Technische Universität München
TUM School of Social Sciences and Technology

# Crossing the Rubicon:

## The Process of Study Choice and its Determinants

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## Abstract

Based on the lack of qualified professionals in fields such as science, technology, engineering, and mathematics (STEM), there has been an increasing interest in the process of study choice and how to provide appropriate learning environments and guidance to students during the choice process. Previous research in the field of study choice has provided evidence for significant influences of school factors, generational status (parents own academic degrees vs. parents do not own academic degrees), and gender on students' study choices. However, researchers have called for more systematic and theory-based research to compare and quantify existing results as well as for longitudinal perspectives on the study choice process. Therefore, the present dissertation seeks to dig deeper into these relationships, especially with the theoretical conception of study choice as a process with the phases (1) pre-decisional motivation (e.g., interest in a study field), (2) pre-actional volition (e.g., aspiration to take up a study program), (3) actional volition (e.g., taking up a study program), and (4) post-actional motivation (e.g., satisfaction with the study program). Especially the transition from pre-decisional motivation to pre-actional volition seems to be critical, as here, the "Rubicon is crossed" and the wish turns into a goal. The dissertation consists of article I, which focuses on school factors related to the first three phases of the choice process and article II exploring the influence of generational status and gender on the last three phases of the choice process. Article I aims to systemize existing research on the influences of school factors on students' choice of STEM fields. Therefore, a systematic review including the steps of literature search, literature selection, coding of relevant variables, and study analysis was conducted. By taking the perspective of a systematic review, Article I provides an overview of underlying models and theories, integrates the investigated constructs on the study choice process in STEM into a procedural model and investigated constructs on school characteristics into an overall model of school factors, and presents an overall picture of qualitative and quantitative results. Based on those findings, theoretical and methodological recommendations for future research were derived. Article II seeks to longitudinally investigate influences of generational status and gender on the study choice process of German students. Self-report questionnaires of the National Educational Panel Study (NEPS) provided data on generational status, gender, study choice, and satisfaction respectively dropout intentions. Data were analyzed using multinomial logit regression (MLR) modeling. Analyses revealed that generational status did not significantly influence the steps of the choice process but reproduced typical gender patterns in nearly

all cases. Together, the two studies highlight that study choice is a process with subsequent steps and that this process of study choice is influenced by individual and environmental factors.

## Zusammenfassung

Angesichts des Mangels an qualifizierten Fachkräften in Bereichen wie Naturwissenschaften, Technik, Ingenieurwesen und Mathematik (MINT) hat das Interesse am Studienwahlprozess und an der Frage, wie Schülern während des Wahlprozesses ein angemessenes Lernumfeld und Beratung geboten werden kann, zugenommen. Frühere Forschungsarbeiten auf dem Gebiet der Studienwahl haben gezeigt, dass schulische Faktoren, der Generationenstatus (Eltern mit akademischem Abschluss vs. Eltern ohne akademischen Abschluss) und das Geschlecht einen erheblichen Einfluss auf die Studienwahl von Schülern haben. Trotzdem werden immer wieder Forderungen nach einer systematischeren und theoriegestützten Untersuchung der Thematik gefordert, um die vorhandenen Ergebnisse vergleichen und quantifizieren zu können. Darüber hinaus bleiben längsschnittliche Untersuchungen des Studienwahlprozesses eher die Ausnahme. Die vorliegende Dissertation versucht daher, diese Zusammenhänge zu vertiefen, insbesondere mit der theoretischen Konzeption der Studienwahl als Prozess mit den Phasen (1) prädezisionale Motivation (z.B. Interesse an einem Studienfach), (2) präaktionale Volition (z.B. Bestreben, ein Studienfach aufzunehmen bzw. Studienfachaspirationen), (3) aktionale Volition (z.B. Aufnahme eines Studiums) und (4) postaktionale Motivation (z.B. Zufriedenheit mit dem Studium). Insbesondere der Übergang von der prädezisionalen Motivation zur präaktionalen Volition gilt als kritisch, da hierbei „der Rubikon überschritten werden muss“ und der Wunsch zum Ziel wird. Die Dissertation besteht aus Artikel I, der sich auf den Einfluss schulischer Faktoren auf die ersten drei Phasen des Studienwahlprozesses konzentriert, und Artikel II, der den Einfluss von Generationenstatus und Geschlecht auf die letzten drei Phasen des Studienwahlprozesses untersucht. Artikel I zielt darauf ab, die bestehende Forschung zu den Einflüssen schulischer Faktoren auf die Wahl von MINT-Fächern durch Schüler zu systematisieren. Dazu wurde ein systematisches Review bestehend aus Literatursuche, Literaturauswahl, Kodierung relevanter Variablen und Studienanalyse durchgeführt. Aus dem Blickwinkel eines systematischen Reviews gibt Artikel I einen Überblick über die zugrundeliegenden Modelle und Theorien, integriert die untersuchten Konstrukte zur MINT-Orientierung in ein Prozessmodell und die untersuchten Konstrukte zu den Schulmerkmalen in ein Gesamtmodell der Schulfaktoren und bietet letztlich einen systematischen Überblick über die qualitativen und quantitativen Ergebnisse. Auf der Grundlage dieser Ergebnisse wurden theoretische und methodische Empfehlungen für die zukünftige Forschung abgeleitet. Artikel II untersucht die Einflüsse

des Generationenstatus und des Geschlechts auf den Studienwahlprozess deutscher Schülerinnen und Schüler längsschnittlich. Fragebogendaten des Nationalen Bildungspanels (NEPS) wurden zur Untersuchung des Einflusses von Generationenstatus und Geschlecht auf Studienfachaspiration, Studienfachwahl und Studienzufriedenheit bzw. Studienabbruchabsichten genutzt. Die Daten wurden mittels multinominaler Logit-Regressionsmodelle (MLR) analysiert. Die Ergebnisse zeigten, dass der Generationenstatus keinen signifikanten Einfluss auf die einzelnen Schritte des Entscheidungsprozesses hatte, aber in fast allen Fällen typische Geschlechterverteilungen reproduzierte. Zusammengenommen unterstreichen die beiden Studien, dass die Studienwahl ein Prozess mit aufeinander folgenden Schritten ist und dass dieser Prozess von individuellen und äußerlichen Faktoren beeinflusst wird.

## Included Publications

The present dissertation project is written publication-based and consists of two articles published in international and peer-reviewed journals.

Regarding Article I, the author of the present dissertation (70%) lead the process of conceptualizing, developing research aims, analyzing data, interpreting results, and publication-based presentation of the article. The co-authors, Prof. Dr. Doris Holzberger (20%), and Prof. Dr. Tina Seidel (10%) supported and advised this process, which resulted in the following publication:

Reinhold, S., Holzberger, D., & Seidel, T. (2018). Encouraging a career in science: a research review of secondary schools' effects on students' STEM orientation. *Studies in Science Education 54*(1), 69-103. doi: 10.1080/03057267.2018.1442900

Regarding Article II, the author of the present dissertation (70%) lead the process of conceptualizing, developing research aims, analyzing data, interpreting results, and publication-based presentation of the article. The co-authors, Prof. Dr. Doris Holzberger (10%), and Prof. Dr. Tina Seidel (10%) supported and advised this process, Dr. Christian Kosel (10%) took a central role concerning choice and conduction of the final statistical analyses. The project resulted in the following publication:

Reinhold, S., Kosel, C., Holzberger, D., & Seidel, T. (2022). Exploring choices in higher education: Female and male first-generation students' trajectories from study aspiration to study satisfaction in Germany. Frontiers in Education 7, 1-16. doi: 10.3389/feduc.2022.964703

# Contents

# 1. Introduction

Asking your friends, „How did you choose your profession?" will probably result in a lot of different answers. Some will answer that they have "*always* known", or that they "liked science in school" and therefore continued with science in academia, others will tell you how difficult they found it to choose between all the alternatives and would have needed more counseling, and again others will say that they never had the chance to do what they "really wanted" and somehow regret their decisions. In the end you will have a colorful bouquet of diverse reasons, pathways, and choices with again diverse economic, social, and motivational outcomes. Finding a way to systemize and investigate this individual and diversely shaped process has been target for decades. Basically, the study choice process can be seen as a process of action – with different phases starting with a wish (i.e., pre-decisional motivational), continuing with setting specific goals (i.e., pre-actional volition), executing those goals (i.e., actional volition), and in the end evaluating the execution of the goals and its results (i.e., post-actional motivation). It is a process of weighing benefits and costs of an action and based on this deciding whether or not to take this action, which has been proposed from a motivational point of theory with the Rubicon[1] Model of Action Phases by Heckhausen and Gollwitzer (1987). As the study choice process has been moved into focus of research, other models with more specifically defined phases and further relationships with the environment were proposed, such as the social cognitive theory by Lent et al. (1994). Still, the models share the assumption, that study choice needs to be recognized as a process with successively connected phases and rather than a single incident in time. This assumption of multiple connected phases of the choice process has consequences for research on possible antecedents – for instance, schools' influences have to be explored not only on the action of choice itself, but also on previous phases such as whishing or aspiring to choose a specific program of study. The same obviously applies to research on the influences of students' individual characteristics such as parents' academic background (in the following 'generational status') or gender.

But why explore the study choice process at all? Reasons for this can easily be understood from practical relevance: (1) society and economy are in need of specialists in particular fields, the most popular ones with an urgent lack of employees are science,

[1] When Julius Caesar crossed the Rubicon river, he caused a civil war and had to take actions in order to solve this conflict. This ancient incident gives its name to the Rubicon model of action phases.

technology, engineering, and mathematics (STEM; European Centre for the Development of Vocational Training, 2016) – three times as many students graduate from humanities, social sciences, law, and education in OECD member states than from STEM fields; this tendency has not changed in recent years (OECD, 2015). Additionally, in the US, more students drop out of STEM subjects than any other subjects (National Science Board, 2015). Another reason from practice can be found in widely discussed inequalities concerning access to and participation in academia based on students' gender and family background. With regard to family background, students with parents lacking academic education, also termed first-generation students have been known to be underrepresented in higher education (Hauschildt et al., 2015) with consequences extending to underrepresentation in more prestigious, better-paid, more secure professions (Cataldi et al., 2018; Roksa & Levey, 2010) as compared to their continuing-generation peers with parents holding academic degrees themselves. Additionally to generational status, gender constitutes an individual factor whose inequal causes have been in the spotlight of societal and scientific discussion, especially focusing on the underrepresentation of women in (1) academic education in general, as they make up only about one third of university students in Germany (German Federal Employment Agency, 2019) and in (2) STEM fields (Ceci & Williams, 2011; Chen & Soldner, 2013; Hughes, 2011; Marsh et al., 2019; OECD, 2019; Yazilitas et al., 2013). This underrepresentation of women in specific fields, parallel to first-generation status causes financial disadvantages in the long-term (Quadlin, 2020) and more generally, cognitive, health, and social disadvantages (Chan, 2016; Griffin et al., 2019; U.S. Bureau of Labour Statistics, 2014). These inequalities stand in stark contrast to public opinion as well as policy objectives for higher education, such as the declaration of the Bucharest Communiqué (2012) in the course of the Bologna Process, where access to higher education is seen as a success factor for societal and economic progress and therefore needs to represent the diversity of Europe's population. On this basis, research on relationships between students' individual factors and the process of study choice are supposed to provide critical information to society and policy about enrollment gaps and attrition rates (Wright et al., 2021).

While research on the effects of these individual background factors provides critical information on the status quo, the question of how to support and reinforce students' pathways throughout the study choice process remains. In these terms, schools form an important environment for the development of interest, motivation, aspirations, and profession choices for students; in Germany, schools are legally obligated to provide

counselling and support for profession and study choices (Dedering, 2002; KMK, 2017). Additionally to the fact that the school environment has proven to be influential for plenty of students outcomes (e.g., Holzberger et al., 2020), school characteristics such as the learning environment and teaching approaches are manipulatable in favour of those outcomes.

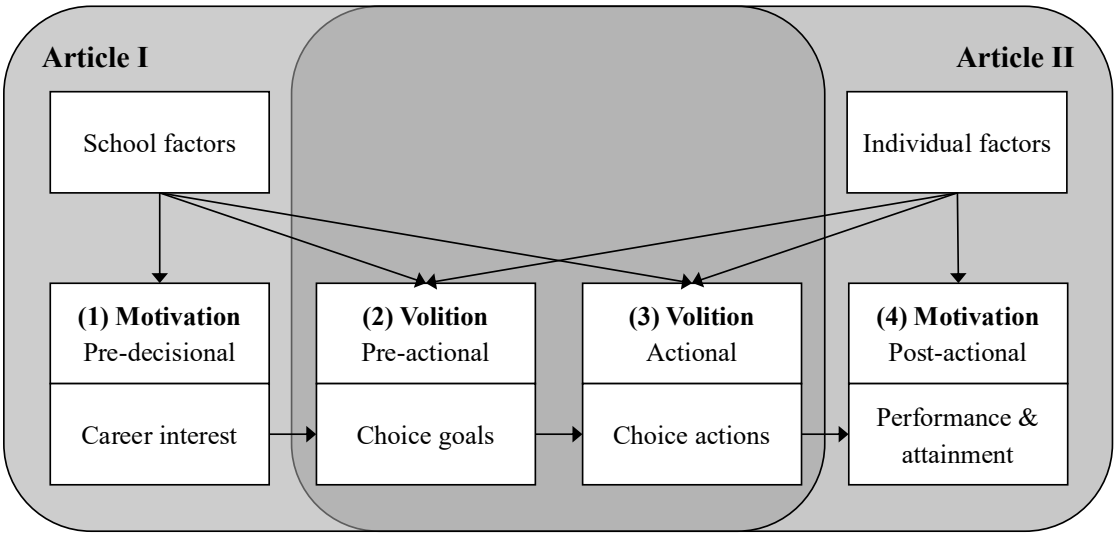
*Aims of the dissertation*. Overall, there has been plenty of research on the study choice process and the diversity of answers to how a profession is chosen has been processed and clarified to a certain extent. Still, there are aspects awaiting to be explored. Starting with a high diversity of research on schools' effects on the study choice process in STEM[2] concerning theoretical bases, construct definitions, methodologies, and selection of investigated constructs, the first part of the present dissertation project sought to systematically review the field of research. Therefore, Article I included in the present dissertation aimed at systemizing the field and provide overviews of used theories, definitions, and results and based on that derive suggestions for future research that is better comparable. Article II of the dissertation project has its rationale in research gaps regarding the influence of individual factors on the study choice process. Whereas most research in this field to date focused on one phase of the choice process, i.e., the actual choice of a major, which disregards the assumption that the phases are interconnected, Article II of this dissertation sought to add insights from a longitudinal perspective. Specifically, students' pathways from aspirations during upper secondary education over study program choices to study satisfaction and dropout intentions during academic studies. Additionally, the influence of generational status on educational participation has a strong research basis for the US context and with the analysis of the National Educational Panel Study (NEPS; Blossfeld & Roßbach, 2019) data, a specifically German perspective provides the possibility of comparisons.

Finally, the present dissertation sought to emphasize the importance of researching study choice as a process. To provide a comprehensive picture, Article I explored the first three phases pre-decisional motivation, pre-actional volition, and actional volition, and Article II analyzed the last three phases pre-actional volition, actional volition, and post-actional motivation. Figure 1 illustrates the described research targets of Article I and Article II.

[2] In Article I, the study choice process was examined with a focus on STEM subjects and was phased "STEM orientation process"

**Figure 1.**

*Research Targets of Article I and Article II.*




*Structure of the dissertation.* The present dissertation starts with the theoretical embedding of the executed research. As the study choice process is at the spotlight, theoretical models and existing research on this are presented in Chapter 2.1. and form the basic red thread to guide through the work. In Chapter 2.2., the investigated environmental and individual antecedents of the study choice process, namely school factors, students' generational status, and students' gender are backed up with an overview of the theoretical and empirical state of research. The following Chapter 3 on the present research provides the justification for the dissertation project in the light of the described theoretical background and its research gaps. Based on this justification, Chapter 4 overviews the methodological approaches used and a Chapter 5 summarizes the main results of Articles I and II follow. The final Chapter 6 provides the overall discussion of the dissertation project, discussing the main findings, limitations, and implications for practice and further research. The dissertation closes with an overall conclusion in Chapter 6.4.

# 2. Theoretical Background

The present chapter starts with central definitional and theoretical issues regarding the study choice process. With the defined study choice process steps as a basis, theory and existing research on environmental and individual antecedents, namely school factors, generational status, and gender are illustrated.

## 2.1. The Study Choice Process

For the purpose of the present dissertation thesis, Heckhausen and Gollwitzer's (1987) Rubicon Model of Action Phases and Lent and colleagues' (1994) Social Cognitive Career Theory were combined, as illustrated in Figure 2. The integrated model serves as a frame for the presently examined phases of the study choice process and for systemizing existing research. In the following, the two underlying models are described first and based on that the four proposed phases are defined in detail.

*Rubicon Model of Action Phases.* With the Rubicon Model of Action Phases Heckhausen and Gollwitzer (1987) suggested a theoretical model seeking to describe the process of action on a horizontal (i.e., chronological) axis as shown in Figure 2. The process is starting with a wish and ending with the assessment of the action. As the authors describe, the model sets out to find answers to questions such as

> How do acting persons choose their goals?
>
> How do they plan their actions?
>
> How do they realize their actions?
>
> How do they assess their action process and their action results?

as described by Achtziger and Gollwitzer (2010). The authors integrate models on the choice of goals and models on the realization of goals into one process and thereby describe the transitions "from wishing to choosing" and "from choosing to wanting" (Achtziger & Gollwitzer, 2010, p. 310). The differentiation between motivational (wishing) and volitional states (choosing, wanting) prevents the mixing of those two constructs theoretically and methodologically but also clarifies that they are interconnected and should not be understood as isolated phenomena. Each of the four proposed consecutive phases inherits distinguished tasks that the acting person needs to

take in order to successfully complete the phase and eventually transcend into the subsequent phase. In examining how actions are planned and carried out, the Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987) has also been used to describe and investigate (parts of) the general career choice process and aspirations (Kasperzack et al., 2014; Shane et al., 2012).

Following Heckhausen and Gollwitzer's (1987) propositions, the action process starts with *(1) the pre-decisional phase*. This phase is characterized by weighting the feasibility of a wish on the one hand and the desirability of potential consequences from realizing this particular wish on the other hand. Based on this weighting the phase ends with the establishment of a goal intention, which is the turning point from motivation to volition and therefore is called "crossing the Rubicon".

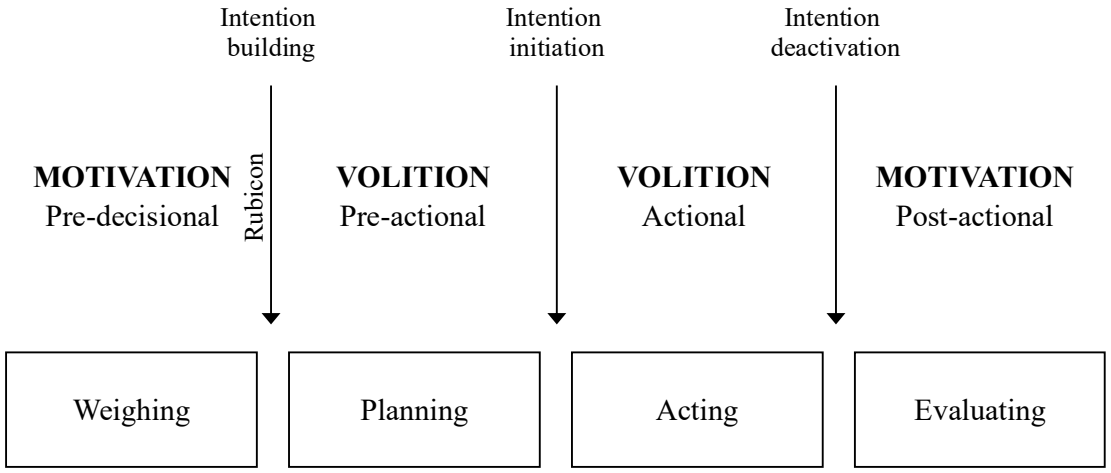
The following *(2) pre-actional phase* is characterized as volitional as the weighting of possible goals is completed and instead the realization of the chosen goal is wanted. This second phase involves planning when, where, and how the action should be implemented, those plans are also called intentions or implementation intentions. Gollwitzer (1993) proposed that those implementation intentions help overcome potential difficulties regarding the realization of the goal and therefore are mainly made for those aspects regarding which the person expects difficulties.

The process is assumed to continue with the *(3) actional phase* where the acting person seeks to put the implementation intentions into action and therefore involves persistence and increased efforts.

Lastly, the *(4) post-actional phase* is defined as motivational, as was the first phase. The acting person evaluates and assesses in how far the goal has been achieved and the anticipated consequences have occurred. At the end of this phase, there are two possible consequences: (a) in case of satisfaction with the outcome the goal is deactivated, or (b) in case of dissatisfaction the goal is deactivated or maintained and new plans are made to achieve the goal in another round (feedback loop).

**Figure 2.**

*The Rubicon Model of Action Phases by Heckhausen and Gollwitzer (1987).*




*Social Cognitive Career Theory.* Lent et al. (1994) proposed a model of how basic career interests develop over time based on the Social Cognitive Theory by Bandura (1986), which sets the persons' self-efficacy into focus, as displayed in Figure 3. Several studies incorporate Lent, Brown, and Hackett's (1994) Social Cognitive Career Theory, with a focus on STEM choice (Bottia, 2015; Fouad et al., 2010; Lee et al., 2015; Nugent et al., 2015). The phases defined in the Social Cognitive Career Theory are similar to the Rubicon Model of Action Phases in that they describe the progression from a general interest in a particular career path from mere interest with little commitment to a specific career goal with growing commitment and then on to specific choice actions regarding the career goal. Once more, the final phase focuses on achievement and performance within the selected professional path.

The model starts with *(1) sociocognitive mechanisms* of the person. Lent et al. (1994) propose that a combination of self-efficacy and outcome expectations fosters interest. Interest is in turn assumed to foster career choice goals, which are chosen in the following phase. Taken together, the motivational focus with the interplay of self-efficacy, outcome expectations, and interest of this first phase can be seen as parallel to the first phase of the Rubicon Model of Action Phases.

The second phase involves *(2) choice goals*. In the context of career choice, this phase is characterized by "intentions, plans, or aspirations to engage in a particular career

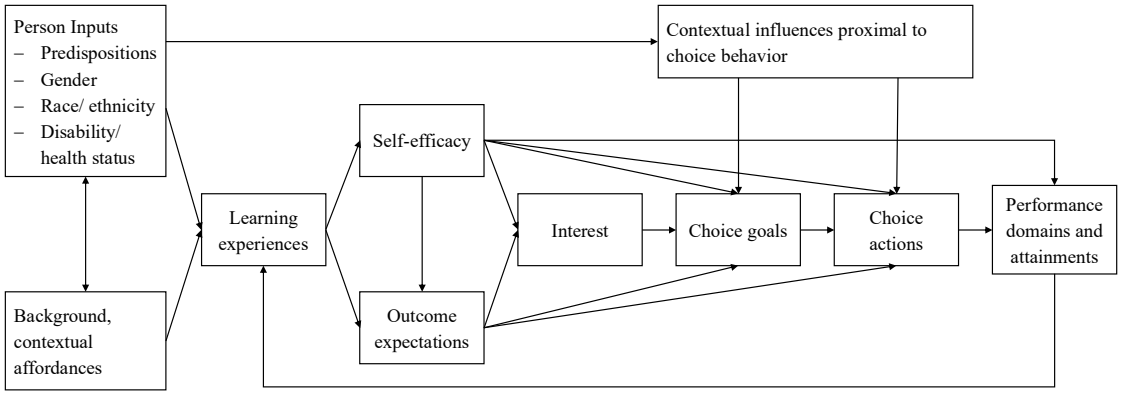
direction" (Lent et al., 1994, p. 95). The intentions that are made in the second phase are in turn assumed to foster choice actions in the next phase. The focus on intentions and planning how to put the goal into action is a parallel to the third phase of the Rubicon Model of Action Phases.

The third phase is characterized by *(3) choice actions*, such as declaring an academic major that corresponds to the choice goals. This phase also corresponds to the third phase of the Rubicon Model of Action Phases. The authors emphasize the importance of differentiating between the second and the third phase as it emphasizes the role of "personal agency" in the process of career choice, or in other words, it underlines the influence of the person itself as compared to influences from the environment in decision-making. Choice actions in turn are assumed to lead to specific performance domains and attainments (Lent et al., 1994).

Finally, the last phase involves *(4) performance domains and attainments* such as goal fulfillment and skill development. The last phase is assumed to "create a feedback loop, affecting the shape of future career behavior" (Lent et al., 1994, p. 94) as is proposed in the last phase of the Rubicon Model of Action Phases.

**Figure 3.**

*Model of How Basic Career Interests Develop Over Time (Lent et al., 1994).*

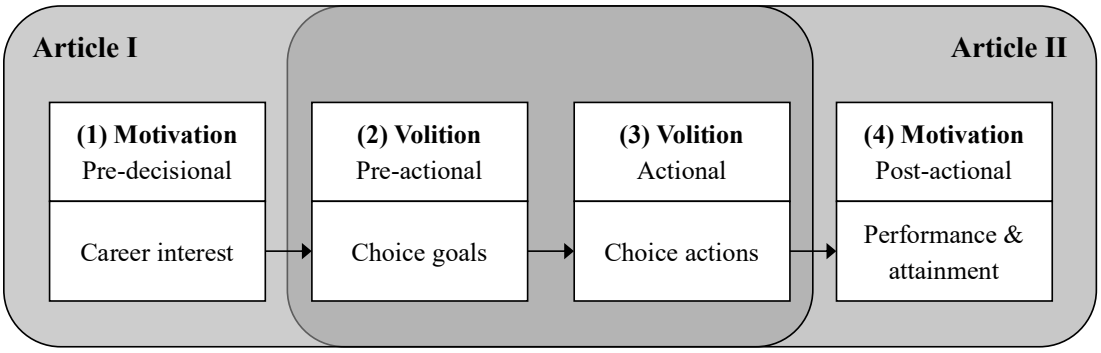



*Integrated model of the study choice process.* Based on the descriptions of the Rubicon Model of Action Phases and the Social Cognitive Theory of Career Development, their integration and use for the present dissertation will be illustrated in the following. The shared assumption that each phase influences the course of the following phase is adopted for the integrated model as existing research provides hints towards its validity: Recent studies, especially the ones focusing on the STEM area, have

shown that, for the first phase of career choice, students' interest in scientific phenomena and aspirations in that field are not stable over time (Ardies et al., 2015) and tend to decline from primary school through graduation (Frenzel et al., 2010; Gottfried et al., 2001; Savelsbergh et al., 2016; Taskinen et al., 2013). Also, the students' perception of not seeing their future selves in STEM fields contrasts with the generally positive attitudes towards STEM (Archer et al., 2015; DeWitt et al., 2013; Osborne et al., 2003). These results offer first indications that it is a complex task to bridge the Rubicon from wishing (pre-decisional motivation) to wanting (pre-actional volition). Yet, there is good news for students who aspire a major in STEM during school: they are more likely to decide to become scientists than those who do not aspire to major in STEM (Schoon, 2001; Tai et al., 2006). This scenario demonstrates that once the Rubicon has been crossed, students show a larger likelihood of moving on to actional volition and enrolling in STEM programs in order to become a scientist. Consequently, the exploration of the career choice phases as isolated constructs becomes insufficient and the interconnection between the phases can be assumed.

**Figure 4.**

*The Study Choice Process: Integration of the Rubicon Model of Action Phases (H. Heckhausen & Gollwitzer, 1987) and Social Cognitive Career Theory (Lent et al., 1994).*




As illustrated in Figure 4, Article I of the present dissertation focuses on phases one to three whereas Study II explores phases two to four. The first phase of the study choice process (i.e., *pre-decisional motivation)* is defined as a motivational state which is not tied to an actual decision towards a specific field of study. More precisely, it expresses motivational preferences or interests for instance for school subjects or specific activities or topics that are associated with those subjects. With the second phase of the study choice

process (i.e., *pre-actional volition)*, the motivation towards a specific subject or field turns into a goal to choose this field for further studies but is still located before the actual action of choice. In the third phase of the study choice process (i.e., *actional volition)*, the goal that was formed in the second phase is turned into an action: the favorized subject is chosen as the subject for further studies. The fourth and last proposed phase of the study choice process (i.e., *post-actional motivation)* is concerned with performance and attainments regarding the chosen study subject. This phase focuses on motivational aspects such as satisfaction with the chosen studies or in contrary the intention to dropout and change the subject.

## 2.2. Antecedents of the Study Choice Process

Numerous potential factors have been identified to potentially influence students' study choice process, including individual factors (such as family background, motivational-affective, cognitive, and gender differences) and environmental factors (such as school characteristics). The present dissertation focuses on school characteristics as environmental factors and generational status and gender as individual factors. The following sections provide an overview of the state of research on these factors.

*Environmental factors: School characteristics.* In Germany, one of the legal obligations of schools is to provide vocational orientation to students (Dedering, 2002; KMK, 2017) and to serve as a link between labour market and students (Butz, 2008). By means of this role schools can enable as well as limit students' vocational education (Kahlert & Mansel, 2007). However, vocational orientation in German schools seems to lack structuring – there is a surplus of information, responsible persons with a lack of pre-knowledge on the topic (Bührmann & Wiethoff, 2013), and a general lack of time and personnel for this purpose (Knauf & Oechsle, 2007). Especially, counselling concerning *study* subject choice (as compared to vocational choice) seems to be widely limited (Kayser, 2013). But what are reasons for schools to serve as a central focus for career choice at all? Existing research on the topic provides several reasons.

The first and practically most relevant reason lies in the changeability of schools with regard to positive effects on students' outcomes: As opposed to individual factors such as students' personal backgrounds (e.g., family characteristics, socioeconomic status [SES], and cultural capital) which have repeatedly been shown to influence student science outcomes (Archer et al., 2012; Fouad et al., 2010; Nugent et al., 2015; Taskinen et al.,

2013) and cannot easily be changed, school characteristics can be manipulated in favor of student outcomes.

The second set of reasons targets the fact that school characteristics have numerously been shown to be significant determinants of cognitive (e.g. achievement, performance, literacy, conceptual understanding) and motivational-affective STEM outcomes of students (e.g. motivation, self-efficacy, self-concept, interest) (Adams, 2014; Areepattamannil & Kaur, 2013; Basl, 2011; Belland et al., 2017; Boaler & Staples, 2008; D'Agostino, 2000; Frenzel et al., 2010; Hogrebe & Tate, 2010; Ma & Klinger, 2000). For example Adams (2014) found a school culture of student trust to positively influence students' beliefs, behavior, and achievement in mathematics and reading, Basl (2011) showed that students attending schools that offer career counselling and guidance showed higher awareness of science-related careers; Hogrebe and Tate (2010) and Ma and Klinger (2000) investigated the influence of other factors at school level such as SES composition, school size, or academic press on students' achievement, Frenzel et al. (2010) explored the role of classroom values and teacher enthusiasm for students' interest in mathematics, and D'Agostino (2000), and Belland et al. (2017) analyzed whether instructional characteristics such as computer-based scaffolding influenced students' achievement in STEM. Over the past few decades, school environments in general have been extensively investigated, as well as theoretically framed and developed (Kyriakides et al., 2010; Scheerens, 1990, 2015), and the effects have already been meta-analyzed (e.g., Holzberger et al., 2020). An example of models containing different levels of school characteristics is the Integrated Multilevel Model of Education (Scheerens, 2015), consisting of more distal school-level predictors of student outcomes, such as school ecology, school leadership, policies, and organization, as well as more proximal categories, such as classroom ecology, classroom climate, and teaching. Even the more distal characteristics of schools can promote student outcomes by offering and expanding learning opportunities and by providing a specific learning environment than can enable necessary learning activities (Seidel & Shavelson, 2007). Therefore, these distal characteristics are assumed to be related to proximal characteristics at the classroom level such as teaching (Maag Merki et al., 2015; Reynolds et al., 2014).

The third reason to explore schools' effects on students' outcomes is concerned with students' motivational development over their time in school, especially in STEM subjects: Interest concerning scientific phenomena and science aspirations are unstable

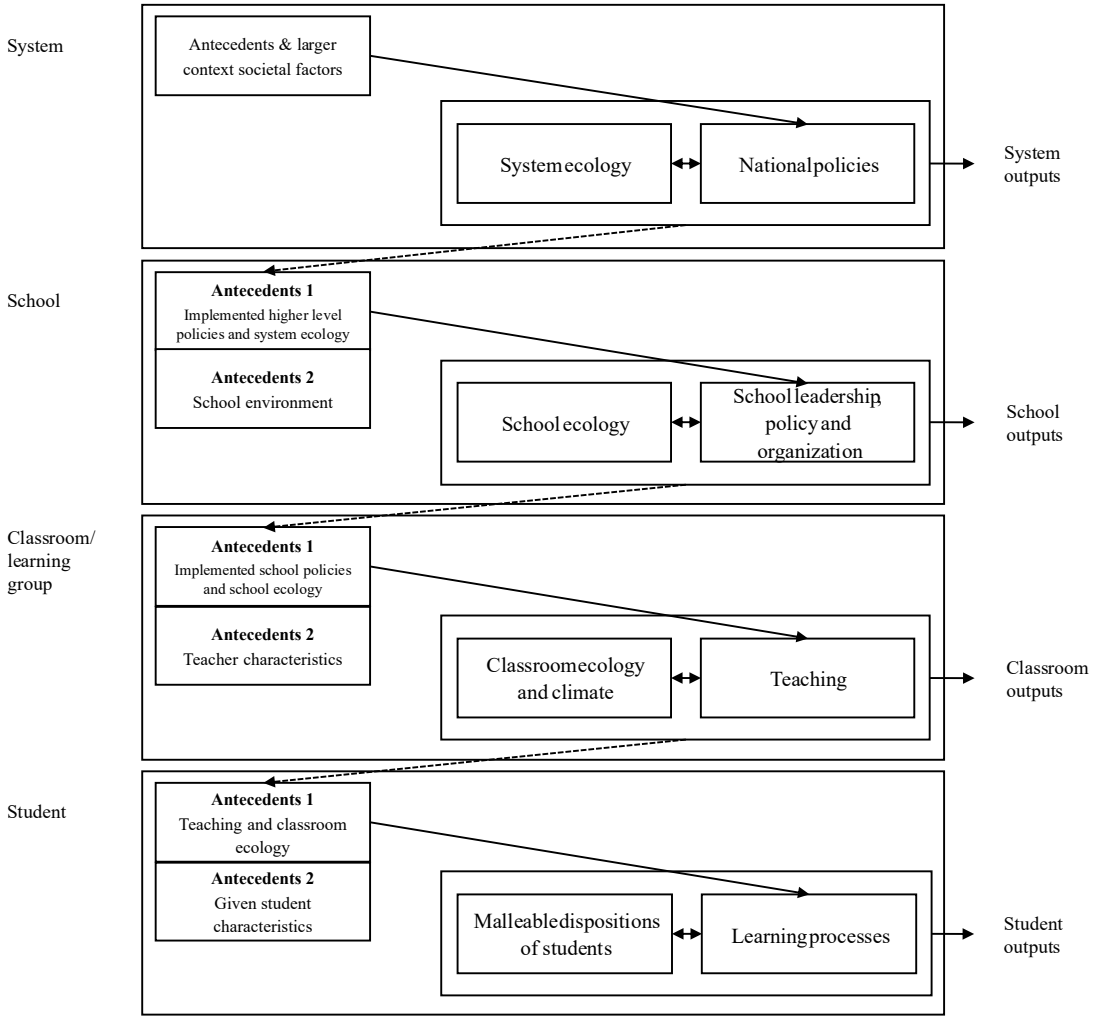
(Ardies et al., 2015) and tend to decrease over school time (Frenzel et al., 2010; Gottfried et al., 2001; Savelsbergh et al., 2016; Taskinen et al., 2013). Additionally, generally positive attitudes regarding STEM subjects contradict students' perspective of not aspiring a future in STEM areas (Archer et al., 2015; DeWitt et al., 2013; Osborne et al., 2003). This instability of STEM interests and aspirations during the school years leads to question the role of schools' possibilities to support and encourage STEM choice.

In summary, schools might play an important role for the study choice process based on their changeability, their significance for other learning outcomes so far, and because of the variability that students' interest in different subject areas over school time shows.

From the state of research, it becomes clear that the influence of a variety of school factors is being investigated, which in turn have been integrated into overall models. These models attempt to categorize the single factors into groups and levels and at the same time propose relationships between those groups and levels. For instance Opdenakker and Van Damme (2006) propose a model with school practice (containing educational framework, organization and management, and work and learning climate as variable groups) as an intermediate level between school composition (containing student population, teaching team, and school leader) and school context (containing descriptive characteristics such as denomination and location, and physical and material characteristics such as school size, study programme offerings, and facilities). The two levels composition and context, which are rather static and not easily subject to change, are hypothesized to influence the level of school practice. A somewhat different model was proposed by Scheerens (2015): the integrated model of education also assumes the school environment to influence the actual teaching and learning at the classroom level, as illustrated in Figure 5. Scheerens (2015) differentiates between the levels (1) system (containing system ecology and national policies), (2) school (containing school ecology and school leadership, policy, and organization), (3) classroom (containing classroom ecology, classroom climate and teaching), and finally (4) student (containing malleable dispositions of students and learning processes). Scheerens (2015) assumes each level to influence the next lower level, for instance processes at school level are subject to change by the implementation of policies from the system level, classroom characteristics are dependent from school leadership and the implementation of school policies from the school level, and student learning processes are influenced by classroom and teaching characteristics from the classroom level.

**Figure 5.**

*Integrated Multilevel Model of Education (Scheerens, 2015).*




*Individual factors: Generational status.* Additionally to environmental factors, the present dissertation explores individual factors to influence the study choice process, in the present section generational status will be discussed. First-generation students are defined as those students with parents lacking academic degrees as compared to their peers with parents holding academic degrees, in the course of the present dissertation called continuing-generation students. First-generation students are generally underrepresented in higher education (Hauschildt et al., 2015) which mirrors in lower enrollment shares in academic studies in Germany (Authoring Group Educational Reporting, 2018) as well as in the US (Cataldi et al., 2018). More specifically, their shares in study programs with more prestigious, better-paid, more secure job perspectives are

smaller than the shares of their continuing-generation peers (Cataldi et al., 2018; Roksa & Levey, 2010). The decrease of educational success with the level of socioeconomic status seems to be a worldwide phenomenon (Dräger, 2021; Elliott et al., 2011; OECD, 2012; Orr et al., 2011). Taking a more detailed glance at those first-generation students who make it to take up academic studies, they can draw on fewer financial resources, skills, and information on the academic environment than continuing-generation students can (Wilbur & Roscigno, 2016). These drawbacks partly stem from the fact that they more often belong to other disadvantaged groups such as being female, of higher age, Black or Hispanic (for the US context), have children to provide for, or come from financially disadvantaged families (Engle, 2007; Ward et al., 2012).

Previous research that has mostly examined the actual choice of a college major (Wright et al., 2021) has already gained insights into differences between study program choices of first-generation and continuing-generation students: Middendorff et al. (2013) have found first-generation students in Germany to tend to choose study programs in social sciences to a higher share compared to their continuing-generation peers, which has been confirmed by Trejo (2016) for first-generation students in the US – they also prefer study programs related to social sciences and additionally engineering. Continuing-generation students on the other hand have been shown to be clearly overrepresented in study programs such as medicine, pharmacology, psychology, or law. In Germany, these programs partly require to pass a state exam, with the exception of teacher education, in which usually first-generation represent the higher share (Middendorff et al., 2017). These preferences agree with the fact that first-generation students seem to choose their majors from a more practical perspective: they tend to end up in programs with higher perceived practical relevance, job-specific credentials, and more secure jobs with higher needs of the job market, leading to immediate success at the job market after graduation (Lehmann, 2009; Wilkins, 2014; Wright et al., 2021). However, those more secure areas potentially offer less prestige and promotion opportunities and therefore represent the less attractive alternative from a long-term perspective (Pascarella et al., 2004; Roksa & Levey, 2010). When it comes to first-generation students' situation during academic studies, previous research mainly focused on grades and attrition rates as Spiegler and Bednarek (2013) stated in their review on the US context and found only few significant differences to their continuing-generation peers. However, research on first-generation students' study satisfaction and dropout intentions or rates is not that clear-cut. On the one hand, Janke et al. (2017) demonstrate that first-generation students are satisfied with

their studies to a lower degree than their continuing-generation peers. Studies on dropout rates point into the same direction: Even after taking factors such as lower first year performance or full-time employment into account, first-generation students drop out of their studies with a higher probability than continuing-generation students do (Cataldi et al., 2018; Choy, 2001), with the first two years of study bearing the highest risk of attrition (Ishitani, 2006). First-generation students' predestination to drop out compared to continuing-generation students becomes even more clear with an increase of the targeted degree (Chen & Carroll, 2005), in Germany for instance, first-generation students' share decreases from bachelor's to master's degrees from 51 to 46 percent (Middendorff et al., 2017). On the other hand, other studies could not confirm these results, for instance Spiegler and Bednarek (2013) state in their review that differences between first-generation and continuing-generation students regarding attrition rates were rarely significant in the US context. In line with that, Behr et al. (2021) did not find significant differences between first-generation and continuing-generation students' motives for dropping out of their studies – however, dropout motives have been shown to be a complex braiding of cumulative and interdependent reasons (Hartl et al.; Heublein et al., 2017; Tinto, 1988).

*Individual factors: Gender.* Gender differences have probably been within the most researched targets in education research with a spotlight on the underrepresentation of specific groups in academic disciplines. More specifically, the underrepresentation of women in STEM study programs has been in focus internationally (Mann & DiPrete, 2013). With regard to Germany, female students are not only outnumbered in STEM study programs but even those with an academic degree in STEM enter a STEM career afterwards to a lesser degree than men (Schwerter & Ilg, 2021). As opposed to the focus on female underrepresentation in specific study programs, male underrepresentation in more female-dominated study areas such as the social sciences have not been targeted to that extent (DiPrete & Buchmann, 2013). A number of studies has proposed a broad variety of reasons for the gender gap in study choices: Eccles (2015) suggested gendered socialization paired with cultural beliefs that pass on the view that men and women are different by nature and therefore possess different strengths, talents, and preferences, Charles and Bradley (2009) explored family-work conflicts and characteristics of the academic institution such as offering "identity-based majors", and Hamilton (2014) investigated campus cultures reinforcing gender-specific career choices. Studies on gendered choice of specific study programs indicated that, in the US, women from upper

and upper-middle class prefer choosing majors which are characterized by “the ease of obtaining a high GPA” (Hamilton, 2014, p. 247), including programs such as business, communications, tourism, recreation studies, education, human development, fitness, or fashion on which little evidence exists that shows an increase on skills such as writing, critical thinking, or complex reasoning (Arum & Roksa, 2011). Compared to that, female students from lower socioeconomic backgrounds tend to more pragmatic choices just as first-generation students: better and immediate chances at the job market seem to be in focus with study programs such as nursing and education (Ma, 2009). But nevertheless, their more practical choices remain stereotypically gendered (England, 2010; Quadlin, 2020; Wright et al., 2021). These choices therefore entail the same disadvantages as already found for first-generation students’ choices, such as less prestige and financial gain and growth over time (Cohen & Huffman, 2003; England et al., 2002; Ma, 2009; Roksa & Levey, 2010).

# 3. The Present Research

The present dissertation project sought to illuminate the study choice process and the influence of environmental and individual factors on the course of this process. Focusing on study choice as a process with successive and interdependent phases has been justified theoretically in Chapter 2.1 and awaits to be explored in more detail, especially accounting for the process as a whole. Research has identified manifold possible determinants of this process of study choice – as described in Chapter 2.2., school characteristics, generational status and gender form a selection that has been shown to be influential and important for several reasons. Thus, the present dissertation aimed to illuminate some remaining ambiguities in the research field by means of Article I and Article II, which had the following alignments.

*Article I*. With Article I, the overarching aim was to systematically review the research field on schools' influence on the three first phases of the study choice process with a focus on STEM subjects. Existing research has focused strongly on the examination of individual prerequisites as influencing factors for STEM choice, much less focus has been laid on the school context which consequently entails calls for systematic and profound research in that area (Kleinert & Jacob, 2012; Nagengast & Marsh, 2012; Taskinen et al., 2013; van Tuijl & van der Molen, 2016). Therefore, Article I targeted the following research aims in particular. First, an overview of the models and the theories used in existing research on the hypothesized relationships between school factors and the STEM orientation process was developed (*Aim 1*). This first aim's justification lies in the fact that existing research on the effects of schools on STEM orientation often does not explicitly use theoretical models, neither for the investigated school factors, nor for the STEM orientation constructs. Investigated STEM orientation constructs, such as STEM aspirations (Mann et al., 2015), the motivation to explore STEM careers (Blustein et al., 2013), or the intention to declare a STEM major (Bottia, 2015) mainly remain unembedded in a procedural model and therefore lack systematic differentiation. Moreover, studies mostly target one single phase of the STEM orientation process instead of acknowledging the procedural character of study choice. A similar picture emerges with respect to school factors – studies analyze different selections of individual factors oftentimes without embedding them into an overall model of school factors. This situation has consequences: First, although the findings point to the school factors' significant positive effects on the STEM orientation process, consistent relationships between

schools and the STEM orientation process have not been able to be established to date (Nagengast & Marsh, 2012; Taskinen et al., 2013), and the comparison, as well as the interpretation of findings, are not always straightforward. Second, based on the theoretical overview, we seek to answer questions on the definitions of and provide both a taxonomy for the investigated STEM orientation constructs (*Aim 2a*) and an integrated framework of school factors and the STEM orientation process as suggestions for future studies (*Aim 2b*). Seidel and Shavelson (2007) provide a somewhat intuitive and highly relevant argumentation for using theoretical models: they show in their meta-analysis of teaching effectiveness that theoretical models facilitate the comparison and interpretation of effects, for instance, by acknowledging that some teaching factors (e.g., learning activities) are more proximal to learning than others (e.g., goal setting), and thus are assumed to produce greater effects on learning. Finally, Article I presents an overview of the main empirical findings from the included studies regarding the relationship between school factors and the STEM orientation process (*Aim 3*). The systematic review remains at the descriptive level as the investigated constructs varied widely and lack comparability. Therefore, the overview character of the review aims at providing suggestions for further (quantifiable) research in order to clarify in how far which school factors influence which phases of the study choice process in STEM.

*Article II*. Article II's main objective was to analyze the influence of students' generational status and gender on the three last phases of the study choice process. Acknowledging the merits of existing studies exploring reasons for differences in study choices between first- and continuing-generation students, as well as between male and female students a stronger focus on study choice as a process was targeted; instead of analyzing a single data point such as the choice itself and its individual determinants, Article II takes up a longitudinal perspective and explores the three last phases of the choice process, namely study program aspiration (pre-actional volition), study program choice (actional volition), and study satisfaction and dropout intentions (post-actional motivation). While plenty of research on first-generation students' study choices and study success has been executed in the US context, research on the situation in the German education system has not received as much attention – although children from lower socioeconomic backgrounds are 40 percent less likely to end up in academia than their peers from higher socioeconomic backgrounds in the German education system (Dräger, 2021), which might especially influence the situation of first-generation students. As existing research has indicated the intersection of generational status and

gender, both individual factors were explored in the article. Based on Wright and colleagues' (2021) conclusions, female and first-generation students were expected to choose more practical and applied as well as more normatively gendered study programs than their male and continuing-generation peers.

Hence, Article II analyzes data from the NEPS, which offers data representative for the German system, in order to provide information about the status quo in Germany and to enable international comparability in the field of research. Finally, the longitudinal perspective on individual factors' influences on the study choice process sought to illuminate whether and when first- and continuing-generation students as well as female and male students can and should be facilitated and counselled. Article II specifically focused on the following research questions:

1) To what degree do students differ in their …
   a. study program aspirations
   b. study program choices
   c. change behavior from aspiration to choice

   … according to generational status and gender?

2) Is there an interaction between generational status and gender regarding aspiration, choice, and change behavior?
3) To what degree do students differ in their study satisfaction levels and dropout intentions according to generational status and gender and depending on their change behavior?
4) Is there an interaction between…
   a. …generational status and change behavior and
   b. …between gender and change behavior

   …regarding study satisfaction and dropout intentions?

# 4. Methodology

The present dissertation includes the Article I which used the qualitative methodology of a systematic review in order to systemize the field of school characteristics' effects on the STEM orientation process and the Article II used a quantitative design examining the influence of generational status and gender on the choice process by means of German large-scale data. The methodology of both studies is described in detail in the following subchapters.

## 4.1. Article I

To summarize the research field of school factors and the study choice process in STEM and provide guidance for future research, a systematic research review was conducted (for definitions of systematic reviews, see for example Cooper & Hedges, 2009; Petticrew & Roberts, 2006; Polanin et al., 2017). The methodological steps are described in the following.

*Literature search.* First, a systematic literature search was conducted. The data bases Education Resources Information Center (ERIC) and Web of Science were searched, using keyword combinations for (1) school factors, (2) school career preparation, (3) STEM subjects, and (4) STEM orientation, as presented in Table 1. Literature search resulted in 293 results.

**Table 1.**

*Search Terms (published in Reinhold et al., 2018).*

| Category | Search terms* |
|---|---|
| (1) School factors | School, school level, school characteristic, school organization, school effect, school environment, school context, school factor, school program, school profile |
| (2) School career preparation | Career interventions, career development, career counseling, career orientation, career guidance, career education, career preparation, career information |

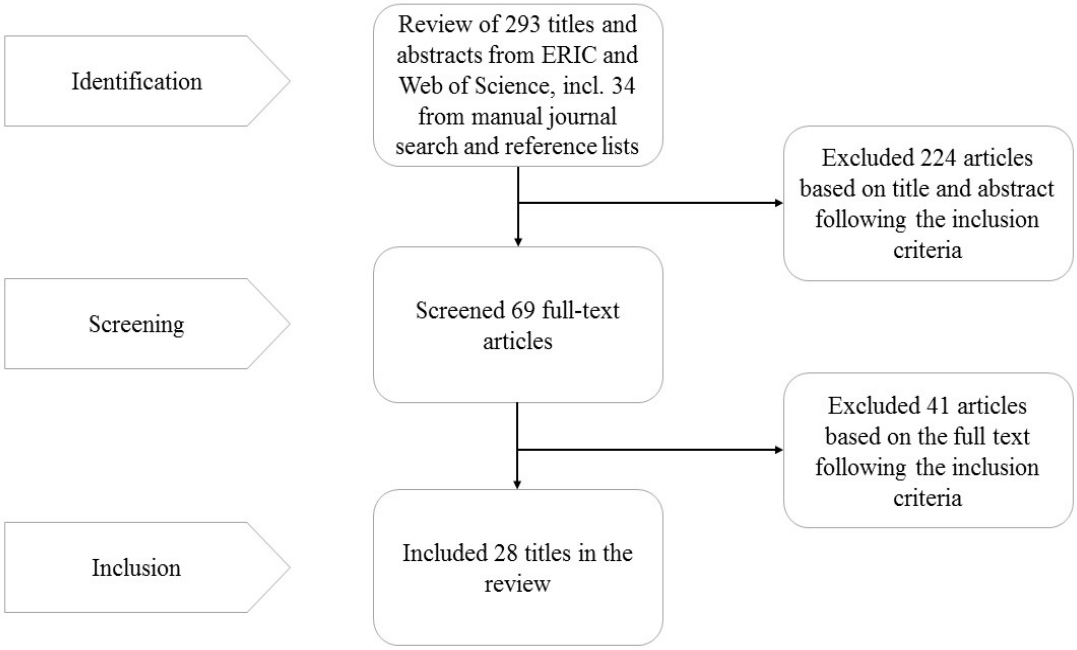
| | | |
|---|---|---|
| (3) | STEM subjects | Mathematics, science, STEM |
| (4) | STEM orientation | Career, major, enrollment, aspiration, orientation |

**Note.* Terms were used in different grammatical forms, such as plural and singular (e.g. characteristic/ characteristics), nouns and verbs (to aspire/ aspiration), or short forms (math/ mathematics) by using the operators in the ERIC and Web of Science advanced search engines

*Inclusion criteria.* The 293 studies were rated against the following inclusion criteria: (1) included articles had to be peer-reviewed, (2) both, quantitative and qualitative studies were included to obtain an overall picture of theoretical foundations and investigated variables, and (3) as the focus of the systematic review was on studies investigating secondary education's effects on the STEM orientation process, the final inclusion criterion was that the studies had to consider at least one combination of secondary school factors and STEM orientation. As illustrated in Figure 6, 293 articles using the titles and the abstracts for inclusion were checked in a first step of identification, resulting in 69 articles meeting the inclusion criteria so far. The co-authors met regularly to discuss and validate the decisions. In the second step of screening, full-texts were checked based on the inclusion criteria which resulted in 28 included articles in the systematic review. Most articles were excluded because they lacked the combination of school factors and student STEM orientation.

**Figure 6.**

*Literature Search and Coding Process. (published in Reinhold et al., 2018).*




*Study analysis and coding.* Seeking to provide an overview of general study characteristics, the included articles were coded according to the following elements: author, publication year, country, sample size, gender (percentage of female participants), mean age (in years), grade, school, student background, methods (qualitative, quantitative, instruments, and analyses), and theoretical foundation of the studies (name of the theory used, explicit and implicit theory use). Including the coded information, an overview table was created as suggested by Petticrew and Roberts (2006). In order to compare the studies, their theoretical foundations and investigated variables for the STEM orientation process and school factors were coded as follows. First, the investigated variables for the STEM orientation process were coded and categorized into the first three phases of the integration of the Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987) and the Social Cognitive Career Theory (Lent et al., 1994), namely pre-actional motivation, pre-decisional volition, and decisional volition. Moreover, as the constructs could refer to different time points, the constructs inductively categorized into the following temporal references: secondary education, tertiary education, a career in general, and a fourth group without a temporal reference. For example, nine studies investigated variables which were categorized into pre-decisional

motivation, with five of them referring to STEM orientation for a career (e.g., Blustein et al., 2013), whereas four studies used the PISA scale for future-oriented science motivation and thus referred to STEM orientation in general (e.g., Basl, 2011). Second, the school factors were categorized into more distal predictors of student outcomes, i.e., school ecology, school leadership, policies, and organization; and more proximal predictors to student outcomes, i.e., classroom ecology and climate; and teaching, based on Scheerens' (2015) Integrated Multilevel Model of School Effectiveness, as presented in Figure 5.

Two independent raters coded a selection of the included studies resulting in an interrater reliability of Cohen's $\kappa = 0.86$.

### 4.2. Article II

In order to explore connections between individual characteristics of students (i.e., generational status and gender), and the study choice process, Article II uses data from the National Educational Panel Study. The dataset was analyzed using Multinominal Logit Regression (MLR).

*Sample.* In order to analyze students' pathways from secondary school to academic education, two measurement points for starting cohort 4 (NEPS Network, 2021) were analyzed for Article II: students in grades 11-13 in secondary school (i.e., wave 5, 7, and 8) and postsecondary study (i.e., waves 8-10). Only data of those participants which were surveyed at both measurement points were included, resulting in 1,694 students. However, three participants were excluded because of missing data on gender[3]. Thus, we analyzed a final sample of 1,691 students of which 1,103 were first-generation students (65%)[4] and 933 were female (55%). Within first-generation students, 57% were female and within continuing-generation students, 51% were female. Compared to the original dataset (students which were surveyed during measurement point 1 in grade 11) in which 73% were first-generation students and 50% were female, there was a decrease of first-generation students to 65% and of female students to 45% was observed in the final sample (students which were surveyed during both measurement points 1 and 2). For

[3] The NEPS item t700031 (self-report) was used to assess gender.
[4] The sample contains a high share of first-generation students as compared to the US where roughly one third of all college students are first-generation students (Whitley et al., 2018).

detailed documentation on the measurement points and missing data, see NEPS Codebook for Starting Cohort 4, Version 9-1-0.

*Measures.* In the following sections the measured study variables and their operationalizations for Article II are described.

*Generational status and gender.* Article II focused the influence of individual factors on the study choice process. For the first individual factor of generational status, first-generation students were defined as those whose parents lacked academic degrees, such as a bachelor's, master's, or doctoral degrees, using International Standard Classification of Education (ISCED 97) levels lower than 9 and 10, as defined in the NEPS. Continuing-generation students were defined as those with at least one parent holding at least a bachelor's degree, using ISCED 97 levels 9 and 10. The second individual factor explored in Article II was gender, which was generated from the self-reported NEPS item t700031.

*The study choice process.* Article II explored the last three phases of the study choice process (i.e., study program aspirations for pre-actional volition, study program choice for actional volition, study satisfaction and dropout intentions for post-actional motivation). To operationalize the second phase of the choice process *study program aspirations*, responses to the open question "What will you probably study?" (NEPS item te06010_g2) were used, measured during grades 11-13 of secondary education. NEPS offers multiple classifications of areas of study; Article II used the categorization based on the German Federal Statistical Office (destatis 2010/11): (1) language and cultural studies, (2) sports, (3) law, economics, and social sciences, (4) mathematics and natural sciences, (5) human medicine and health sciences, (6) agricultural, forestry, veterinary, and nutrition sciences, (7) engineering, (8) arts, and (9) other. The category "other" includes comparatively study program areas with comparatively low numbers of students, such as sports, aesthetics, and agriculture. To investigate the third phase of the choice process *study program choice*, students' first major study subject was used for Article II, measured in students' first year of academic studies: "Which subjects have you been studying and are you studying at the moment?" (NEPS item ts15404_g2). Further or minor subjects were not included in the analyses. We used the same categorization of study areas as for study program aspirations. To further compare students' pathways from aspirations to choices, we calculated a dichotomous variable *subject change* (change, no change) that reflected whether students changed their subject area from study program aspiration to study program choice. For the last phase of the choice process *study*

*satisfaction* was operationalized by means of six items from the NEPS survey. The items were measured on a five-point Likert scale (1 = does not apply at all, 2 = applies a little, 3 = partly applies, 4 = mostly applies, 5 = fully applies) with a reliability of Cronbach's α = .82. Another factor representing the last phase of the choice process *dropout intentions* were operationalized using five items from the NEPS survey. The items were measured on a four-point Likert scale (1 = does not apply at all, 2 = somewhat applies, 3 = mostly applies, 4 = fully applies) with a reliability of Cronbach's α = .83. We scaled satisfaction down to four points to achieve better comparability, as satisfaction and dropout intentions were originally measured on different response formats.

*Socioeconomic status*. Additionally, to the central variables of Article II, all analyses used parents' SES as a control variable. Therefore, the internationally comparable International Socio-Economic Index (ISEI-08) scale of students' parents was used which is offered by the NEPS database. The ISEI-08 is based on the International Standard Classification of Occupations (ISCO) and Ganzeboom's (2010) proposals and integrates education, occupation and income. Based on the ISEI-08, parents' highest socioeconomic status (HISEI) was generated by using fathers' ISEI-08. When fathers' ISEI-08 was lower than mothers' ISEI-08 or not available, it was replaced with mothers' ISEI-08. Finally, the variable was categorized into 0 = low (0 to under 25 percent of HISEI values), 1 = medium (25 to under 75 percent of HISEI values), and 2 = high (75 to 100 percent of HISEI values) status groups (Authoring Group Educational Reporting, 2018).

The variables described above are case-specific variables, which means that they vary only across students.

*Analyses.* The central dependent variables in Article II (study program aspiration, study program choice, and change of study program) were nominal variables with multiple unordered values (e.g., the different program areas of study). Based on this, the influence of gender and generational status on the dependent variables was modeled with MLR. In general, MLR is used to estimate a categorical classification or the probability of belonging to a category (x = 1, 2, 3, …) for a dependent variable based on multiple independent variables. For Article II, maximum likelihood was used as the method to estimate the parameters of the model. One important requirement in MLR is that the minimum number of valid cases for each explanatory variable is 10, and preferred case to explanatory variable ratio is at least 20 to 1 (Hosmer et al., 2013). In the models used for Article II, this ratio is 543 cases to 1 explanatory variable and therefore meets the

requirement. However, interpreting logistic regression coefficients or log odds which result from MLR models, tend to be difficult to interpret as they represent the change in the log of odds of a dependent variable for a given change in an independent variable. An often-used alternative of assessing covariates influence on dependent variables in MLR which was used in Article II instead is to examine the average marginal effect (AME). AMEs are used to express the change of a predicted probability of a nominal outcome while the influencing factor changes. In Article II, the margins post estimation command in Stata 16 (StataCorp., 2019) was used to estimate and interpret the AMEs for each level of the dependent variables. With this approach, the marginal effects are first calculated for each individual of the full sample with their observed levels of covariates. The individual AMEs are then averaged across all individuals. Finally, in order to contrast the margins for the different factor levels of the independent variables, i.e., boys vs. girls, the contrast post estimation command (Williams, 2012) was used.

# 5. Summaries of Journal Article I and II

In the following, the results of Article I and Article II are summarized.

## 5.1. Article I

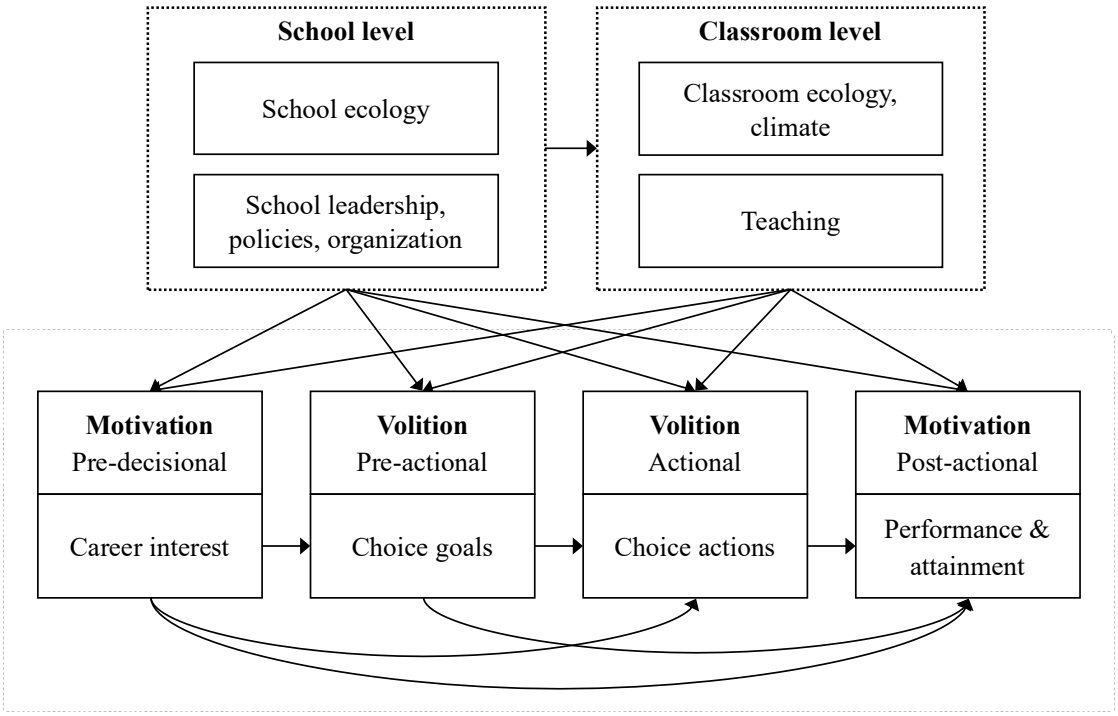
Journal article I (see Reinhold, Holzberger, & Seidel, 2018) sought to systemize the field of research on school characteristics affecting students' STEM choice process by providing (1) an overview of models and theories, (2) an integrated framework of investigated STEM orientation constructs and school factors, and (3) based on the overview and framework, an overview of empirical findings of the included studies.

Therefore, existing research was systematically reviewed following the steps suggested by Petticrew and Roberts (2006) as described in Chapter 4.1. Regarding the study's first aim, the systematic review resulted in an overview of applied models and theories. The variety of models and theories was categorized into three groups: theories on the general person-environment interaction (e.g., Bourdieusian theory, gender theories, theories on interest and motivation), theories on the person-school interaction (e.g., constructivist learning theories, social learning theory), and theories on the person-environment interaction with STEM orientation as an outcome (e.g. social learning theory of career selection, social cognitive career theory). The last group shares the assumption that STEM orientation is a process with steps building on one another. In contrast, seven of the 28 included studies did not base their research on any theory or model but used for instance practical relevance of the topic as a justification. Concerning the second aim, the 38 different outcome variables from the 21 included studies were extracted and integrated them into Heckhausen and Gollwitzer's (1987) Rubicon Model of Action Phases combined with Lent and colleagues' (1994) social cognitive career theory. The extracted 66 school factors were then categorized according to a simplified version of Scheeren's (2015) integrated model of education. Based on these categorizations, the integrated framework of school factors and STEM orientation was derived as shown in Figure 7. Regarding the third and final aim of the study, the comparison of empirical findings generally suggests school factors to be influential and meaningful regarding students' STEM orientation. However, existing findings neither revealed whether the STEM orientation phases are being affected differentially by school factors (e.g., pre-decisional motivation could not be identified as more influenceable by schools than actional volition) nor provided explicit information about the relative importance of the single

school factors. Nevertheless, a higher number of insignificant results at the school level was detected compared to the classroom level, which may be a first hint for a proximal-distal decline of effects.

**Figure 7.**

*Integrated Framework of School Factors and STEM Orientation. (published in Reinhold et al., 2018).*




*Note*. The last phase of post-actional motivation was theoretically assumed but exceeded the empirical scope of Article I.

## 5.2. Article II

Article II (see Reinhold et al., 2022) sought to shed light on students' study choice process from study aspirations in grade eleven over study program choices and finally to study satisfaction and dropout intentions in postsecondary education as shown in Figure 4.

By means of MLR (as described in Chapter 4.2.) the relationships under question were modeled, controlling for parents' SES throughout each of the analyses. Based on the calculated contrasts, differences between first- and continuing-generation students, male and female students, as well as between those who changed the subject from aspiration

to choice and those who did not change are illustrated and were tested for significance. Regarding research question 1 which targeted differences concerning generational status and gender in students' aspirations, choices, and change behavior, results indicate that (a) no contrasts were significant concerning the relationship between *generational status and aspirations*, except for the one that first-generation students had a 3% higher probability of aspiring to study aesthetics than continuing-generation students. A quite different picture opened up concerning the relationship between *gender and aspirations*: almost all contrasts were significant and confirmed already established gender differences with women aspiring humanities with a 7 % higher probability, law, economics, and social science with a 16 % higher probability, and medicine and health science with a 5 % higher probability than men. In contrast, women aspired mathematics and natural sciences with a 10 % lower probability and engineering with a 24 % lower probability than men. Results concerning (b) the relationship between *generational status, gender and choices* provide a quite similar picture as concerning the relationship to (a) aspirations: no contrast concerning differences between first- and continuing-generation students were significant, whereas gender differences appeared to be significant throughout all subjects except from the smaller ones (i.e., sports, agriculture, forestry, nutrition, veterinary medicine): women had higher probabilities to choose humanities (19%), law, economics, and social sciences (6%), medicine and health sciences (3%), and aesthetics (2%) than men. Again, they had lower probabilities of choosing mathematics and natural sciences (12%) and engineering (20%) than their male counterparts. In order to further explore students' trajectories from aspiration to choice, (c) the relationships between *generational status, gender, and change behavior* (from aspiration to choice) were analyzed. However, logistic regression modeling (as the dependent variable was binary) did not yield any significant differences, neither between first- and continuing-generation nor between male and female students.

Research question 2 sought to explore the interaction effect of generation status and gender on aspiration and choice. However, as analyses did not reveal any significant main effects of generational status on aspiration and choice, no interaction effects were interpreted. Research questions 3 and 4 explored differences in study satisfaction and dropout intentions according to generational status, gender, and subject change and did not result in any significant main effects except from gender – female students were significantly more satisfied with their studies than male students. This effect did not hold

for dropout intentions. Based on the mostly insignificant main effects with a small R2 = 0.01, interaction effects were not interpreted.

# 6. Overall Discussion

Overall, the present dissertation project sought to examine study choice as a process with subsequently connected steps and its individual and environmental antecedents, specifically generational status and gender, as well school characteristics. The present chapter discusses the central findings of the two included journal articles, reviews possible implications for practice and future research in that area, reflects methodological and theoretical limitations, and finally derives an overall conclusion.

## 6.1. Discussion of Central Results

In the present subchapter, central results from the two articles forming the dissertation project are discussed and placed in the context of existing research.

*Crossing the Rubicon: Integrating existing research into a process model of study choice.* As argued in the theory section, authors have proposed theoretical approaches that model study choice as a process with connected phases influencing the subsequent ones, such as the Rubicon Model of Action Phases by Heckhausen and Gollwitzer (1987) and the Social Cognitive Career Theory by Lent et al. (1994). In Article I, 28 studies exploring 38 single constructs with regards to STEM orientation have been reviewed. By carefully analyzing and comparing the construct definitions, the 38 different constructs were integrated into the first three steps (pre-decisional motivation, pre-actional volition, actional volition) of the study choice process. This integration is the key element that enabled comparability of the studies' results and systematically reviewing the field of research in the first place. Overall, only five studies included in the review acknowledged the procedural character of STEM orientation by researching more than one phase or point in time (Bystydzienski et al., 2015; Lee et al., 2015; Salto et al., 2014; Schoon, 2001; Ting et al., 2012). Schoon (2001) went a step further in also analyzing the interconnection of the phases and showed that students with a pre-decisional motivation towards STEM were more likely to cross the Rubicon and consequently decide for a STEM career.

Overall, the dissertation project sought to add to this point in exploring the entire study choice process by examining the first three phases (i.e., pre-decisional motivation, pre-actional volition, actional volition) with Article I and the last three phases (i.e., pre-actional volition, pre-decisional volition, post-actional motivation) with Article II, thereby providing a comprehensive picture of the process.

*Schools are relevant for the study choice process in STEM.* Schools are assumed to be a significant factor for study choice that is worthwhile to be examined as school characteristics can be manipulated to a certain degree (e.g., Holzberger et al., 2020) – as opposed to individual factors such as gender or generational status, for instance. The systematic overview on schools' quantitively and qualitatively determined influence on the STEM choice process revealed that in fact, almost all included studies point to schools' potential to foster students in that process. By this general finding, schools' obligation to counsel and inform students during their professional choice process (Butz, 2008; Dedering, 2002; KMK, 2017) turns into a feasible task. A more detailed look on the results revealed that at the school level, a higher number of insignificant effects occurred than at the classroom level. This finding may be a first sign pointing to a higher relevance of school factors, that are more proximal to students' individual processes of study choice. Research on classroom level factors more often used qualitative methods than research on the school level. This means that a relatively detailed picture of classroom level factors emerged, offering important starting points and potential directions for future research, especially to quantify these potential relationships. However, this general finding of more proximal factors at the classroom level such as teaching methods to be promising in comparison to more distal factors such as material or personal resources confirms previous data (e.g., OECD, 2016). In other words, what happens in the classroom is of crucial importance, not only for learning but also for the study choice process. Additionally, this does not mean that school level factors should be disregarded, as they are theoretically assumed to influence classroom level factors (Maag Merki et al., 2015; Reynolds et al., 2014; Scheerens, 2015), which was not sufficiently explored by the included studies.

*Generational status does not affect the study choice process.* With Article II, the main goal was to investigate differences between first- and continuing-generation students' pathways through the study choice process. Differences were assumed to be based on a probable lack of first-generation students regarding social and cultural capital as well as financial resources that might be relevant for the choice of a study program as compared to continuing-generation students (Pascarella et al., 2004; Wilbur & Roscigno, 2016). This lack of resources may lead first-generation students to end up in more practical study programs with secure job opportunities but in the long-term less growth in payment and prestige (Wright et al., 2021). In line with that, Middendorff et al. (2013) demonstrated in their review on the situation in Germany, that first-generation students tend to choose

study programs related to social sciences, whereas continuing-generation students are overrepresented in psychology and human medicine programs. However, contrary to existing research showing considerable differences, no significant differences concerning first- and continuing-generation students' study program aspirations and choices were revealed with Article II. Furthermore, considering the longitudinal character of the data, we examined differences between first- and continuing-generation students concerning their probabilities to change the study program from aspiration to choice, but differences were barely existent and not significant. Finally, investigating the last phase of the study choice process did also not result in significant differences between first-generation students and their continuing-generation peers' study satisfaction and dropout intentions. This is again partly contrary to prior research in the US context, showing that first-generation students have a higher probability to drop out of their study program than continuing-generation students, even after taking factors such as first-year GPA or full-time work into account (Choy, 2001). Janke et al. (2017) also found that first-generation students showed generally lower study satisfaction than their continuing-generation peers. Behr et al. (2021) on the other hand compared dropout motives of students from more educated with students from less educated backgrounds and could not confirm significant differences between the two groups as well as Spiegler and Bednarek (2013) stating in their review that only very few differences were significant between first-generation and continuing-generation students' attrition rates in the US. However, descriptive results pointed to the direction that students from less educated backgrounds more often indicated to drop out because of financial reasons.

*The study choice process is partly gendered.* With Article II, well-researched and cross-nationally established gender differences (Buccheri et al., 2011) concerning students' study program aspirations and choices have been confirmed. These two volitional phases of the study choice process show similar gendered patterns: female students form the predominant group in programs regarding humanities and law, economics, and social sciences, male students prevail programs regarding mathematics, natural sciences and especially engineering. Additionally, the rates of program change from aspiration to choice remain at a low level for both, men and women. The stability of gender patterns concerning the two volitional phases is in line with the basic assumption of the Rubicon Model of Action Phases, i.e., that once the Rubicon is crossed (turning from pre-decisional motivation to pre-actional volition), more loose whishes are turned into more fixed goals and therefore a change of these goals become more unlikely

to a certain extent. Concerning the last phase of the study choice process, i.e., satisfaction and dropout intentions regarding the chosen study program, Article II partly confirmed existing research. Female students showed significantly higher study program satisfaction than their male peers but differences regarding dropout intentions were not evident. Differences may occur, when investigating the choice of "gender atypical" study programs as shown by Riegle-Crumb et al. (2016): in their study, men entering female-dominated domains switched programs with a higher probability than male students in other domains.

### 6.2. Implications

Based on the discussed results, the present chapter provides suggestions for practical implications and future research.

*Practical implications.* The results of the present dissertation indicate some practical implications. Starting with the *longitudinal character of the study choice process*, policy and practice for instance in schools or higher education institutions need to acknowledge that the study choice itself is a product of an individually ongoing process and that the study choice is not the final step of the process, but that motivational outcomes such as study satisfaction during postsecondary studies result from the steps previously gone through. In practical terms, this means that, for example, a one-off test on career and study choices at a fixed time during secondary school, as is common in Germany, may be of help to some students if they have not yet taken the step into the pre-actional phase. For those who have already taken this step, however, other support options are probably more important, for example information on the selection and selection criteria of universities. This means that for different students, completely different support services can be useful at the same time - this leads to the assumption that generic methods for all students are rather ineffective compared to individual counselling. In addition to these points, the present dissertation also provided practical implications regarding the role of *school factors* in the study choice process. The overarching finding from Article I that schools are generally influential in the process, combined with the legal obligation of schools to provide career guidance and counselling in Germany, suggests that they can also be held responsible for this obligation. Furthermore, the results of the dissertation provide initial indications that especially the proximal factors at the classroom level are influential for the study choice process. While proximal factors at the school level are also more easily to be changed or improved than those distal factors at the school level or above, this is an

encouraging result for practitioners and policy: all the efforts that have been and still are made to improve and develop classroom characteristics and processes are effective also for the study choice process. Therefore, further interventions acknowledging the individual and procedural character of the study choice process can be assumed to be promising. Further, practical inferences regarding *individual factors*' influences on the choice process can be derived from the present dissertation. As Wright et al. (2021) stated, especially policy profits from more information on enrollment gaps and attrition based on students' generational status and gender. With Article II's confirmation of the well-known gender differences in the phases of the study choice process, another building block has been added on the already heavy pile of blocks pointing to the underrepresentation of women in STEM and men in social sciences. Policy therefore is urged to continue efforts to provide equal possibilities and counselling to women and men, taking the longitudinal character of the study choice process into account. The same goes for educational institutions, offering equal access and opportunities to both genders as schools have repeatedly been shown to serve as important environments for unfolding one's interests and aspirations (e.g., Reinhold et al., 2018; Holzberger et al., 2020). Deriving conclusions for practice from Article II's findings on the lack of differences between first-generation and continuing-generation students' study choice processes is a more challenging task. As the lack of differences so harshly contradicts previous research, this result should be interpreted with cautious optimism: It might be a first hint pointing to (perceived) equal opportunities of first-generation and continuing-generation students but as well be a product of factors that have been out of focus of the present dissertation, as will be discussed in the sections implications for future research and limitations.

*Future research.* In addition to the previously described practical implications, suggestions for future research in the research field can be derived.

A first group of suggestions for future research is concerned with the *study choice process* itself, as it was in the spotlight of the present dissertation project. As extensively described before, the existing body of research has tended to focus on single phases of the study choice process, whereas the procedural character and the interconnectedness of the phases has been widely neglected, although theoretically claimed. Those studies which have already applied a longitudinal perspective, confirmed the interconnectedness of the examined phases, for instance, students aspiring to choose STEM careers have increased probabilities to actually take up a STEM profession (Schoon, 2001; Tai et al.,

2006). The present dissertation sought to add to this research gap by incorporating all four proposed phases with Article I and Article II. Especially with Article II, a comparison of individual factors' effects on the three last phases have been insightful, for instance by revealing generational status and gender patterns within study program aspirations being similar to those within study program choices, which is consistent with theoretical assumptions of the Rubicon Model of Action Phases as described in the discussion of central results. Still, the present dissertation only provides a single examination of the process and the demand for further research in that area remains to be adequate, not only to reproduce the results but also to address further questions such as the investigation of the theoretically assumed feedback loop of the process: At which points do students restart the study choice process and with which consequences? Or to further explore the connectedness of the phases: How stable are students from wish to goal (i.e., crossing the Rubicon from pre-decisional motivation to pre-actional volition) as compared to the stability from goal to action (i.e., from pre-actional volition to actional volition, which was targeted with Article II)? By digging deeper into these questions, the theoretical basis for the study choice process can be empirically underpinned and insights into critical points in the process, for research as well as for practice may be revealed.

A second group of suggestions refers to the investigation of *schools' effects* on the study choice process. As examined with Article I, school factors' influences on student outcomes, and in particular on STEM choice have been target of research for decades. However, as revealed by the systematic review of the results, a high amount of qualitive findings concerning the classroom level provided detailed insights, but still await to be consolidated quantitatively. This is of particular interest, as classroom level factors are more proximal to students' individual choice processes than school level factors, and have therefore been assumed to be more influential on student outcomes (Seidel & Shavelson, 2007). Moreover, classroom level factors might be easier to be manipulated in favor of student outcomes. Consequently, quantifying research may be able to explore and answer the question about the relative importance of the single school factors and whether they have higher impacts on certain phases of the study choice process. By that, schools' sustainability and the long-term value of school-based interventions with regard to students' career decision-making may be illuminated. Finally, as hypothesized by school factor models such as the one by Scheerens (2015) which was used as a basis for the present dissertation, indirect effects of the school level on the study choice process through the classroom level have not yet been researched sufficiently.

The third group of future research proposals concerns the influence of the explored individual factors *generational status and gender* on the study choice process. Concerning *gender*, well-researched and well-known patterns in choices have been confirmed with Article II. To find out more about reasons and thereby gain further insights on possible counseling targets, future research might explore the transition from the first pre-decisional to the second pre-actional phase (i.e., the crossing of the Rubicon), for example investigate questions such as: what pros and cons do female and male students weigh against each other to proceed from wish to goal? What does females and males possibly keep from choosing gender atypical study programs? As research has shown, present efforts to mitigate the gender gap in STEM fields have not yet been a groundbreaking success as for instance course-taking reforms in upper secondary education in Germany did not significantly compensate for the underrepresentation of female students in STEM (Biewen & Schwerter, 2022; Hübner et al., 2017).

As discussed, findings regarding *generational status* from Article II showed opposing results to existing research in the US and the German context in so far as first-generation and continuing-generation students did not significantly differ in their study choice processes. At first glance, this could be interpreted as a good sign, as the lack of differences could indicate that first-generation students see the same opportunities for their study choices as their continuing-generation peers, despite their different backgrounds. This could again be a first clue that first-generation students face similar obstacles and difficulties during the study choice process as continuing-generation students. Based on these conjectures, future research could have the turn to more deeply investigate the study choice process with regard to the challenges, first-generation and continuing-generation students face during the single phases: What advantages and disadvantages do they weigh up for the transition from the pre-decisional motivation phase to the pre-actional volition phase in order to cross the Rubicon? Are there differences between first- and continuing-generation students? Are there cross-national differences? A popular example is the high tuition fees in the US compared to Germany, which presumably lead to higher financial barriers for first-generation students compared to their continuing-generation peers. Finally, further research is needed on the last phase of the study choice process to clarify first-generation and continuing-generation students' levels of satisfaction and dropout intentions, as existing research has shown contradicting results and the present dissertation did not find significant differences concerning generational status.

Other future quests of course would concern questions such as whether there could be other intermediating effects that have not been in focus of the present dissertation which could have caused the lack of differences between first-generation and continuing-generation students. For instance, does the preselection of those students who in the end manage to take up university studies at all make differences in study choices disappear? And finally, validation with further German data would help complete the picture.

### 6.3. Limitations

Interpreting the present dissertation's findings involves considering a number of theoretical and methodological limitations regarding the two included articles.

With regard to *methodological limitations of Article I*, a first limitation that probably partly stems from the literature search that was restricted to publications in English or German language was that studies examining the situation in the US context dominated the systematic review. However, a good third of the studies still originated in other national contexts so that international comparability was still possible to a certain degree. Although the main goal of the systematic review was to provide an overview of theoretical foundations and quantitative as well as qualitative results and therefore no statistical reanalyzes were conducted, the possibility of publication bias in favor of significant results (Matt & Cook, 2009) needs consideration because the literature search was restricted to peer-reviewed journal articles for quality issues. Further methodological restraints could relate to missing publications due to the selection of search terms or due to incorrect application of inclusion criteria which, however, was tried to be avoided as far as possible through a joint coding process of two independent raters, as described in the methods section of Article I. A further methodological limitation originates in the included studies as they rarely make use of randomized experimental designs or randomized sampling and therefore restrict comparability and interpretation.

Taking the *theoretical limitations of Article I* into account, the first point to emphasize is that the theoretical models which were used to integrate the study choice process and school factors are only one possibility among many. The aim here was to provide a theoretical basis for strengthening comparability and unambiguity of constructs, as well as to derive hypotheses on possible relationships between those constructs. This point also needs consideration with regard to Article II and the present dissertation as a whole. Further theoretical restraints of Article I originate again in the included studies as they

were situated in a lot of different theoretical bases and research contexts, used different construct definitions, methods, and stem from different national and cultural environments. However, these differences were among other things, targeted by the systematic review itself. As one limitation of Article I was that its' focus disregarded the important role of students' individual characteristics for the study choice process, this topic was spotlighted with Article II.

Concerning *methodological limitations of Article II*, one main point lies in the fact that only those students who had valid scores at all three measurement points were included in the analyses. Based on this preselection, a possible bias regarding generational status and gender shares which were detected could be explained (comparing the original and the selected dataset, a decrease of first-generation students from 73 to 65% and a decrease of male students from 50 to 45% were detected). Even more relevant to the findings could be, that by this preselection, those students who did not take up postsecondary studies were filtered out and therefore, possible differences between first-generation and continuing-generation students' pre-actional volition phase have not been visible. Reason for this approach was that only by selecting students with valid answers in all three measurement points enabled longitudinal comparison of the study choice process. This issue was discussed as a quest for future research in the previous subchapter. Another methodological issue was that Article II's results are based on certain categorizations of study subjects, partly for the sake of larger subgroups for the analyses. For instance, law and social sciences or as well mathematics and natural sciences were grouped into one category, although the first category probably features a high within variance concerning first- and continuing-generation students (for a separate consideration of law and social science see for example Middendorf et al., 2013 and Wright et al., 2021), and the second category might feature the same with regard to male and female students (see for example Dicke et al., 2019).

Additionally to the described methodological limitations, further *restraints related to theoretical decisions within the scope of Article II* need consideration. First and foremost, Article II did not tackle general access to or participation in academic studies but rather focused on the choice of certain study programs. This point needs emphasis as it might cause expectations of more extreme differences between first-generation and continuing-generation students if mixed up. Second, as already discussed in the implications section, the missing differences between the two groups might have been caused by intermediating variables out of focus of Article II as well as might become visible when

digging deeper into the single phases of the study choice process (for instance, what are the advantages and disadvantages that first-generation students weigh against each other from pre-decisional motivation to pre-actional volition?). In this light, the findings comparing first-generation and continuing-generation students need to be interpreted with caution. Moreover, researchers have critiqued the exploration of generational status defining first-generation students as a group at risk from a mere deficit perspective (Ives & Castillo-Montoya, 2020; Terenzini et al., 1996; Valencia, 1997) and therefore stigmatizing first-generation students as lacking social and cultural capital based on their parents' lack of academic degrees. This view reinforces expectations that first-generation students need to assimilate to institutional characteristics instead of calling for institutional modifications in favor of all student groups (Reay, 2009). Hence, first-generation students need to be viewed as "fully legitimate participants in higher education" (Spiegler & Bednarek, 2013). A more basic limitation of Article II concerns the comparison of only the two "extreme" groups of students with parents owning academic degrees versus students with parents lacking academic degrees. Other authors have suggested to add more sub-groups for instance students with parents with some academic experience or one versus both parents with academic degrees (e.g., Ishitani, 2006). However, repeating the analyses with more subcategories did not lead to substantially different findings for Article II. While these theoretical constraints need consideration, the exploration of differences between first-generation and continuing-generation students might illuminate challenges and problems that are unique to each group and therefore need individual counseling.

### 6.4. Conclusion

The core of this dissertation was the consideration of study choice as an action process with successive phases as proposed by Heckhausen and Gollwitzer (1987). This approach made it possible to systematize this individual and diversly shaped process as described in the introduction, and to examine environmental and individual factors influencing it. Article I included in the present dissertation integrated existing research on the relationships between school factors and STEM study choice into the Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987) and the integrated multilevel model of education (Scheerens, 2015). Based on that, Article I systematically reviewed and provided overviews of underlying theories, methods, and findings in this research field, showing that schools are generally effective for STEM study choice and have the potential

to be modified in favor of supporting students through their study choice process. Ultimately, the findings lead to the derivation of methodological and theoretical challenges for further research in this area in order to provide comparable and useful information for research, policy, and school practicioners. While Article I mainly sought to systemize the field of research on schools' effects on STEM study choice, Article II examined influences of generational status and gender from a German education system view. Thereby, the theoretical integration of study choice into a procedural model was investigated empirically and findings confirmed conjectures such as the stability from pre-actional to actional volition or in other words from study program aspiration to choice, as the Rubicon had already been crossed and the whish had turned into a goal. As data on study program aspiration had been collected during secondary grade 11, the results point to the direction that the pre-decisional motivation phase has been gone through earlier. Therefore, counseling and support for students' choice of a study program might be of help at earlier points in time. Respectively, counseling in terms of university choice or application training would be of help at this stage. Additionally, Article II added to existing research on study choice depending on generational status and gender. While confirming well-established gender patterns in study program choices with women being overrepresented in law, economics, and social sciences and men dominating mathematics, natural sciences, and engineering, the article's findings concerning generational status contradicted previous studies harshly: By examining data which was considered representative for the German system, differences between first-generation and continuing-generation students have not been found. Existing research by constrast has established considerable differences regarding generational status, which is why this finding should be interpreted with caution.

Overall, the present dissertation illuminated the whole process of study choice by examining the assumed four phases pre-decisional motivation over pre-actional volition and actional volition to post-actional motivation via the two included articles. By that, the procedural character of study choice was emphasized and has proven as a useful framework for the conducted research. Future research can build on the present dissertation's findings and dig deeper into the logitudinal examination of the choice process, relationships to individual and environmental factors and thereby provide more stable information to policy and practice.

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## Appendices

### A. Journal Article I

Reinhold, S., Holzberger, D., & Seidel, T. (2018). Encouraging a career in science: a research review of secondary schools' effects on students' STEM orientation. *Studies in Science Education 54*(1), 69-103. doi: 10.1080/03057267.2018.1442900

### B. Journal Article II

Reinhold, S., Kosel, C., Holzberger, D., & Seidel, T. (2022). Exploring choices in higher education: Female and male first-generation students' trajectories from study aspiration to study satisfaction in Germany. Frontiers in Education 7, 1-16. doi: 10.3389/feduc.2022.964703

*Note:*

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