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Does Gender Composition in a Field of Study Matter? Gender Disparities in College Students' Academic Self-Concepts

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Abstract

Gendered field-of-study choice is a lively topic of discussion. The explanation usually given for the fact that women are still an exception in typically 'male' fields—particularly STEM (Science, Technology, Engineering and Mathematics)—employs domain-specific stereotypes regarding men's and women's 'natural' abilities in different fields. The central argument of our study is that domain-specific gender stereotypes help explain why few women *enter* such fields; however, they are not necessarily the driving forces behind the finding that female students who *chose* typically male subjects have weaker academic self-concepts than their male peers. If it were only domain-specific gender stereotypes that influence students' perceptions of their abilities, we should find the opposite result in typically female fields of study and no differences in gender-mixed fields. Because existing studies often focus on the male-dominated STEM domain alone, research may have drawn the wrong conclusions. By comparing students in male-dominated, female-dominated, and gender-mixed fields of study, we ask: Does gender composition in the field of study matter for gender disparities in college (university) students' academic self-concepts? Using data from 10,425 students in the German National Educational Panel Study, our results suggest that it is not only in male-dominated fields of study that women rate their own abilities to be poorer than men rate theirs; the same is true in female-dominated and gender-mixed fields. Therefore, domain-specific gender stereotypes regarding students' abilities do not (alone) seem to drive gender disparities in STEM students' perception of their own abilities. No matter what academic field we consider, female students generally exhibit weaker academic self-concepts; however, the gap is most pronounced in male-dominated fields.

Keywords Academic self-concept · Gender stereotypes · Higher education · Fields of study · STEM · Gender composition

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Introduction and Guiding Research Question

For some time, a debate has grown around the changing gender dynamics in higher education (e.g., Leathwood & Read, 2008). Participation in higher education has seen a shift in recent decades, with the number of women undertaking tertiary study now surpassing that of men, whereas until the 1990s, OECD countries still had more male than female students (Vincent-Lancrin, 2008). Nowadays, women not only enroll in college more frequently than men, but female students also graduate just as often as male students (OECD, 2022). In Germany, the country of our focus, approximately 48% of higher education graduates are female (World Bank, 2023). However, despite women's growing participation in higher education, gender disparities persist at the horizontal level of education—that is, in the choice of academic fields and professions (e.g., Kriesi & Imdorf, 2019). The German labor market remains gender-segregated, and this segregation is mirrored in higher education choices (e.g., Barone, 2011; Lažetić, 2020; OECD, 2022). Fields where women predominate, such as education, humanities, or care, tend to be associated with lower incomes and, in part, less favorable career outlooks, whereas male-dominated fields, such as engineering or computer sciences, usually provide high-paying jobs and promising career prospects (Leuze & Strauß, 2009; Reimer & Steinmetz, 2007).

Although patterns of gendered subject choice have changed over time and vary across cultures, the general tendency of men and women to choose different academic disciplines is a well-known global phenomenon that has remained stable over time (Barone, 2011; Charles & Bradley, 2009) and the persistence of gender disparities has been a topic of lively discussion. One issue that has sparked considerable debate is the underrepresentation of women in fields of Science, Technology, Engineering, and Mathematics (STEM), both in higher education and on the labor market (e.g., Tandrayen-Ragoobur & Gokulsing, 2021; Thébaud & Charles, 2018; Xu, 2008). International comparative data shows that, on average, less than 40% of STEM graduates worldwide—and under 30% in Germany—are women, highlighting the male dominance in these fields (World Bank, 2023). Of course, in specific STEM disciplines, e.g., biology, pharmacy, and architecture, women are no longer a small minority; however, in Germany and many other Western countries, all the very male-dominated subjects—such as engineering, physics, computer sciences, and technology—belong to STEM; and these fields also have the highest number of students among STEM subjects (OECD, 2022).

A rich body of research has been dedicated to exploring the reasons behind the persistent gender disparities in STEM participation (e.g., Eccles & Wang, 2015; Sax et al., 2015; Su & Rounds, 2015; Wang et al., 2015). One of the main arguments is that deeply-rooted gender stereotypes about the 'natural' gifts and abilities of boys and girls or men and women contribute to this gender gap by reducing women's expectations of success, interest, and self-perceived abilities in these areas (e.g., Cheryan et al., 2011; Eccles & Wang, 2015; Förtsch & Schmid, 2018; Makarova et al., 2019; Master & Meltzoff, 2020; Nosek et al., 2002). This belief is particularly pervasive in the Western context, where the stereotype of STEM as a 'male' domain prevails, potentially deterring women from pursuing careers within this sector (e.g., Nosek et al., 2009).

Interestingly, however, even the selective group of women who have chosen a 'male' field of study *despite* existing gender stereotypes, and who display high-level mathematical achievements, still report weaker academic self-concepts than their male peers (e.g., van

Soom & Donche, 2014). But is it only women in 'male' fields who suffer from poorer academic self-concepts? This is still a largely unresolved question, as studies usually focus only on fields within the STEM spectrum—which is predominantly male-dominated—when examining gender disparities in college students' perceptions of skills (Espinosa, 2008; Förtsch & Schmid, 2018; van Soom & Donche, 2014). By design, these studies are blind to the question of whether the gender gap in students' academic self-concepts is unique to male-dominated fields of study or is more general in nature and also occurs in female-dominated and gender-mixed fields of study. Therefore, the central question of our study is: *Do gender disparities in college students' academic self-concepts exist in all fields of study? And if so, how do they relate to gender composition in the field?*

Despite its essential importance, to the best of our knowledge, this crucial point has not yet been investigated. To examine the question, our empirical study uses data from 10,425 college students in the German National Educational Panel Study (NEPS) (Blossfeld & Roßbach, 2019). Among other things, the survey asked students how they perceived their subject-related academic abilities. To classify subjects and compare gender disparities in students' academic self-concepts across fields of study, we use data from official statistics on the share of male students, distinguishing male-dominated STEM subjects from female-dominated or gender-mixed fields. As Germany and other OECD countries show overarching similarities regarding gender dynamics and stereotypes (e.g., Charles & Bradley, 2009; Nosek et al., 2009), Germany can serve as an example for several other countries.

Theoretical Background and State of Research: Why is it Important to Compare Gender Disparities in College Students' Academic Self-Concepts *Across* Fields of Study?

We can broadly define the academic self-concept as an individual's subjective perception of their own academic abilities (Shavelson et al., 1976). It is a multifaceted and multidimensional construct that divides into various subareas, such as mathematical and verbal academic self-concepts (Marsh, 1986, 1990; Shavelson et al., 1976). As children grow up, their academic self-concepts become increasingly elaborate, and in young adulthood, individuals have complex and differentiated understandings of their own abilities in various academic fields (e.g., Guay et al., 2003). Besides being an important outcome, the academic self-concept is also an important predictor for individuals' development and behavior. Various studies have shown that an individual's academic self-concept affects not only their learning behavior and competence development (e.g., Dulay, 2017; Marsh & Martin, 2011) but also educational choices and decision-making processes (Dickhäuser et al., 2005; Henderson et al., 2017; Nagy et al., 2008).

Explanations of how individuals form their academic self-concept strongly emphasize the role of academic achievements. Individuals use information they receive about their (potential) abilities, e.g., in the form of school grades, to develop an understanding of their own abilities and talents. The close interrelation of individuals' academic achievements in specific domains and their domain-specific academic self-concepts is empirically well documented (e.g., Chen et al., 2012; Chen et al., 2013; Guay et al., 2003; Marsh, 1986).[1] However, research has also pointed out that individuals do not only refer to their achieve-

[1] Research also suggests that this interrelation is complex, with individuals' academic self-concepts not only being shaped by their achievements but also shaping their achievements. The connection between academic

ments—their 'objectified' abilities—to form their academic self-concepts (e.g., Wolff et al., 2018; Wolff et al., 2019) but also to 'socially attributed' abilities based on their gender (e.g., Wolter & Hannover, 2016; Wolter et al., 2011). Particularly for STEM, a domain predominantly considered as 'male', the role of gender stereotypes—that is, "socially shared beliefs about which characteristics male and female persons have or should have" (Wolter & Hannover, 2016, p. 682)—has been the subject of a lively debate (e.g., Eccles, 1989; Kessels & Hannover, 2008; Nagy et al., 2010).

The basic assumption is that societally deeply-rooted and individually incorporated stereotypes regarding male and female 'natural' dispositions and talents in different domains influence not only how boys and girls grow up (e.g., McHale et al., 1999), what interests and abilities they develop (e.g., Bian et al., 2017), what choices they make (e.g., Sinclair et al., 2019), and how they behave (e.g., Wolter & Hannover, 2016), but also how they think of themselves and their own abilities, regardless of how able they really are (e.g., Marsh, 1986; Schilling et al., 2006; Wolter & Hannover, 2016; Wolter et al., 2011). Hence, no matter how 'objectively' able individuals may be in a specific domain, and even if their academic achievement in that domain is the same as that of others, they may still perceive their abilities differently just because of their gender.

Several studies have shown that gender differences in individuals' self-concepts exist from a young age; they only partially reflect gender disparities in actual performance, but conform to common gender stereotypes (e.g., Eccles et al., 1989; Eccles et al., 1993; Möller & Trautwein, 2015; Schilling et al., 2006; Wigfield et al., 1991; Wigfield et al., 1997). This finding is particularly well-documented among school-aged children both in the German and the international literature (e.g., Schilling et al., 2006; Skaalvik & Skaalvik, 2004; Wilgenbusch & Merrell, 1999). For instance, research has shown that girls have a weaker mathematical self-concept than boys (e.g., OECD, 2015; Schilling et al., 2006) and are more critical of their abilities in science and other academic fields typically deemed to be male fields. Conversely, boys report a weaker verbal academic self-concept (e.g., Schilling et al., 2006; Skaalvik & Skaalvik, 2004).

When it comes to gender disparities in the academic self-concept of college students, a central limitation of the state of research is that empirical studies tend to concentrate only on very specific fields of study, namely, those belonging to STEM (e.g., Espinosa, 2008;Förtsch & Schmid, 2018; Niepel et al., 2019; Robnett, 2016; Sikora & Pokropek, 2012; van Soom & Donche, 2014).[2] Despite making important contributions, this analytical narrowing to specific fields of study limits the explanatory power of these studies. A critical methodological issue is that such a restricted focus does not allow us to identify whether *domain*-specific gender stereotypes or more *general* stereotypes about men's and women's abilities (or both) contribute to gender disparities in students' academic self-concept. However, this is a crucial point, not only from a scientific perspective, with an interest in understanding the mechanisms that drive gender disparities in higher education, but also for the development and implementation of effective measures to overcome gender disparities in higher education.

achievements and academic self-concepts is thus assumed (and empirically proven) to be reciprocal (Marsh & Martin, 2011; Marsh et al., 2018).

[2] There are some studies that address the topic of academic self-concept across or in other disciplines and include gender as controls (e.g., Kim & Sax, 2014; Pascarella et al., 1987). However, these studies do not aim to examine gender differences in academic self-concepts in higher education.

There is evidence that female students generally tend to be more self-critical than male students (Lörz & Schindler, 2011), and some lines of theory have discussed that gender stereotypes concerning individuals' abilities exist not only in specific academic domains but also at a broader level, ascribing more talent and higher-level abilities to men in general, regardless of academic field (Bian et al., 2017; Napp & Breda, 2022). For example, it has been shown that such qualities as 'brilliance' and 'intelligence' are attributed more frequently to men than to women (Bennett, 1996; Furnham et al., 2006; Thébaud & Charles, 2018), meaning that higher levels of ability are usually ascribed to men, quite irrespective of the specific domain. Hence, it may not be just female students in typically male STEM fields of study who assess their academic abilities more poorly than male students assess theirs, but female students *in general*. However, by systematically excluding other fields of study, research cannot reliably answer what exactly drives the existing gender gap in students' perception of their own abilities in male-dominated STEM fields. This may even result—by design—in drawing mistaken conclusions on the dynamics of gender disparities in college students' academic self-concepts, due to limiting this problem to specific academic fields despite the possibility that it may be a more general issue in higher education.

Based on these broad theoretical and methodological considerations, what expectations can we formulate for our empirical analysis including students from all fields of study? In line with the results of previous studies (e.g., Espinosa, 2008; Förtsch & Schmid, 2018; Sikora & Pokropek, 2012; van Soom & Donche, 2014), we expect female students in typically male STEM fields of study to report academic self-concepts less positive than those of male students, even though their achievements in mathematics—an important prerequisite for entering STEM subjects —are the same. However, theoretically, whether only those female students in typically male fields of study rate their academic abilities as poorer than the male students rate theirs, or whether the same is also true in typically female and in gender-mixed fields of study, remains unclear. If only *domain*-specific gender stereotypes are at work, and they affect male and female students alike, then male college students in typically female fields of study should exhibit weaker academic self-concepts than female college students in the same field. Accordingly, gender-mixed fields of study should reflect no gender disparity in students' academic self-concepts. Still, if it is not (only) domain-specific gender stereotypes that drive female students' lower-level perceptions of their own abilities but, at least partly, also more *general* gender stereotypes regarding students' abilities, we should observe poorer academic self-concepts among female students not only in typically male fields of study but also in all other fields of study. If both general *and* domain-specific gender stereotypes are at work, then the gender gap in students' academic self-concepts—though present in all academic fields—should be most pronounced in the typically male STEM areas. We should thus find a significant interaction between the gender composition in the subjects and male and female students' perceptions of skills.

Research Design, Data, and Methods

The basis of our empirical analysis is data from the fifth starting cohort of the German National Educational Panel Study (NEPS Network, 2020). The initial stratified cluster sample consisted of first-year students who started their studies at a German university or university of applied sciences in winter term 2010/2011 (Aßmann et al., 2019; Zinn et al., 2017). The data was collected in recurring surveys using computer-assisted telephone interviews (every year) and web interviews (every one to two years), with participation rates fluctuating between 60% and just above 70% (Zinn et al., 2020). For our analyses, we used information from the first two panel waves. The first wave, conducted right after students began their studies, collected all key information on students, including their gender, social origin, migration background, age, and previous school grades. The second wave one year later also asked students about their perception of skills. After excluding respondents who dropped out of higher education or had missing information on the variables of interest ($n = 1{,}848$), our analytic sample included a total of 10,425 students.

The NEPS used a shortened version of an instrument developed by Dickhäuser et al. (2002) to collect information on students' academic self-concepts. Two items asked students to rate their subject-specific abilities on a seven-point scale ranging from low (1) to high (7). The first question was about assessing their level of *talent* regarding their studies ("How do you rate yourself regarding your studies? I think my talent for studying is …" [rating from low (1) to high (7)]); the second question asked them to rate their level of *ability* in their studies ("My study-related skills are …" [rating from low (1) to high (7)]). Two additional items addressed students' learning strategies and task management skills. Since these two items do not explicitly refer to students' perception of their own *domain*-specific skills but rather to the effort put into studies (Dickhäuser et al., 2002), we did not use them for our analysis. This decision was justifiable also on empirical grounds. Confirmatory factor analyses indicated that a two-factor model was statistically preferable to a single-factor model. Nonetheless, we performed additional robustness checks that showed that the results of our analyses remained stable when using a four-item operationalization of students' academic self-concepts (see Table A1 in the appendix).

To create the dependent variable, we used the mean value of the two items that asked students to rate their level of talent and ability on a scale from low (1) to high (7).[3] We performed linear regression models predicting the student's academic self-concept. Since the dependent variable of academic self-concept was somewhat skewed, we additionally estimated logistic regression models with the dichotomized two-item-factor. By comparing students with strong academic self-concepts with those who do not have high-level perceptions of their abilities, we examined whether a gender gap exists in students' belief of being *particularly* gifted in their studies. We report the results of the corresponding analyses in Table A2 in the appendix.

Information on students' gender was collected using a binary survey question. We operationalized students' domain-specific prior achievements using their last mid-term school grades in mathematics and German.[4] Additionally, we included information on students' final average school grades. Grades in Germany range from 1 (excellent) to 6 (insufficient), and we included them in our models as continuous variables. To make the results of the regression models easier to read, we inverted the school grades. Hence, the better the grade was, the higher is the value of the inverted variable. As control variables, our models included information on students' social origin (parents' highest level of education), migration background, age, and type of higher education entrance qualification attained. To make our results easy to understand, and because they are not of interest for our research question,

[3] Internal consistency: $\alpha = 0.79$; Pearson's correlation: $r = 0.65$.

[4] Academic achievements in mathematics and German have proved to be distinctive factors for mapping gender differences in both individuals' abilities and their academic self-concept (e.g., Marsh, 1986).

we do not report estimates for these control variables. Table A3 in the appendix provides a descriptive overview of the dependent and independent variables in our analytic sample.

To examine whether gender disparities in students' academic self-concepts vary across fields of study depending on gender composition, we merged our individual-level data with administrative data on the share of male and female first-year students in different fields of study in the winter term of 2010/2011. We differentiated between three types of academic fields: male-dominated, female-dominated, and gender-mixed. Subjects in which less than 30% of the students were female were classified as male-dominated fields of study. This group consisted exclusively of fields that belong to STEM, such as engineering, physics, and computer sciences. Subjects with more than 70% women were defined as female-dominated fields of study. This category comprised most of the humanities and educational and health sciences. We categorized all fields of study in between as gender-mixed.[5] Fields such as teacher training, arts, social and behavioral science, business and administration, law, agriculture, and medicine belonged to this group. Based on this classification, 2,153 of the students in our sample were enrolled in male-dominated fields of study, 5,236 in gender-mixed fields, and 3,036 in female-dominated fields of study.[6] Several studies investigating gender segregation in the labor market use the cut-off values of 30% and 70% to define male- or female-dominated occupations (e.g., Althaber & Leuze, 2020; Bächmann & Gatermann, 2017; Leuze & Strauß, 2016). But since these cut-off values are still somewhat arbitrary, we performed robustness checks with more extreme threshold values of 25% and 75%, as well as less extreme values of 35% and 65%, and obtained similar results to the findings reported below. To consider the full variation of the gender distribution, we additionally included the share of male students in a field of study as a continuous measure.

Our empirical analysis consisted of three steps. First, besides control variables, we included only students' gender in the model. Second, we added information on students' previous academic achievements in mathematics and German, as well as their final school grades. This allowed us to understand whether potentially existing gender differences in students' academic self-concepts resulted from systematic differences in their academic achievements. Third and finally, we included an interaction term between students' gender and the share of male students in the different fields of study. Thus, we could find out whether the gender gap in students' academic self-concepts varied across fields of study and if so whether it was greatest in male-dominated fields of study.

Results

Table 1 presents the results of two linear regression models that estimated students' perception of talents and abilities in their studies, showing male-dominated, female-dominated, and gender-mixed fields of study separately. While Model 1 included only gender and con-

[5] Note that 'gender-mixed' reflects a heterogeneous category which includes fields that are strongly dominated neither by male nor by female students.

[6] Table A4 in the appendix provides further information on the different categories and the fields of study assigned to them. Information on the mean values of the dependent variable academic self-concepts of male and female students across the three categories of fields of study and the results of mean comparison tests (t-tests) are given in Table A5 in the appendix.

Table 1 Gender disparities in college students' academic self-concepts by gender composition in the field of study (linear regression, unstand. coeff.)

	Model 1			Model 2		
	Male-dominated	Gender-mixed	Female-dominated	Male-dominated	Gender-mixed	Female-dominated
Students' gender						
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	–0.251**	–0.177**	–0.080	–0.264**	–0.205**	–0.097*
Prior academic achievement						
Mathematics				0.085**	0.015	0.007
German				–0.026	0.031	0.008
GPA				0.322**	0.241**	0.165**
Constant	5.620**	5.521**	5.276**	3.461**	3.826**	4.312**
Adjusted R^2	0.034**	0.014**	0.005**	0.090**	0.045**	0.016**
N	2,153	5,236	3,036	2,153	5,236	3,036

** $p \leq 0.01$; * $p \leq 0.05$. Additional control variables: social origin, migration background, age, and type of higher education entrance qualification. Students' previous school grades were inverted

trol variables, Model 2 additionally accounted for students' prior academic performance in mathematics and German, as well as their final school grades.

The estimates from both models clearly show that female students tended to report less positive academic self-concepts not just in typically male fields but in *all* fields of study. However, in female-dominated fields, this negative effect was smaller compared to male-dominated and gender-mixed fields, and it was not statistically significant on the 5% level (see Model 1).

When we controlled for students' prior academic achievements, the negative effect for female students was significant across all fields of study (see Model 2). Thus, the female students' disadvantage in their perception of talents and abilities in their studies was not attributable to their lower-level domain-specific or general academic achievements. However, this was not surprising considering the descriptive findings that Table A6 (in the appendix) reports by presenting students' average academic performance in mathematics and German, as well as final school grades, by field of study and gender. Despite the gender-stereotypical differences in students' prior domain-specific academic performance that the overall sample reported (see the first column in Table A6), female students performed as well as male students—in most cases even better—when they were students in the same field of study (see the second, third and, fourth columns in Table A6).

In line with theoretical models and previous research, the results in Table 1 (Model 2) show that poor(er) academic performance was generally associated with a lower-level perception of skills and talent among college students. In all fields of study, college students' final school grades significantly impacted their subject-related academic self-concepts. The better their final school grades were, the more likely college students were to have strong academic self-concepts. Predictably, in male-dominated fields, prior achievements in mathematics also played an important role. Students with great(er) mathematical achievements were significantly more likely to perceive higher levels of talent and abilities in their studies than students with few(er) mathematical achievements. In gender-mixed and female-dominated fields of study, neither their prior academic achievement in mathematics nor their academic performance in German affected college students' perception of their subject-related abilities; only for final school grades did we find a significant effect.

To this point, our results indicate that it is not only those female students in typically male fields of study that have weaker academic self-concepts than male students, but also those in typically female and gender-mixed fields of study. In *all* fields, women reported a significantly lower-level perception of study-related skills and talents. The analysis results using the binary dependent variable to compare students with a strong self-perception of their academic abilities and students with a weak or moderate self-perception underscored this finding (Table A2 in the appendix).[7] Therefore, *domain*-specific gender stereotypes do not appear (at least not exclusively) to make female students in male fields of study assess their academic abilities more critically.

However, the findings reported in Table 1 also suggest that the most pronounced gender gap might occur in fields in which male students dominate. Thus, despite weaker academic self-concepts among female students in *all* fields of study, the question remains as to whether the gap is *most pronounced* in typically male areas. To answer this question, we estimated joint regression models that included all students in our sample and introduced different interaction terms between gender and the share of male students in the various fields of study. First, we introduced the interaction between gender and the three (i.e., male-dominated, gender-mixed, and female-dominated) field-of-study categories. Second, we ran an interaction model that used a continuous variable for the exact percentage of male students in various fields of study, a finer measure to identify potential interrelations between the share of male students in a field of study and gender gaps in students' academic self-concepts.

For easier understanding, we present the results of our interaction analysis graphically (Figs. 1 and 2). The corresponding regression table including interaction terms is available in the appendix (Table A7). Figure 1 displays the results of the interaction between gender and each of male-dominated, gender-mixed, and female-dominated fields of study (Model 3 in Table A7). Figure 2 shows the interaction between gender and the exact proportion of male students in each field of study (Model 4 in Table A7). In both cases, male students were the reference group. Besides control variables, both models also included information on students' prior academic achievements.

Like the results of the separate models (Table 1, Models 1 and 2), the estimates of the joint regression model presented on the left side of Fig. 1 confirmed that female students across all three categories reported significantly poorer academic self-concepts than male students reported—again, the gender gap seemed most pronounced within male-dominated fields. Examining the contrasts of linear prediction presented on the right-hand side, with male-dominated fields as the reference, it becomes evident that the gender gap in students' self-perception of talents and abilities was significantly more pronounced in male-domi-

[7] We observed that female students were about 11% points less likely than men to exhibit high-level academic self-concepts. This gender gap could be found across all fields of study.

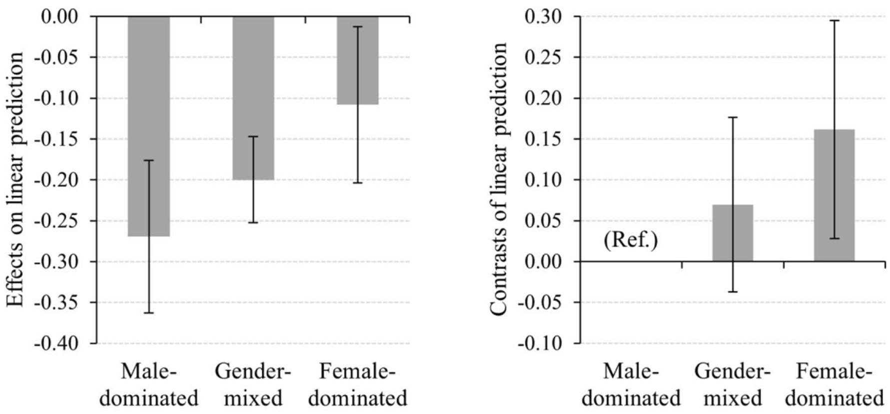

Fig. 1 Gender disparities (ref.: male) in students' academic self-concept by gender composition in the field of study (interaction effects derived from a joint linear regression model, effects on linear prediction (left) and contrasts of linear prediction (right) with 95% confidence interval; controlled for prior academic achievement, social origin, migration background, age, and type of higher education entrance qualification)

nated fields than in female-dominated fields, as the confidence intervals of the estimates did not include zero. Yet compared to gender-mixed fields of study, the difference was not statistically significant.

However, using a continuous variable for the gender composition in different subjects (Fig. 2), we found evidence that female students' poor(er) academic self-concept seemed systematically related to the share of male students. The upper part of Fig. 2 again reveals that female students tended to exhibit significantly poorer academic self-concepts than those of their male peers.[8] The upper graph also indicates that the gender gap in the academic self-concepts of students became more pronounced as the proportion of male students in the field of study increased. To evaluate whether this pattern was significant in statistical terms, the lower part of Fig. 2 shows the contrasted linear predictions presented in the upper part of Fig. 2.

Using fields of study with 50% male students as the reference point, our results revealed that, indeed, significant differences existed. Although female students in fields with less than 50% male students also tended to report poorer academic self-concepts than their male peers (see the upper part of Fig. 2), the female disadvantage was significantly less pronounced than in areas with 50% male students. We also found significant results for most fields of study with more than 50% male students. Compared to subjects with 50% male students, the female disadvantage in students' academic self-concept was significantly more pronounced in those fields with more than 52% male students.[9]

Overall, our results suggest that a combination of both domain-specific *and* generalized stereotypes regarding the abilities of men and women contribute to female students' lower-level perceptions of their abilities. Although female students tended to report poorer

[8] Only in fields of study with less than 15% male students did we not find a significant gender gap in students' academic self-concepts (up to this percentage the confidence interval included zero).

[9] This was indicated by the fact that the confidence intervals did not include zero for a male share of over 52%.

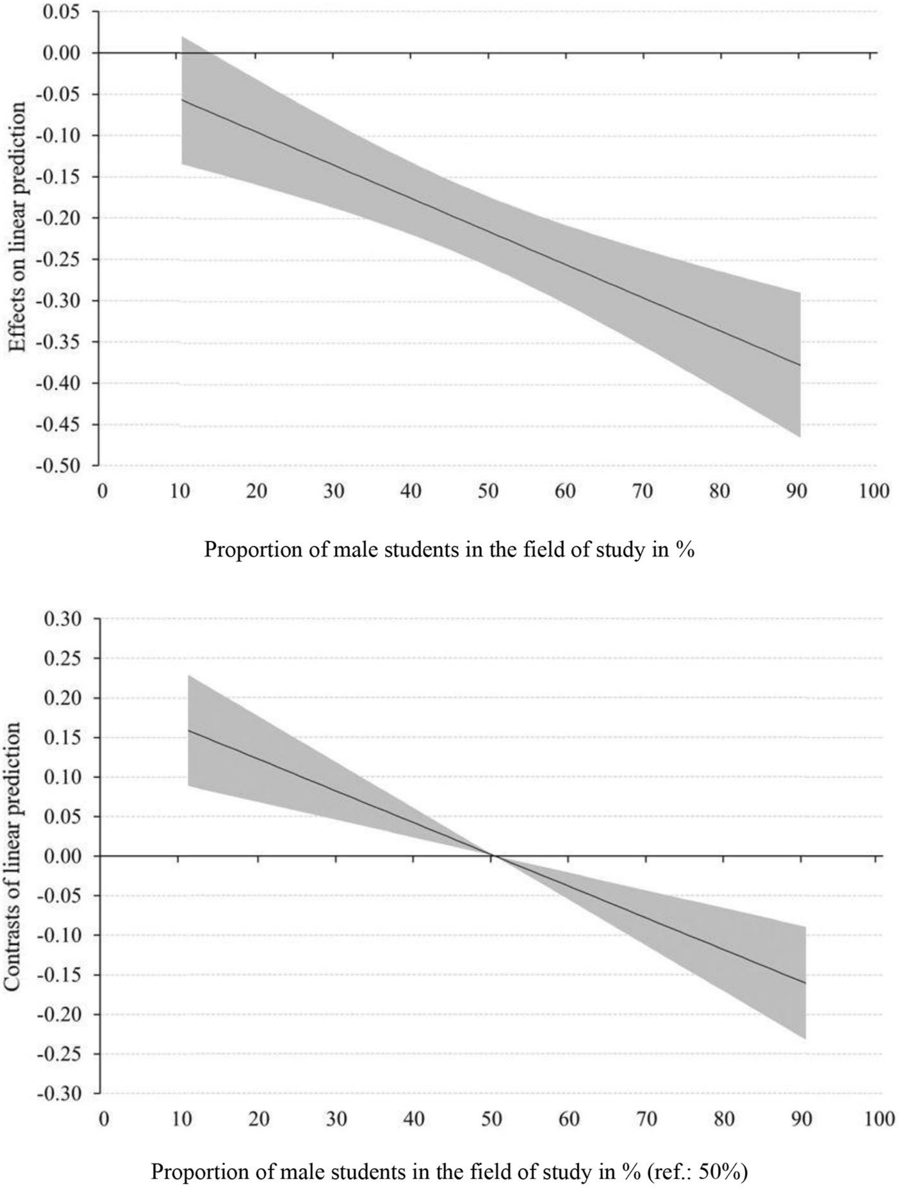

Fig. 2 Gender disparities (ref.: male) in college students' academic self-concepts by proportion of male students in the field of study (interaction effects derived from a joint linear regression model, effects on linear prediction (upper part) and contrasts of linear prediction (lower part) with 95% confidence interval; controlled for prior academic achievement, social origin, migration background, age, and type of higher education entrance qualification; since the field-specific share of male students in the data ranges from 12–92%, only values within this range are displayed)

academic self-concepts than their male peers in almost all fields of study, the gender gap seemed to become significantly more pronounced as the proportion of male students in a field of study increased.

Discussion and Outlook

Our empirical study was guided by the question: Do gender disparities in the academic self-concepts of students depend on their field of study? Specifically, we wanted to find out whether female students exhibit a weaker academic self-concept than male students only in typically *male* fields of study or, whether they think less of their own academic abilities *in general*. The following observations and considerations inspired this research interest.

In Germany, girls and women are typically considered the 'winners' in educational expansion (Hannum & Buchmann, 2005). This is indeed true for the *vertical* dimension of educational differentiation—i.e., individuals' levels of educational attainment, where girls and women are increasingly outperforming boys and men. Not only are girls nowadays more likely to attain a higher education entrance qualification (Autorengruppe Bildungsberichterstattung, 2020, p. 67), but significantly more young women than men enter tertiary education (Autorengruppe Bildungsberichterstattung, 2020, Tab. F3-1web), and in the younger age cohorts, the proportion of higher education graduates is higher among women than among men (Autorengruppe Bildungsberichterstattung, 2020, p. 67). However, this observation neglects the fact that gender disparities still exist at the *horizontal* level of educational differentiation, especially in the individual choice of subjects and professions, which work to women's disadvantage.

One field for which this issue has been the subject of a lively debate is STEM, where, on average, women are still a minority (e.g., Eccles & Wang, 2015; Lörz & Schindler, 2011; Sax et al., 2015; Su & Rounds, 2015). The usual explanation for STEM being a domain still dominated by men is the existence of domain-specific stereotypes regarding men's and women's 'natural' abilities (e.g., Cheryan et al., 2011; Nosek et al., 2002; Schuster & Martiny, 2017). While such stereotypes have helped to explain why few women enter these fields of study, it is still unclear whether domain-specific gender stereotypes are also the reason that even those women studying in 'male' fields rate their academic abilities as so much lower than their male peers—that is, the reason that they have a poorer academic self-concept. The critical point we raised is that existing studies cannot conclusively answer this crucial question because they often focus on the male-dominated STEM domain alone. To answer this question fully, the data analysis must also include female-dominated and gender-mixed fields of study. Therefore, we asked: Does gender composition in a field of study play a role in gender disparities in the academic self-concepts of students?

Based on the results of our study, the answer is no *and* yes at the same time. No, because we found that it was not only female students in male-dominated fields of study that had weaker academic self-concepts than male students—although they had the same, often even higher, levels of academic achievement—but female students *in general*. This result remained consistent when using different thresholds for defining fields of study as male-dominated, female-dominated, or gender-mixed. It was also robust when analyzing the full 4-item scale to measure students' academic self-concepts or the dichotomous outcome variable. Therefore, female students in typically male fields of study are not the only ones needing support; female students in typically female and gender-mixed fields of study also do. This result has far-reaching implications for the development of student-support programs. It indicates that more general beliefs about male and female students' (academic) abilities appear to drive gender disparities in students' academic self-concepts.

At the same time, the answer to our research question is yes because differentiated analyses revealed that the gender gap in academic self-concepts was significantly larger in male-dominated than in female-dominated fields. A more differentiated analysis showed that the gender gap significantly correlated with the proportion of male students in a field of study. Thus, domain-specific gender stereotypes seem to add to the overall disadvantage of female students in male-dominated academic areas.

Our study faced some limitations. First, we analyzed data that was collected in Germany; as cultural and educational systems differ, this could affect the generalizability of our findings. Therefore, future research should include more diverse societal contexts—although the situation in Germany is not unique and our results and considerations may also be relevant for other countries. Second, due to the data that we used for our analyses we operationalized students' academic self-concepts using only two items; however, research has shown that an individual's academic self-concept is complex and has various facets (Marsh, 1986; Marsh et al., 2018). Therefore, investigating whether the results of our study can be replicated with other data sources that provide more sophisticated measures for academic self-concepts would be important. In addition, the question of how to best operationalize the gender specificity of fields of study urgently requires an answer. Our operationalization was quantitatively driven; we used information on the share of men and women in different fields of study. However, using a *quantitative* measure does not address the *qualitative* aspects of gender, such as the required competencies, the level of influence, or the types of roles that are held by each gender within a field (e.g., Buchmann & Kriesi, 2012). Therefore, a replication of our analysis using alternative ways of classifying study subjects would be of interest. Another critical point of our classification is that while male-dominated fields of study contained quite a homogeneous STEM group—i.e., mathematically oriented study subjects— the subjects represented in female-dominated and gender-mixed fields of study were far more diverse. This could also be the reason for the puzzling result that students' prior achievements in German were not a good predictor of their perception of abilities.

In addition, the mechanisms behind the remarkable association between the gender gap in students' academic self-concepts and the proportion of male students in the field of study remain to be explored. The effect of domain-specific stereotypes in male academic areas is only one explanation. In line with Kanter's (1977) theory of tokenism one might also argue that the more male students there are in a subject, the more visible it becomes that female students are a minority. In this case, male students become more aware of what distinguishes their female peers (Kanter, 1977). As a result, female students in these fields are likely to face negative evaluations from their male peers (Kanter, 1977) potentially harming their academic self-concepts. Kanter's tokenism theory is gender-neutral, i.e., it assumes that the disadvantages resulting from being a token apply equally to women and men. However, the results of our study were not able to support that assumption and there is other research that suggests that the influence of gender composition of a person's environment depends on their individual characteristics (e.g., Chatman & O'Reilly, 2004; Sax, 1996, 2008).

Another explanation could be found in the disciplinary culture of male- and female-dominated fields. Disciplinary cultures, defined by their unique set of norms, values, and practices, shape how members of a discipline interact and approach their work (Multrus, 2004). For instance, engineering culture is characterized by lecturer-centered teaching, an emphasis on practical problem-solving and technical focus, and a preference for group norms over individual preferences, aligning with traditional masculine traits (e.g., Gilbert, 2009; Multrus, 2004; Riley, 2017, Schaeper, 1997). This culture can inadvertently result in a gendered environment, which can be challenging for women who do not closely identify with these traits (e.g., Litzler & Young, 2012; Lojewski, 2011). In comparison, disciplines such as humanities and social sciences, where women are more prevalent, emphasize student-centered teaching styles, humanistic practices, interpretive understanding, and societal contributions (Multrus, 2004; Lojewski, 2011; Schaeper, 1997). Consequently, students in these fields often experience positive interactions with faculty and have more opportunities to explore their own academic interests (Multrus, 2004). The distinctive teaching methods inherent to these disciplinary cultures significantly influence students' academic experiences and can shape their self-perceptions of abilities. We did find support for these considerations in our data, as Table A5 illustrates that female-dominated fields tended to foster higher levels of perceived abilities among students compared to male-dominated fields, but with the positive effect being particularly pronounced among female students. This indicates a higher benefit for female students from the student-centered approaches prevalent in female-dominated fields, in contrast to the less supportive lecturer-centered styles typical of male-dominated disciplines (Schaeper, 1997).

Yet, understanding what factors contribute to female students being generally more skeptical of their own abilities warrants more research. For example, a study by Sax and Harper (2007) revealed that origins of various gender gaps in college manifest through pre-college characteristics, such as values, aspirations, or personality-traits. The question remains as to what role these characteristics play for the gender-specific differences we found in students' academic self-concepts. Unfortunately, we were not able to investigate this question as the data only provided limited information on pre-college characteristics. Thus, the actual cause of female students underestimating their abilities and/or male students overestimating theirs across the different fields remains unclear. Like other research in this area, our study uses a 'bridging hypothesis', namely, that gender effects that persist when controlling for academic achievement are due to gender stereotypes. Ertl and colleagues (2017) addressed this proposition by analyzing the impact of gender stereotypes on the academic self-concepts of female STEM students. They showed that stereotypes negatively impacted women's self-concepts even when they performed well in STEM. However, to determine whether this is the case for female students in general and what mechanisms figure in underestimating and/or overestimating students, we need data that allow us to model the complexity of gender stereotypes in academic contexts, and samples that include female and male students from all disciplines.

Investigating these and related issues was beyond the scope of our study, however, future research should consider them. The academic self-concept is not only an important educational outcome variable but also a relevant determinant of individuals' educational and career decisions (Dickhäuser et al., 2005; Henderson et al., 2017; Rubie-Davies & Lee, 2013). And while there is extensive research on school-age students, we still know little about the academic self-concept of young adults. Yet, an enhanced understanding of the gender differences in academic self-concepts among university students may illuminate underlying mechanisms that contribute to gender disparities within broader societal contexts.

Appendix

Table A1 Gender disparities in students' academic self-concepts (using a four-item factor) by gender composition in the field of study (linear regression, unstand. coeff.)

	Model 1			Model 2		
	Male-dominated	Gender-mixed	Female-dominated	Male-dominated	Gender-mixed	Female-dominated
Students' gender						
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	–0.099*	–0.109**	–0.043	–0.113*	–0.140**	–0.067*
Prior academic achievement						
Mathematics				0.085**	–0.007	0.006
German				–0.015	0.039	0.025
Final GPA				0.294**	0.278**	0.210**
Constant	5.411**	5.438**	5.250**	3.354**	3.617**	3.958**
Adjusted R^2	0.027**	0.012**	0.006**	0.086**	0.054**	0.032**
N	2,153	5,236	3,036	2,153	5,236	3,036

** $p \leq 0.01$; * $p \leq 0.05$. Additional control variables: age, social origin, migration background, and type of higher education entrance qualification. Students' previous school grades were inverted

Table A2 Gender disparities in the likelihood of college students reporting a strong academic self-concept by gender composition in the field of study (logistic regression, Average Marginal Effects)

	Model 1			Model 2		
	Male-dominated	Gender-mixed	Female-dominated	Male-dominated	Gender-mixed	Female-dominated
Students' gender						
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	–0.112**	–0.073**	–0.092**	–0.115**	–0.085**	–0.101**
Prior academic achievement						
Mathematics				0.038*	–0.008	0.004
German				–0.015	0.016	0.016
GPA				0.124**	0.112**	0.067**
Pseudo R^2	0.020**	0.008**	0.006**	0.048**	0.023**	0.013**

Table A2 Gender disparities in the likelihood of college students reporting a strong academic self-concept by gender composition in the field of study (logistic regression, Average Marginal Effects)

	Model 1			Model 2		
	Male-dominated	Gender-mixed	Female-dominated	Male-dominated	Gender-mixed	Female-dominated
Log likelihood	–1,409.45	–3,493.44	–2,091.83	–1,368.83	–3,438.73	–2,077.31
N	2,153	5,236	3,036	1,999	5,236	3,036

** $p \leq 0.01$; * $p \leq 0.05$. Students with a mean value of 5.5 or higher on the two self-concept items combined are classified as students with a strong academic self-concept; students with a mean value of less than 5.5 are labeled as students with a moderate or weak academic self-concept. On the theoretical scale of the composed self-concept variable, which ranges from 1 (low) to 7 (high), the value 4 lies exactly in the middle of the scale. Values greater than 4 clearly tend towards high. A value of 5.5 means that at least one "6" must have been indicated. Additional control variables: social origin, migration background, age, and type of higher education entrance qualification. Students' previous school grades were inverted. Average Marginal Effects represent the average differences in students' probability of reporting a high subject-related academic self-concept. In the case of gender, they can be read as percentage point differences between male and female students (Mood, 2010)

Table A3 Descriptive overview of the analytic sample

		All	Female	Male
Academic self-concept	mean (*SD*)	5.06 (0.94)	5.04 (0.94)	5.09 (0.94)
Talent	mean (*SD*)	5.14 (1.04)	5.12 (1.04)	5.17 (1.05)
Abilities	mean (*SD*)	4.98 (1.02)	4.96 (1.02)	5.01 (1.04)
Strong academic self-concept	*N*	4,442	2,725	1,717
Last mid-term grade: Mathematics	mean (*SD*)	4.66 (1.04)	4.62 (1.05)	4.72 (1.02)
Last mid-term grade: German	mean (*SD*)	4.77 (0.80)	4.91 (0.74)	4.54 (0.84)
Final GPA	mean (*SD*)	4.81 (0.61)	4.84 (0.60)	4.75 (0.63)
Age in years	mean (*SD*)	21.65 (2.62)	21.51 (2.69)	21.89 (2.47)
Students with academic background	*N*	4,816	2,991	1,825
Students with migration background	*N*	1,651	1,014	637
Non-traditional students	*N*	33	20	13
N		**10,425**	**6,562**	**3,863**

School grades were inverted and now range from '1' (insufficient) to '6' (excellent). Academic background means at least one parent obtained an academic degree. Migration background means at least one parent and/or grandparent migrated to Germany. Non-traditional students are vocationally qualified first-year students without a school-based higher education entrance qualification

Table A4 Classification of fields of study

	Subjects (percentage of male first-year students in winter term 2010/2011)
Female-dominated fields of study	Special Education (13%), Nutritional and Domestic Sciences (14%), Veterinary Medicine (15%), Romance Studies (16%), Educational Sciences (16%), Arts and Art Science (16%), Cultural Studies (18%), Social Services (20%), General and Comparative Literature and Linguistics (20%), Slavic, Baltic, Finno-Ugrian Studies (20%), Library Science and Documentation (21%), Psychology (21%), English and American Studies (21%), German Studies (21%), Linguistic and Cultural Studies (23%), Health Sciences (24%), Regional Sciences (24%), Pharmacy (26%)

Table A4 Classification of fields of study

	Subjects (percentage of male first-year students in winter term 2010/2011)
Gender-mixed fields of study	Teacher Training (30%), Non-European Linguistics and Cultural Studies (32%), Dentistry (32%), Law, Economics, and Social Sciences in general (32%), Social Sciences (35%), Philology (35%), Biology (37%), Performing Arts (37%), protestant Theology and Religious Education (37%), Human Medicine (38%) Architecture and Interior Design (38%), Design (38%), Law (40%),, Landscape Management and Environmental Design (42%), Administrative Science (46%), Fine Arts (46%), Mathematics, natural sciences in general (46%), Economics (48%), Music and Musicology (49%), Geography (49%), Spatial Planning (50%), catholic Theology and Religious Education (52%), Philosophy (53%), History (53%), Agricultural Sciences (54%), Political Sciences (54%), Chemistry (55%), Physical Education and Sports Science (57%), Mathematics (58%), Earth Sciences (60%), Land Surveying (70%)
Male-dominated fields of study	Forestry and Timber Industry (72%), Civil Engineering (73%), Industrial Engineering with Economics Focus (76%), Physics, Astronomy (81%), Industrial Engineering with Engineering Focus (81%), General Engineering (82%), Computer Sciences (82%), Mechanical and Process Engineering (82%), Mining and Metallurgy (86%), Traffic Engineering and Nautical Science (89%), Electrical Engineering (91%)

Table A5 College students' average academic self-concepts across fields of study

All fields of study				Male-dominated				Gender-mixed				Female-dominated			
All	Male	Female		All	Male	Female		All	Male	Female		All	Male	Female	
5.06	5.09	5.04	**	4.96	5.01	4.77	**	5.01	5.12	4.96	**	5.21	5.28	5.20	*
10,425				2,153				5,236				3,036			

** $p \leq 0.01$; * $p \leq 0.05$ (t-test comparing male and female students)

Table A6 College students' average school achievements in mathematics and German, as well as final school grades by field of study and gender

	All fields of study				Male-dominated				Gender-mixed				Female-dominated			
	All	Male	Female		All	Male	Female		All	Male	Female		All	Male	Female	
Mathematics	4.66	4.72	4.62	**	4.90	4.89	4.92		4.73	4.65	4.76	**	4.36	4.29	4.37	
German	4.77	4.54	4.91	**	4.45	4.37	4.73	**	4.81	4.64	4.90	**	4.94	4.77	4.97	**
Final GPA	4.81	4.75	4.84	**	4.75	4.73	4.81	**	4.85	4.78	4.89	**	4.78	4.68	4.79	**
N	10,425				2,153				5,236				3,036			

** $p \leq 0.01$; * $p \leq 0.05$ (t-test comparing male and female students). School grades were inverted and range from '1' (insufficient) to '6' (excellent)

Table A7 Gender disparities in college students' academic self-concept (linear regression with interaction terms, unstand. coeff.)

	Model 3	Model 4
Students' gender		
Male	Ref.	Ref.
Female	–0.270**	–0.005
Gender composition		
Male-dominated	Ref.	
Gender-mixed	0.097**	
Female-dominated	0.288**	
Male student share (continuous)		–0.004**
Interaction		
Female*male-dominated	Ref.	
Female*gender-mixed	0.070	

Table A7 Gender disparities in college students' academic self-concept (linear regression with interaction terms, unstand. coeff.)

	Model 3	Model 4
Female*female-dominated	0.161*	
Female*male student share		–0.004**
Prior academic achievement		
Mathematics	0.021	0.023
German	0.012	0.013
GPA	0.243**	0.234**
Constant	3.730**	4.063**
Adjusted R^2	0.054**	0.052**
N	10,425	10,425

** $p \leq 0.01$; * $p \leq 0.05$. Additional control variables: social origin, migration background, age, and type of higher education entrance qualification. Students' previous school grades were inverted

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Code Availability Analyses of this paper were performed using Stata Version 16.1.

Declarations

Conflict of Interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

References

Althaber, A., & Leuze, K. (2020). Der Einfluss Der Beruflichen Geschlechtersegregation und beruflicher Arbeitszeitarrangements auf Teilzeitarbeit: Gleiche Übergangsbedingungen für Frauen Und Männer? *KZfSS Kölner. Zeitschrift für Soziologie und Sozialpsychologie*, *72*(S1), 317–349. https://doi.org/10.1007/s11577-020-00666-3

Aßmann, C., Steinhauer, H. W., Würbach, A., Zinn, S., Hammon, A., Kiesl, H., Rohwer, G., Rässler, S., & Blossfeld, H.-P. (2019). Sampling designs of the National Educational Panel Study: Setup and panel development. In H.-P. Blossfeld, & H.-G. Roßbach (Eds.), *Education as a lifelong process: The German National Educational Panel Study (NEPS)* (2nd ed., pp. 35–55). Springer VS. Edition ZfE).

Autorengruppe Bildungsberichterstattung. (2020). *Bildung in Deutschland 2020. Ein indikatorengestützter Bericht mit einer Analyse zu Bildung in einer digitalisierten Welt.* wbv. https://doi.org/10.3278/6001820gw

Bächmann, A.-C., & Gatermann, D. (2017). The duration of family-related employment interruptions – the role of occupational characteristics. *Journal for Labour Market Research*, *50*(1), 143–160. https://doi.org/10.1007/s12651-017-0226-4

Barone, C. (2011). Some things never change: Gender segregation in higher education across eight nations and three decades. *Sociology of Education*, *84*(2), 157–176. https://doi.org/10.1177/0038040711402099

Bennett, M. (1996). Men's and women's self-estimates of intelligence. *Journal of Social Psychology*, *136*(1), 411–412. https://doi.org/10.1080/00224545.1996.9714021

Bian, L., Leslie, S.-J., & Cimpian, A. (2017). Gender stereotypes about intellectual ability emerge early and influence children's interests. *Science*, *355*(6323), 389–391. https://doi.org/10.1126/science.aah6524

Blossfeld, H.-P., & Roßbach, H.-G. (Eds.). (2019). *Education as a lifelong process: The German National Educational Panel Study (NEPS)*. *Edition ZfE* (2nd ed.). Springer VS.

Buchmann, M., & Kriesi, I. (2012). Geschlechtstypische Berufswahl: Begabungszuschreibungen, Aspirationen und Institutionen. In R. Becker & H. Solga (Hrsg.), *Soziologische Bildungsforschung* (Bd. 52, S. 256–280). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-00120-9_11

Charles, M., & Bradley, K. (2009). Indulging our gendered selves? Sex segregation by field of study in 44 countries. *American Journal of Sociology*, *114*(4), 924–976. https://doi.org/10.1086/595942

Chatman, J. A., & O'Reilly, C. A. (2004). Asymmetric reactions to work group sex diversity among men and women. *Academy of Management Journal*, *47*(2), 193–208. https://doi.org/10.2307/20159572

Chen, S.-K., Hwang, F.-M., Yeh, Y.-C., & Lin, S. S. J. (2012). Cognitive ability, academic achievement and academic self-concept: Extending the internal/external frame of reference model. *British Journal of Educational Psychology*, *82*(2), 308–326. https://doi.org/10.1111/j.2044-8279.2011.02027.x

Chen, S.-K., Yeh, Y.-C., Hwang, F.-M., & Lin, S. S. J. (2013). The relationship between academic self-concept and achievement: A multicohort-multioccasion study. *Learning and Individual Differences*, *23*, 172–178. https://doi.org/10.1016/j.lindif.2012.07.021

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? *Social Psychological and Personality Science*, *2*(6), 656–664. https://doi.org/10.1177/1948550611405218

Dickhäuser, O., Schöne, C., Spinath, B., & Stiensmeier-Pelster, J. (2002). Die Skalen zum akademischen Selbstkonzept: Konstruktion und Überprüfung eines neuen Instrumentes. *Zeitschrift für Differentielle Und Diagnostische Psychologie*, *23*(4), 393–405. https://doi.org/10.1024//0170-1789.23.4.393

Dickhäuser, O., Reuter, M., & Hilling, C. (2005). Coursework selection: A frame of reference approach using structural equation modelling. *The British Journal of Educational Psychology*, *75*(4), 673–688. https://doi.org/10.1348/000709905X37181

Dulay, S. (2017). The effect of self-concept on student achievement. In E. Karadağ (Ed.), *The factors effecting student achievement*: *Meta-analysis of empirical studies* (pp. 117–132). Springer. https://doi.org/10.1007/978-3-319-56083-0_7

Eccles, J. S. (1989). Bringing young women to math and science. In M. Crawford & M. Gentry (Eds.), *Gender and thought: Psychological perspectives* (pp. 36–58). Springer. https://doi.org/10.1007/978-1-4612-3588-0_3

Eccles, J. S., & Wang, M.-T. (2015). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106. https://doi.org/10.1177/0165025415616201

Eccles, J. S., Wigfield, A., Flanagan, C. A., Miller, C., Reuman, D. A., & Yee, D. (1989). Self-concepts, domain values, and self-esteem: Relations and changes at early adolescence. *Journal of Personality*, *57*(2), 283–310. https://doi.org/10.1111/j.1467-6494.1989.tb00484.x

Eccles, J. S., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development*, *64*(3), 830–847. https://doi.org/10.1111/j.1467-8624.1993.tb02946.x

Ertl, B., Luttenberger, S., & Paechter, M. (2017). The impact of gender stereotypes on the self-concept of female students in STEM subjects with an under-representation of females. *Frontiers in Psychology*, *8*, 703. https://doi.org/10.3389/fpsyg.2017.00703

Espinosa, L. L. (2008). The academic self-concept of African American and Latina(o) men and women in STEM majors. *Journal of Women and Minorities in Science and Engineering*, *14*(2), 177–203. https://doi.org/10.1615/JWomenMinorScienEng.v14.i2.40

Förtsch, S., & Schmid, U. (2018). The influence of academic self-concept on the study program choice of computer scientists. In A. Zamfira, C. d. Montlibert, & D. Radu (Eds.), *Gender in focus*: *Identities, codes, stereotypes and politics* (pp. 275–292). Barbara Budrich Publishers.

Furnham, A., Crawshaw, J., & Rawles, R. (2006). Sex differences in self-estimates on two validated IQ test subscale scores. *Journal of Applied Social Psychology*, *36*(2), 417–440. https://doi.org/10.1111/j.0021-9029.2006.00013.x

Gilbert, A. (2009). Disciplinary cultures in mechanical engineering and materials science: Gendered/gendering practices? *Equal Opportunities International*, *28*(1), 24–35. https://doi.org/10.1108/02610150910933613

Guay, F., Marsh, H. W., & Boivin, M. (2003). Academic self-concept and academic achievement: Developmental perspectives on their causal ordering. *Journal of Educational Psychology*, *95*(1), 124–136. https://doi.org/10.1037/0022-0663.95.1.124

Hannum, E., & Buchmann, C. (2005). Global educational expansion and socio-economic development: An assessment of findings from the social sciences. *World Development*, *33*(3), 333–354. https://doi.org/10.1016/j.worlddev.2004.10.001

Henderson, M., Hansen, K., & Shure, N. (2017). *Does academic self-concept predict further and higher education participation?* (Centre for Global Higher Education Working Paper, No. 26). London. Centre for Global Higher Education. Retrieved October 13, 2022, from https://www.researchcghe.org/perch/resources/publications/wp262.pdf

Kanter, R. M. (1977). *Men and women of the corporation*. Basic Books.

Kessels, U., & Hannover, B. (2008). When being a girl matters less: Accessibility of gender-related self-knowledge in single-sex and coeducational classes and its impact on students' physics-related self-concept of ability. *British Journal of Educational Psychology*, *78*(2), 273–289. https://doi.org/10.1348/000709907X215938

Kim, Y. K., & Sax, L. J. (2014). The effects of student–faculty interaction on academic self-concept: Does academic major matter? *Research in Higher Education*, *55*(8), 780–809. https://doi.org/10.1007/s11162-014-9335-x

Kriesi, I., & Imdorf, C. (2019). Gender segregation in education. In R. Becker (Ed.), *Research handbook on the sociology of education* (pp. 193–212). Edward Elgar Publishing. https://doi.org/10.4337/9781788110426.00020

Lažetić, P. (2020). The gender gap in graduate job quality in Europe – A comparative analysis across economic sectors and countries. *Oxford Review of Education*, *46*(1), 129–151. https://doi.org/10.1080/03054985.2019.1687439

Leathwood, C., & Read, B. (2008). *Gender and the changing face of higher education: A feminized future?* Society for Research into Higher Education & Open University.

Leuze, K., & Strauß, S. (2009). Lohnungleichheiten zwischen Akademikerinnen und Akademikern: Der Einfluss von fachlicher Spezialisierung, frauendominierten Fächern und beruflicher Segregation / Wage inequality between male and female university graduates: The influence of occupational specialization, female-dominated subjects and occupational segregation. *Zeitschrift für Soziologie*, *38*(4), 262–281. https://doi.org/10.1515/zfsoz-2009-0401

Leuze, K., & Strauß, S. (2016). Why do occupations dominated by women pay less? How 'female-typical' work tasks and working-time arrangements affect the gender wage gap among higher education graduates. *Work Employment and Society*, *30*(5), 802–820. https://doi.org/10.1177/0950017015624402

Litzler, E., & Young, J. (2012). Understanding the risk of attrition in undergraduate engineering: Results from the project to assess climate in engineering. *Journal of Engineering Education*, *101*(2), 319–345. https://doi.org/10.1002/j.2168-9830.2012.tb00052.x

Lojewski, J. (2011). Geschlecht und Studienfachwahl – fachspezifischer Habitus oder geschlechtsspezifische Fachkulturen? In P. Bornkessel, & J. Asdonk (Eds.), *Der Übergang Schule Cultural stereotypes and sense of belonging contribute to gender gaps in STEM– Hochschule* (pp. 279–348). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-94016-8_8

Lörz, M., & Schindler, S. (2011). Geschlechtsspezifische Unterschiede beim Übergang ins Studium. In A. Hadjar (Ed.), *Geschlechtsspezifische Bildungsungleichheiten* (pp. 99–122). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-92779-4_5

Makarova, E., Aeschlimann, B., & Herzog, W. (2019). The gender gap in STEM fields: The impact of the gender stereotype of math and science on secondary students' career aspirations. *Frontiers in Education*, *4*, 60. https://doi.org/10.3389/feduc.2019.00060

Marsh, H. W. (1986). Verbal and math self-concepts: An internal/external frame of reference model. *American Educational Research Journal*, *23*(1), 129–149. https://doi.org/10.3102/00028312023001129

Marsh, H. W. (1990). The structure of academic self-concept: The Marsh/Shavelson model. *Journal of Educational Psychology*, *82*(4), 623–636. https://doi.org/10.1037/0022-0663.82.4.623

Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology*, *81*(1), 59–77. https://doi.org/10.1348/000709910X503501

Marsh, H. W., Pekrun, R., Murayama, K., Arens, A. K., Parker, P. D., Guo, J., & Dicke, T. (2018). An integrated model of academic self-concept development: Academic self-concept, grades, test scores, and tracking over 6 years. *Developmental Psychology*, *54*(2), 263–280. https://doi.org/10.1037/dev0000393

Master, A., & Meltzoff, A. N. (2020). Cultural stereotypes and sense of belonging contribute to gender gaps in STEM. *International Journal of Gender Science and Technology*, *12*(1), 152–198. Retrieved October 13, 2022, from https://genderandset.open.ac.uk/index.php/genderandset/article/view/674

McHale, S. M., Crouter, A. C., & Tucker, C. J. (1999). Family context and gender role socialization in middle childhood: Comparing girls to boys and sisters to brothers. *Child Development*, *70*(4), 990–1004. https://doi.org/10.1111/1467-8624.00072

Möller, J., & Trautwein, U. (2015). Selbstkonzept. In E. Wild & J. Möller (Eds.), *Pädagogische Psychologie* (2nd ed., pp. 177–199). Springer. https://doi.org/10.1007/978-3-642-41291-2

Mood, C. (2010). Logistic regression: Why we cannot do what we think we can do, and what we can do about it. *European Sociological Review*, *26*(1), 67–82. https://doi.org/10.1093/esr/jcp006

Multrus, F. (2004). *Fachkulturen: Begriffsbestimmung, Herleitung und Analysen; eine empirische Untersuchung über Studierende deutscher Hochschulen. [Doctoral dissertation, University of Konstanz].* Retrieved January 11, 2024, from https://nbn-resolving.de/urn:nbn:de:bsz:352-opus-13267

Nagy, G., Garrett, J., Trautwein, U., Cortina, K. S., Baumert, J., & Eccles, J. S. (2008). Gendered high school course selection as a precursor of gendered careers: The mediating role of self-concept and intrinsic value. In H. M. G. Watt, & J. S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 115–143). American Psychological Association. https://doi.org/10.1037/11706-004

Nagy, G., Watt, H. M. G., Eccles, J. S., Trautwein, U., Lüdtke, O., & Baumert, J. (2010). The development of students' mathematics self-concept in relation to gender: Different countries, different trajectories? *Journal of Research on Adolescence*, *20*(2), 482–506. https://doi.org/10.1111/j.1532-7795.2010.00644.x

Napp, C., & Breda, T. (2022). The stereotype that girls lack talent: A worldwide investigation. *Science Advances*, *8*(10). https://doi.org/10.1126/sciadv.abm3689

NEPS Network (2020). National Educational Panel Study, Scientific use file of starting cohort first-year students. *Leibniz Institute for Educational Trajectories (LIfBi), Bamberg*. https://doi.org/10.5157/NEPS:SC5:14.0.0

Niepel, C., Stadler, M., & Greiff, S. (2019). Seeing is believing: Gender diversity in STEM is related to mathematics self-concept. *Journal of Educational Psychology*, *111*(6), 1119–1130. https://doi.org/10.1037/edu0000340

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math ≠ me. *Journal of Personality and Social Psychology*, *83*(1), 44–59. https://doi.org/10.1037/0022-3514.83.1.44

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., Bar-Anan, Y., Bergh, R., Cai, H., Gonsalkorale, K., Kesebir, S., Maliszewski, N., Neto, F., Olli, E., Park, J., Schnabel, K., Shiomura, K., Tulbure, B. T., Wiers, R. W., Somogyi, M., Akrami, N., Ekehammar, B., Vianello M., Banaji, M. R., & Greenwald, A. G. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences*, *106*(26), 10593–10597. https://doi.org/10.1073/pnas.0809921106

OECD (2015). *The ABC of gender equality in education: Aptitude, behaviour, confidence*. PISA. OECD Publishing. https://doi.org/10.1787/9789264229945-en

OECD (2022). *Education at a Glance 2022: OECD Indicators*, OECD Publishing. https://doi.org/10.1787/3197152b-en

Pascarella, E. T., Smart, J. C., Ethington, C. A., & Nettles, M. T. (1987). The influence of college on self-concept: A consideration of race and gender differences. *American Educational Research Journal*, *24*(1), 49–77. https://doi.org/10.3102/00028312024001049

Reimer, D., & Steinmetz, S. (2007). *Gender differentiation in higher education: Educational specialization and labour market risks in Spain and Germany* (Arbeitspapiere – Working Papers No. 99). Mannheim. Universität Mannheim, Mannheimer Zentrum für Europäische Sozialforschung (MZES). Retrieved October 13, 2022, from https://nbn-resolving.org/urn:nbn:de:0168-ssoar-111078

Riley, D. (2017). Rigor/Us: Building boundaries and disciplining diversity with standards of merit. *Engineering Studies*, *9*(3), 249–265. https://doi.org/10.1080/19378629.2017.1408631

Robnett, R. D. (2016). Gender bias in STEM fields: Variation in prevalence and links to STEM self-concept. *Psychology of Women Quarterly*, *40*(1), 65–79. https://doi.org/10.1177/0361684315596162

Rubie-Davies, C. M., & Lee, K. (2013). Self-concept of students in higher education: Are there differences by faculty and gender? *Educational Studies*, *39*(1), 56–67. https://doi.org/10.1080/03055698.2012.671513

Sax, L. J. (1996). The dynamics of "tokenism": How college students are affected by the proportion of women in their major. *Research in Higher Education*, *37*(4), 389–425. https://doi.org/10.1007/BF01730108

Sax, L. J. (2008). *The gender gap in college: Maximizing the developmental potential of women and men*. Jossey-Bass/Wiley.

Sax, L. J., & Harper, C. E. (2007). Origins of the gender gap: Pre-college and college influences on differences between men and women. *Research in Higher Education*, *48*(6), 669–694. https://doi.org/10.1007/s11162-006-9046-z

Sax, L. J., Kanny, M. A., Riggers-Piehl, T. A., Whang, H., & Paulson, L. N. (2015). "But I'm not good at math": The changing salience of mathematical self-concept in shaping women's and men's STEM aspirations. *Research in Higher Education*, *56*(8), 813–842. https://doi.org/10.1007/s11162-015-9375-x

Schaeper, H. (1997). *Lehrkulturen, Lehrhabitus und die Struktur der Universität: Eine empirische Untersuchung fach- und geschlechtsspezifischer Lehrkulturen*. Deutscher Studien Verlag.

Schilling, S. R., Sparfeldt, J. R., & Rost, D. H. (2006). Facetten schulischen Selbstkonzepts. *Zeitschrift für Pädagogische Psychologie*, *20*(1/2), 9–18. https://doi.org/10.1024/1010-0652.20.12.9

Schuster, C., & Martiny, S. E. (2017). Not feeling good in STEM: Effects of stereotype activation and anticipated affect on women's career aspirations. *Sex Roles*, *76*, 40–55. https://doi.org/10.1007/s11199-016-0665-3

Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, *46*, 407–441. https://doi.org/10.3102/00346543046003407

Sikora, J., & Pokropek, A. (2012). Gender segregation of adolescent science career plans in 50 countries. *Science Education*, *96*(2), 234–264. https://doi.org/10.1002/sce.20479

Sinclair, S., Nilsson, A., & Cederskär, E. (2019). Explaining gender-typed educational choice in adolescence: The role of social identity, self-concept, goals, grades, and interests. *Journal of Vocational Behavior*, *110*, 54–71. https://doi.org/10.1016/j.jvb.2018.11.007

Skaalvik, S., & Skaalvik, E. M. (2004). Gender differences in math and verbal self-concept, performance expectations, and motivation. *Sex Roles*, *50*, 241–252. https://doi.org/10.1023/B:SERS.0000015555.40976.e6

Su, R., & Rounds, J. (2015). All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields. *Frontiers in Psychology*, *6*, 189. https://doi.org/10.3389/fpsyg.2015.00189

Tandrayen-Ragoobur, V., & Gokulsing, D. (2021). Gender gap in STEM education and career choices: What matters? *Journal of Applied Research in Higher Education*, *14*(3), 1021–1040. https://doi.org/10.1108/JARHE-09-2019-0235

Thébaud, S., & Charles, M. (2018). Segregation, stereotypes, and STEM. *Social Sciences*, *7*(7), 111. https://doi.org/10.3390/socsci7070111

Van Soom, C., & Donche, V. (2014). Profiling first-year students in STEM programs based on autonomous motivation and academic self-concept and relationship with academic achievement. *PLoS ONE*, *9*(11), e112489. https://doi.org/10.1371/journal.pone.0112489

Vincent-Lancrin, S. (2008). The reversal of gender inequalities in higher education: An on-going trend. In OECD (Eds.), *Higher Education to 2030 – Vol. 1: Demography* (pp. 265–298). OECD Publishing. https://doi.org/10.1787/9789264040663-11-en

Wang, M.-T., Degol, J., & Ye, F. (2015). Math achievement is important, but task values are critical, too: Examining the intellectual and motivational factors leading to gender disparities in STEM careers. *Frontiers in Psychology*, *6*, 36. https://doi.org/10.3389/fpsyg.2015.00036

Wigfield, A., Eccles, J. S., Mac Iver, D., Reuman, D. A., & Midgley, C. (1991). Transitions during early adolescence: Changes in children's domain-specific self-perceptions and general self-esteem across the transition to junior high school. *Developmental Psychology*, *27*(4), 552–565. https://doi.org/10.1037/0012-1649.27.4.552

Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbreton, A. J. A., Freedman-Doan, C., & Blumenfeld, P. C. (1997). Change in children's competence beliefs and subjective task values across the elementary school years: A 3-year study. *Journal of Educational Psychology*, *89*(3), 451–469. https://doi.org/10.1037/0022-0663.89.3.451

Wilgenbusch, T., & Merrell, K. W. (1999). Gender differences in self-concept among children and adolescents: A meta-analysis of multidimensional studies. *School Psychology Quarterly*, *14*(2), 101–120. https://doi.org/10.1037/h0089000

Wolff, F., Helm, F., Zimmermann, F., Nagy, G., & Möller, J. (2018). On the effects of social, temporal, and dimensional comparisons on academic self-concept. *Journal of Educational Psychology*, *110*(7), 1005–1025. https://doi.org/10.1037/edu0000248

Wolff, F., Nagy, G., Retelsdorf, J., Helm, F., Köller, O., & Möller, J. (2019). The 2I/E model: Integrating temporal comparisons into the internal/external frame of reference model. *Journal of Educational Psychology*, *111*(7), 1131–1161. https://doi.org/10.1037/edu0000319

Wolter, I., & Hannover, B. (2016). Gender role self-concept at school start and its impact on academic self-concept and performance in mathematics and reading. *European Journal of Developmental Psychology*, *13*(6), 681–703. https://doi.org/10.1080/17405629.2016.1175343

Wolter, I., Kessels, U., & Hannover, B. (2011). Geschlechtsspezifische Unterschiede in der Selbstkonzeptentwicklung. In F. Hellmich (Ed.), *Selbstkonzepte im Grundschulalter: Modelle, empirische Ergebnisse, pädagogische Konsequenzen* (pp. 119–132). W. Kohlhammer.

World Bank (2023). Female share of graduates from Science, Technology, Engineering and Mathematics (STEM) programs, tertiary (%) [Data file]. Retrieved October 16, 2023, from https://databank.worldbank.org/source/gender-statistics

Xu, Y. J. (2008). Gender disparity in STEM disciplines: A study of faculty attrition and turnover intentions. *Research in Higher Education*, *49*(7), 607–624. https://doi.org/10.1007/s11162-008-9097-4

Zinn, S., Steinhauer, H. W., & Aßmann, C. (2017). Samples, weights, and nonresponse: The student sample of the National Educational Panel Study (Wave 1 to 8). *NEPS Survey Papers*. https://doi.org/10.5157/NEPS:SP18:1.0

Zinn, S., Würbach, A., Steinhauer, H. W., & Hammon, A. (2020). Attrition and selectivity of the NEPS starting cohorts: An overview of the past 8 years. *AStA Wirtschafts- und Sozialstatistisches Archiv*, *14*(2), 163–206.