which were created during the preparation phase for the interviews, are attached. Thus, besides the invitation emails in English and German and also the self-constructed consent forms in both English and German.

A.1 OECD Data

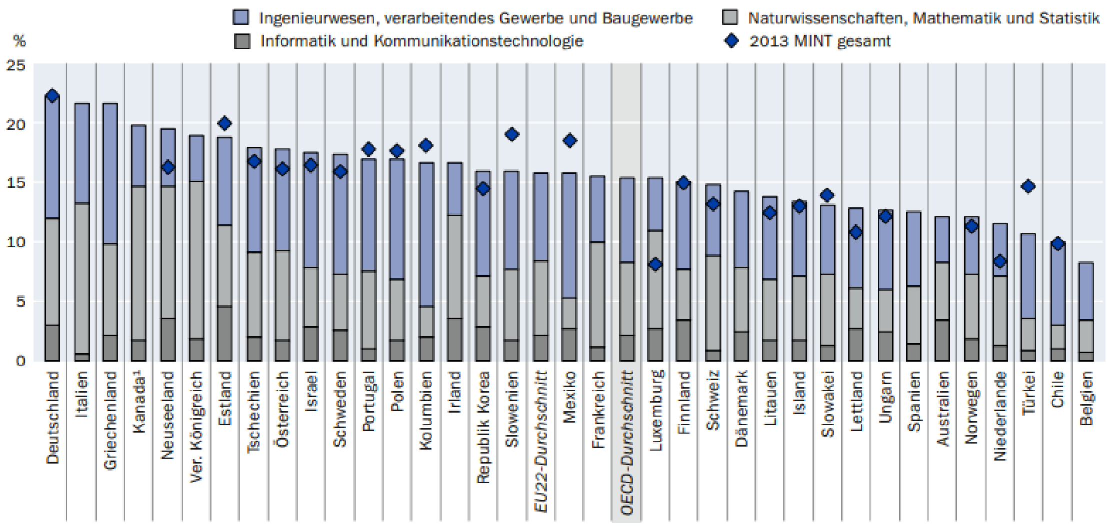

Figure A.1: Distribution of female freshman to tertiary education, by STEM subject group (2013 and 2019) [OEC21]

Verteilung der Anfänger im Tertiärbereich, nach Fächergruppe (2019)

	Anteil Anfänger nach Fächergruppe (in %)											Frauenanteil in MINT-Fächergruppen (in %)		
									Mathematik, Informatik, Naturwissenschaften, Technik					
	Generische Bildungsgänge und Qualifikationen	Pädagogik	Gesundheit und Sozialwesen	Sozialwissenschaften, Journalismus und Informationswesen	Wirtschaft, Verwaltung und Recht	Geisteswissenschaften und Künste	Dienstleistungen	Landwirtschaft, Forstwirtschaft, Fischerei und Tiermedizin	Naturwissenschaften, Mathematik und Statistik	Informatik und Kommunikationstechnologie	Ingenieurwesen, verarbeitendes Gewerbe und Baugewerbe	Naturwissenschaften, Mathematik und Statistik	Informatik und Kommunikationstechnologie	Ingenieurwesen, verarbeitendes Gewerbe und Baugewerbe
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
OECD-Länder														
Australien	0	8	18	6	33	11	2	1	5	8	9	51	25	25
Österreich	0	11	8	7	25	9	6	2	8	5	20	52	18	23
Belgien[1]	0	7	23	11	24	10	1	2	4	3	13	40	11	21
Kanada[2]	2	3	16	10	22	9	7	1	13	5	13	56	20	21
Chile	0	11	20	4	24	4	7	3	2	4	21	49	12	18
Kolumbien	0	8	6	11	38	4	4	3	3	5	20	52	20	31
Costa Rica	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Tschechien	0	9	13	9	19	9	7	4	7	7	16	60	17	32
Dänemark	0	6	19	9	30	10	3	1	5	5	12	53	24	29
Estland	0	6	11	6	23	14	5	2	7	10	15	58	25	28
Finnland	0	5	23	5	20	9	6	2	4	9	19	58	22	22
Frankreich	0	3	12	9	30	14	4	1	11	3	13	45	18	25
Deutschland	0	8	6	7	25	10	3	2	9	6	24	49	23	21
Griechenland	0	6	9	12	21	12	3	4	8	4	19	50	30	33
Ungarn	0	10	11	10	22	10	7	4	4	8	13	50	16	27
Island	0	12	13	14	21	14	5	1	6	5	10	59	22	39
Irland	1	7	15	7	25	14	4	1	9	9	10	53	22	24
Israel	0	22	7	16	15	8	0	0	7	6	18	43	30	32
Italien	0	4	8	15	16	20	3	3	12	2	17	58	14	27
Japan[3]	0[d]	9[d]	16[d]	7[d]	20[d]	16[d]	8[d]	3[d]	3[d]	x	18[d]	27	m	16
Republik Korea	0	7	16	5	13	16	11	1	5	5	21	48	27	21
Lettland	0	6	15	8	27	7	8	1	3	8	16	58	20	23
Litauen	0	3	16	9	27	11	3	2	5	7	17	60	14	23
Luxemburg	0	11	9	10	29	10	1	3	9	8	10	50	18	23
Mexiko	0	10	11	8	34	4	3	2	3	6	19	49	24	29
Niederlande[4]	0	7	15	14	29	8	5	1	7	4	10	47	15	25
Neuseeland	0	7	11	11	23	14	4	2	11	7	9	57	28	30
Norwegen	0	13	16	14	17	12	5	1	6	5	12	51	20	23
Polen	0	7	10	12	22	11	8	2	5	7	16	63	15	36
Portugal	0	4	13	11	24	12	7	2	6	3	18	57	17	29
Slowakei	0	13	16	11	19	7	7	3	5	6	14	65	13	24
Slowenien	0	9	11	8	20	9	9	3	6	6	20	54	16	23
Spanien	0	11	15	8	20	11	8	1	5	6	14	48	13	24
Schweden	0	11	16	11	16	12	2	1	5	5	19	54	29	31
Schweiz	0	8	15	7	28	8	4	1	9	3	16	46	13	19
Türkei	0	10	13	7	30	13	8	3	3	2	13	52	25	28
Ver. Königreich	1	6	14	11	26	13	0	1	13	5	9	57	21	25
Vereinigte Staaten	m	m	m	m	m	m	m	m	m	m	m	m	m	m
OECD-Durchschnitt	**0**	**8**	**14**	**10**	**24**	**11**	**5**	**2**	**6**	**6**	**15**	**52**	**20**	**26**
EU22-Durchschnitt	**0**	**8**	**13**	**10**	**23**	**11**	**5**	**2**	**7**	**6**	**16**	**54**	**19**	**26**
Partnerländer														
Argentinien	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Brasilien	m	m	m	m	m	m	m	m	m	m	m	m	m	m
China	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Indien	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Indonesien	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Russische Föd.[4]	0	9	9	8	21	5	10	2	3	7	26	m	m	m
Saudi-Arabien	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Südafrika	m	m	m	m	m	m	m	m	m	m	m	m	m	m
G20-Durchschnitt	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**	**m**

Figure A.2: Distribution of all first-year students in the tertiary sector (2019) [OEC21]

A.2 List of Questions

List of questions for interview A

- From the consent form I got that you are studying computer science/software engineering. I would like to start with why did you choose this curricula?
- Can you tell me about how you grew up?
- But did you still enjoy it?
- And what did you play with when you were little? How did that develop?
- So you've never had a real relationship with dolls, more with Legos.
- Did you have any role models? How was it with your friends?
- In which directions did they study or continue studying?
- And you couldn't even imagine something like that? Ever since?
- I would be interested to know how exactly you ended up in the field of computer science and software engineering.
- You didn't have a strict career that you were determined to pursue, just an area.
- What I'm interested in. Was there a person in your environment who tempted you to do it?
- Was there a person in your life who encouraged you?
- Do you have formative people?
- Can I ask you, when did you have your first computer?
- Was there a key moment in your life where you said, this is exactly what you want to study? What was it?
- Were there any dissuasive arguments against it for you?
- Do you see a difference for yourself personally?
- Were there situations in your life where you doubted?
- Which points play a role in your decision?
- Did other points play a role in your decision?
- How would you rate yourself?
- Would you consider yourself talented in the field of computer science?
- From your perspective, I'd like to know why you think women study computer science.
- From your perspective, I'd like to know why you think so few women study computer science.
- You brought up the point of family. How is it with you?
- Do you have goals in your life?
- What improvements do you think could be made?
- You talked about the programming class, were you required to take it?
- Do you have any things you want to get off your chest that you still want to say or bring in?
- So there were only two subjects? Can you tell me about your decision?
- You didn't have a strict career that you were determined to pursue, just an area.

Figure A.3: List of questions for interview A

List of questions for interview B

- From the consent form I got that you are studying computer science/software engineering. I would like to start with why did you choose this curricula?
- Can you tell me about how you grew up?
- Can you tell me a little bit more about your educational background?
- Intermediate question, did you study computer science there?
- Can you tell me what your interests were when you were 3, 4 years old?
- How your interests evolve?
- What have you been playing with? Did you have any hobbies (as a child)?
- What did you like to do in the past?
- Did you have other reasons for studying computer science?
- Can you tell me something about your environment, how you grew up?
- Did they influence you in your decision?
- And what about your friends and the rest of your environment?
- What I would be interested in. Did you have role models?
- What used to be your dream job?
- How did you have your first contact with computer science, do you remember?
- Was this a required subject?
- Were there also opportunities to participate in programs?
- What were your main subjects at school?Where were you particularly good?
- So you already had a knack for math and computer science?
- Was there a key moment in your life when you knew that this is what you wanted to study? Can you still remember it?
- What convinced you?
- When did you start questioning that?
- So already with your first computer?
- What were your interests?
- Were there any arguments for you against studying computer science?
- Did your image of it influence you?
- You've also noted that so few women study computer science. What do you think, so few women study computer science?
- What do you think women study computer science?
- Is it your passion? What did you do there?
- What exactly do you find difficult?
- What do you like most? Did you have any support?
- How did you get that idea?
- Do you remember when you first heard about computer science?
- And do you know what the reason is?
- Did you have a favorite game that you remember particularly well?
- What's that all about? Why did you study this?
- Would you consider yourself impressionable?

Figure A.4: List of questions for interview B

List of questions for interview C

- Why did you decide to study computer science?
- To help me understand a little better and figure out where your interests lie, could you tell me how you grew up?
- What were your main subjects at school?
- Did you have a connection to that?
- Can you still remember your favorite toy?
- And what about hobbies?
- How did you meet your first computer?
- What were your first steps?
- How is it with you?
- Did you have role models?
- Did you know what you wanted to be when you grew up?
- Tell me about your family.
- You also went to high school, where there's an in-service internship in the 10th grade. Where did you do that?
- Do you remember when you first got involved with computer science?
- Was there a key moment when you realized that this is exactly what you want to study?
- What were your favorite subjects? Why?
- There are different images of computer science or computer scientists and I would be interested to know which picture do you have of them?
- There are other points that speak in favor of studying computer science.
- Why do you think so few women study computer science?
- Why do you think women study computer science?
- Was computer science a required subject at your school?
- How did you come up with it?
- What did your family have to do with your decision?
- What influenced you?
- What improvements do you think can be implemented to attract more women to computer science? have any goals in life that you are pursuing?
- How do you feel about that?
- If you were advertising to attract more women to study computer science, what arguments would you make?
- What arguments would you use to discourage women from studying computer science?

Figure A.5: List of questions for interview C

List of questions for interview D

- Why did you decide to study software engineering?
- To get to know you a little better, could you tell me about how you grew up?
- May I ask what your parents' professions are?
- What did they study, if you still remember?
- How did that affect you?
- What were your majors and favorite subjects?
- Do your brothers study too?
- Did you also have this in-service internship in the 10th grade?
- What were you doing there?
- Did you go to university directly after graduating from high school?
- What else interested you?
- Did you have any particular hobbies?
- Approximately when did you get your first computer?
- What did you do with it?
- Do you had any role models?
- Were there any formative people in your life? How did they influenced you?
- What did you learn there?
- The computer science course was an elective. Did you like the programming course before?
- Did you have friends who also went in that direction?
- Was there a key moment where you said, this is exactly what I want to study?
- What has convinced you?
- Would you call yourself a nerd?
- Did you have a positive or negative image of the software engineering program?
- Were there situations in which you doubted?
- Why do you personally think so few women major in computer science?
- Why do you personally think why women study in computer science?
- How would you rate yourself? How impressionable are you?
- Have you heard of computer science before your programming class? Did you know the term?
- Can you still remember when and how you first came into contact with computer science?
- What improvements could be introduced that more women study computer science/software engineering?
- What factors speak for you personally in favor of studying software engineering? And which ones speak against it?
- Did you have any preconceptions or fears about studying software engineering?
- If you had to advertise to women, what would be your top 5 buzzwords?
- Is that important to you?

Figure A.6: List of questions for interview D

List of questions for interview E

- From the consent form, I understand that you are studying computer science. So I wanted to start with the introductory question, why did you decide to study computer science?
- Can you tell me how you grew up?
- May I know what majors you had?
- Did you have any contact with computer science at school?
- What was the trigger for you to do this?
- Was this a required subject?
- What did you like to play when you were 3, 4 years old?
- Did you have any other hobbies?
- Did you have role models when you were little?
- I still wanted to ask about your friends, what directions they went, if they studied with you.
- Did you have a career-oriented internship as well?
- What exactly convinced you?
- You have to teach yourself?
- When did you have your first computer?
- What were your first steps?
- Do you remember what it was exactly?
- Is anyone reinforcing that?
- You had your dream of studying. Did you see that somewhere? Where did you get that dream?
- What did your father study?
- Did he teach you anything?
- How do you rate yourself? Are you more impressionable?
- Was there a key moment in your life when you could say, computer science is what you want to study?
- Did this also lead or motivate you?
- So you are more attracted to computer science?
- From your personal perspective, why do you think so few women study computer science?
- From your personal perspective, why do you think women want to study computer science?
- Do you feel addressed when this happens to you yourself?
- Can you tell me what your computer science class was like?
- You wanted to study something else first, and biology would be the closest.
- Do you know what factors played a role there?
- What improvements could be introduced to attract more women to study computer science?
- You mentioned that women are taught that they are less talented. Has that ever happened to you?
- If you had to advertise for young girls, what arguments would you use from your personal point of view to attract more women to computer science?
- Did you have other affinities?
- What factors speak for you, for a computer science curricula?

Figure A.7: List of questions for interview E

A.3 Documents

A.3.1 Invitation Mail English

Dear female students,

women have always been underrepresented in Germany's computer science programs. In the context of my master thesis I would like to investigate your individual decisions, in order to conceptualize a theory that explains the motivations of women to study computer science and to derive improvements for future female students.

Therefore, I address all female students of computer science or software engineering curricula at the University of Stuttgart to support my master thesis by an online interview. All data will be treated anonymously.

The duration of an interview takes about 1 hour and can be arranged individually.

Questions or messages at st107376@stud.uni-stuttgart.de.

Best regards,
Melanie Schäfer

A.3.2 Invitation Mail German

Liebe Kommilitoninnen,

Frauen sind an Deutschlands Informatik-Studiengängen seit jeher unterrepräsentiert. Im Rahmen meiner Masterarbeit möchte ich deshalb eure individuellen Entscheidungen untersuchen, um mithilfe dessen eine Theorie zu konzeptionalisieren, die die Beweggründe von Frauen, ein Informatikstudium aufzunehmen, erklärt und Verbesserungen für künftige Studentinnen ableitet.

Daher wende ich mich an alle Studentinnen der Informatik- oder Softwaretechnik-Studiengänge der Universität Stuttgart, meine Masterarbeit durch ein von mir geführtes online Interview zu unterstützen. Alle Daten werden dabei anonym behandelt.

Die Dauer eines Interviews beträgt ca. 1 Stunde und kann individuell vereinbart werden.

Fragen oder Meldungen unter st107376@stud.uni-stuttgart.de.

Viele Grüße,
Melanie Schäfer

A.3.3 Consent Form English and German

Melanie Schäfer
st107376@stud.uni-stuttgart.de

Universität Stuttgart

Project description

Dear Interview-Participant,

thank you very much for participating in the interviews as part of my master's thesis on "*What Are The Factors That Enhance Female Participation in German Computer Science Curricula?* ".

The proportion of female students in Germany's computer science and software engineering curricula has hardly changed over the years. To explain this phenomenon, the aim is to uncover within a scientifically sound research method those causal factors that encourage and drive female students to pursue a degree in computer science or software engineering curricula. In particular, potential improvements can be derived for future female students in order to design said courses to be more attractive.
With the help of the so-called *Theory Building* according to the approach of Charmaz, individual decisions and motivations of female students are to be detected, which can be conceptualize into a theory.
Decisive here are the individually conducted interviews, in which the personal factors of the participant play a central role. The purpose of the interviews is to examine an in-depth understanding of the choices and motivations of individual female students, embedded in the overall portrait of their personality.

Terms and conditions for the interview environment

In order to smooth and shorten the interview, some key points need to be answered in advance.

Which major are you studying or have you studied?

☐ Computer Science ☐ Software Engineering

In which language should the interview be conducted? *

☐ German ☐ English

What is the preferred tool for conducting the interview? *

☐WebEx ☐ Microsoft Teams ☐

Capturing the participant's facial expressions and gestures is an important and integral part of an interview. An evaluation of these data contributes to a significant part of the developing theory. Is it possible to use a webcam or similar during the interview? *

☐ Yes ☐ No

*Mandatory fields

Figure A.8: Consent form in English: Project description & Terms and conditions

Melanie Schäfer
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Universität Stuttgart

Rights and obligations to the interview

During the interview on the topic "What *Are The Factors That Enhance Female Participation in German Computer Science Curricula?*" Rights and obligations are granted by both the interviewer and the interviewee, which are listed below.

1. Registration and participation in the interview on the above-mentioned project is voluntary. I would like to thank you very much for your support and willingness to participate.

2. The safety of the participant has top priority. It is ensured that a mental injury to the interviewee is avoided and that the well-being of the participant is more important than the interests in significant results.

3. The participant has the right to cancel the interview at any time if excessive stress occurs. In this case, the participant has no negative consequences to expect. The previously recorded audio track is destroyed when the interview is cancelled and is then no longer available for further processing.

3.1 During the interview, individually adapted questions can be asked, which may exceed the personal limit of the participant. In the event of a violation, the participant has the right to refuse, cancel or skip a response without expecting any negative consequences.

4. The participant has the right to withdraw existing consents to audio recording, writing by transcription and/or use of the camera.

5. The participant has the right to request an appropriate, satisfactory explanation on the topic of the master's thesis that occurs in relation to the interview. In addition, he has the right to be informed of the results of the research work, if he so wishes.

6. The extensive planning and execution of the interview requires a lot of time and effort. As a result, the participant is obliged to answer the questions asked as well, openly and honestly as possible. Low interest and superficial participation can lead to a distorted result.

7. All data and personal disclosures will be kept strictly confidential. All personal information is removed from the transcribed text and/or anonymized. The interview is only quoted in excerpts in the master's thesis in order to ensure to third parties that the overall context of events arising in the interviews with the stories does not make the participant recognizable as a person.

8. In order to sufficiently exploit the anonymous data, the audio recordings will be stored until the end of the master's thesis and destroyed upon completion.

Thank you for your participation!

Figure A.9: Consent form in English: Rights & Obligations

Melanie Schäfer
st107376@stud.uni-stuttgart.de

Universität Stuttgart

Declaration of consent

I have read the terms and conditions, my rights and obligations to the interview and agree to participate in the interview as part of the mentioned master's thesis.

Name des Interviewers: Melanie Schäfer

Name of the interviewee:

Interview Date:

Place, date Signature

Declaration of consent for the use of the interview and the obtained data

I agree that the interview will be recorded and then transcribed or written down. In addition, I agree that the data resulting from the interview may be used for further processing until the completion of the master's thesis.

Place, date Signature

Figure A.10: Consent form in English: Declaration of consent

Melanie Schäfer
st107376@stud.uni-stuttgart.de

Universität Stuttgart

Projektbeschreibung

Sehr geehrte Interview-Teilnehmerin,

vielen Dank für die Teilnahme an den Interviews im Rahmen meiner Masterarbeit zum Thema „*What Are The Factors That Enhance Female Participation in German Computer Science Curricula?*".

Weil sich der Anteil weiblicher Studenten an Deutschlands Informatik- und Softwaretechnik-Studiengängen über die Jahre kaum verändert hat, sollen nun innerhalb einer wissenschaftlich fundierten Forschungsmethode jene ursächlichen Faktoren aufgedeckt werden, die Studentinnen dazu ermutigt und antreibt einen Abschluss in einem Informatik- oder Softwaretechnik-Studiengang anzustreben. Insbesondere sollen darüber hinaus Verbesserungen für zukünftige weibliche Studenten entwickelt werden, um entsprechende Studiengänge attraktiver zu gestalten.
Mithilfe des sogenannten Theory Building nach dem Ansatz von Charmaz sollen individuelle Entscheidungen und Beweggründe von Studentinnen detektiert werden, die sich durch Konzeptionierung zu einer Theorie entwickeln lassen.
Entscheidend sind hier die individuell geführten Interviews, in der die persönlichen Faktoren des Interviewten eine zentrale Rolle spielen. Zweck der Interviews ist es, ein tiefschürfendes Verständnis über die Entscheidungen und Beweggründe einzelner weiblicher Studenten zu untersuchen, eingebettet in das Gesamtportrait ihrer Persönlichkeit.

Bedingungen zur Interview-Umgebung

Um den Ablauf des Interviews zu verkürzen, sind vorab einige Eckpunkte zum Interview zu beantworten.

Welches Hauptfach studierst du bzw. hast du studiert?

☐ Informatik ☐ Softwaretechnik

In welcher Sprache soll das Interview geführt werden? *

☐ Deutsch ☐ Englisch

Welches ist das präferenzierte Tool zur Durchführung des Interviews? *

☐ WebEx ☐ Microsoft Teams ☐

Die Erfassung von Mimiken und Gestiken des Teilnehmers ist ein wichtiger und fester Bestandteil eines Interviews. Eine Auswertung dieser Daten trägt zu einem signifikanten Teil der zu entwickelnden Theorie bei. Ist die Nutzung einer Webcam oder Ähnliches während des Interviews möglich? *

☐ Ja ☐ Nein

*Verpflichtende Felder

Figure A.11: Consent form in German: Project description & Terms and conditions

Melanie Schäfer
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Universität Stuttgart

Rechte und Verpflichtungen zum Interview

Während des Interviews zum Thema *„What Are The Factors That Enhance Female Participation in German Computer Science Curricula?"* werden sowohl von Seiten des Interviewers als auch des Interviewten Rechte und Verpflichtungen eingeräumt, die im Folgenden aufgelistet werden.

1. Die Meldung und Teilnahme am Interview zum oben genannten Projekt ist freiwillig. Für die Unterstützung und Bereitschaft zur Teilnahme bedanke ich mich vielmals.

2. Die Sicherheit des Teilnehmers hat oberste Priorität. Es wird sichergestellt, dass eine mentale Verletzung des Interviewten vermieden wird und dass das Wohlbefinden des Teilnehmers wichtiger als die Interessen an signifikanten Ergebnissen ist.

3. Der Teilnehmer hat das Recht das Interview jeder Zeit abzubrechen, falls übermäßige Belastungen auftreten. In diesem Falls hat der Teilnehmer keine negativen Folgen zu erwarten. Die bis dahin aufgezeichnete Tonspur wird mit Abbruch des Interviews vernichtet und steht anschließend nicht mehr zur Weiterverarbeitung zur Verfügung.

3.1 Während des Interviews können individuell auf das Gespräch angepasste Fragen gestellt werden, die die persönliche Grenze des Teilnehmers überschreiten können. Bei einer Übertretung hat der Teilnehmer das Recht, eine Beantwortung abzulehnen, abzubrechen oder zu überspringen ohne negative Folgen zu erwarten.

4. Der Teilnehmer hat das Recht, stattgefundene Einwilligungen zur Audio-Aufzeichnung, Niederschrift durch Transkription und/oder Nutzung der Kamera zurückzuziehen.

5. Der Teilnehmer hat das Recht eine angemessene, zufriedenstellende Erläuterung zum Thema der Masterarbeit zu verlangen, die in Bezug auf das Interview auftreten. Darüber hinaus hat er das Recht über die Ergebnisse der Forschungsarbeit in Kenntnis gesetzt zu werden, sofern er dies wünscht.

6. Die umfangreiche Planung und Durchführung des Interviews benötigt viel Zeit und Aufwand. Aufgrund dessen ist der Teilnehmer dazu verpflichtet, so gut, offen und ehrlich wie möglich auf die gestellten Fragen zu antworten. Ein geringes Interesse und eine oberflächliche Teilnahme können zu einem verfälschten Ergebnis führen.

7. Alle Daten und persönlichen Offenbarungen werden strikt vertraulich behandelt. Alle Angaben zur Person werden aus dem transkribierten Text entfernt und/oder anonymisiert. Das Interview wird in der Masterarbeit nur in Ausschnitten zitiert, um gegenüber Dritter sicherzustellen, dass der in den Interviews mit den Erzählungen entstehende Gesamtzusammenhang von Ereignissen den Teilnehmer nicht als Person erkennbar macht.

8. Zur ausreichenden Verwertung der anonymen Daten, werden die Audio-Aufzeichnungen bis zur Beendigung der Masterarbeit gespeichert und mit Beendigung vernichtet.

Vielen Dank für deine Teilnahme!

Figure A.12: Consent form in German: Rights & Obligations

Melanie Schäfer
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Universität Stuttgart

Einverständniserklärung

Ich habe die Bedingungen, meine Rechte und Verpflichtungen zum Interview gelesen und willige ein, im Rahmen der genannten Masterarbeit am Interview teilzunehmen.

Name des Interviewers: Melanie Schäfer

Name des Interviewten:

Interview Datum:

Ort, Datum Unterschrift

Einverständniserklärung über die Nutzung des Interviews und der gewonnen Daten

Ich bin damit einverstanden, dass das Interview aufgezeichnet wird und im Anschluss in Schriftform transkribiert bzw. niedergeschrieben wird. Zudem willige ich ein, dass die aus dem Interview hervorgegangen Daten zur Weiterverarbeitung bis zum Abschluss der Masterarbeit genutzt werden dürfen.

Ort, Datum Unterschrift

Figure A.13: Consent form in German: Declaration of consent

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All links were last followed on April 10, 2022.

Declaration

I hereby declare that the work presented in this thesis is entirely my own and that I did not use any other sources and references than the listed ones. I have marked all direct or indirect statements from other sources contained therein as quotations. Neither this work nor significant parts of it were part of another examination procedure. I have not published this work in whole or in part before. The electronic copy is consistent with all submitted copies.

place, date, signature