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# Bridging the gap: gender-specific preferences in STEM occupations in vocational education and training

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## Abstract
Women's underrepresentation in science, technology, engineering, and mathematics (STEM) has been widely studied, particularly in the context of general and tertiary education. However, less is known about gendered STEM sorting within vocational education and training (VET), despite VET systems playing a key role in occupational gender segregation. This study investigates gender differences in the likelihood of choosing a STEM occupation in VET using nationally representative data from Switzerland. We examine to what extent commonly studied individual-level mechanisms—such as math achievement, math self-concept, and career values—can explain the gender gap in STEM participation. To assess whether these mechanisms operate similarly across educational pathways and outcome types, we compare students pursuing or intending to pursue VET to those aspiring to an academic degree, and examine three STEM-related outcomes: intended VET occupation, aspirations for a STEM job at age 30, and intentions to pursue a math-intensive job. We find that the gender gap in STEM participation is largest in VET occupations and considerably smaller for the other two outcomes. Moreover, a larger share of the gender gap can be explained regarding occupational aspirations as opposed to VET occupations, and among students aspiring to academic education. These findings suggest that theoretical models of STEM sorting should be adapted to better reflect the specific features of VET and the types of occupations it comprises.

**Keywords:** Gender inequality, STEM, Vocational training, Career choices, Occupations

## Introduction
Occupational gender segregation is a key driver of gender inequalities in labor market outcomes such as income, occupational status, and unemployment risk (e.g.,Busch 2020; Charles and Grusky 2004; England 1992; Kleinert et al 2023; Valentino 2020). Several studies have examined how gender-typical educational choices translate into gender segregation in the labor market, particularly highlighting the lower likelihood of women entering the fields of science, technology, engineering, and mathematics (STEM) compared to men (e.g.,Barone 2011; Cheryan et al 2017; Smyth and Steinmetz 2008). The underrepresentation of women in STEM is of concern from both an inequality and a

policy perspective. STEM professions are associated with high prestige and pay (e.g.,Bol and Heisig 2021; Jacob and Klein 2019; Black et al 2021), contributing to broader social inequalities. Furthermore, in light of the challenges posed by climate change, digitalization, and ongoing technological advancements, the demand for a skilled STEM workforce is steadily increasing in many industrialized countries (e.g.,OECD 2017).

Most prior research on STEM participation (e.g.,Sikora 2019; McDaniel 2016; Hägglund and Leuze 2021; Mann and DiPrete 2016, 2013; van der Vleuten et al 2018) or gender-typical occupational preferences more generally (e.g.,Hardie 2015; Busch-Heizmann 2015; Van De Werfhorst 2017; Van De Werfhorst et al 2003; Hägglund and Lörz 2020) has focused on aspirations or field of study choice in general and in tertiary education. These studies identified several explanatory factors for the gender imbalance in STEM participation, such as gender-specific socialization and stereotypes, differences in achievement and self-perceptions, as well as preferences for work-family balance (e.g.,Wang and Degol 2017).

While prior research has significantly contributed to our understanding of pathways into the STEM workforce, it has largely centered on pathways through tertiary education. Consequently, an equally critical route—vocational education and training (VET)—has received considerably less attention. In many European countries VET plays a major role in shaping the technical workforce. Just over half of all jobs in the European Union (EU) are in VET occupations (CEDEFOP 2024), many of which are directly linked to STEM fields such as engineering, manufacturing, or information technology. Failing to attract more women to STEM-related VET pathways means missing out on an untapped resource to fill increasing labour shortages in STEM. Thus, to fully understand gender disparities in the STEM workforce, it is essential to consider VET as a major entry point into technical and engineering occupations.

Some studies have emphasized the role of the VET system in the transmission of horizontal gender segregation from education to the labor market (e.g.,Smyth and Steinmetz 2015; Heiniger and Imdorf 2018; Beckmann et al 2023), for example, by showing that VET systems tend to be more gender-segregated than tertiary education systems (e.g.,Imdorf et al 2015; Prix 2012; Leemann and Keck 2005). This has been partly attributed to the fact that the VET track typically involves earlier and more binding career decisions, often made during mid-adolescence—at an age when gender stereotypes are particularly salient (e.g.,Basler et al 2021). Studies on gender segregation in VET mostly analyzed institutional characteristics of VET systems (e.g.,Smyth and Steinmetz 2015; Heiniger and Imdorf 2018; Imdorf et al 2014), or experiences and drop-out behavior of apprentices in gender-atypical VET occupations more broadly (e.g.,Beckmann 2023; Makarova et al 2016; Fischer-Browne et al 2024). However, to the best of our knowledge, no prior research has systematically assessed whether the micro-level explanatory factors identified in studies on STEM participation in general or tertiary education-such as gender stereotypes, school grades, self-concept, or job values-can similarly shed light on understanding the gender gap in STEM occupations accessed through VET pathways.

Against this background, this study contributes to the debate on women's underrepresentation in STEM by examining gender differences in STEM participation specifically within VET pathways. Focusing on Switzerland, we investigate (i) the extent of gender differences in accessing STEM occupations through VET and (ii) whether and how well theoretical mechanisms suggested by prior research on general and tertiary education can explain these gender gaps. Furthermore, we examine gender gaps in the outcomes of STEM occupational aspirations and aspirations for math-intensive jobs, considering two groups of students: those aiming for their highest educational attainment via a VET route versus those pursuing academic education. By examining both gender differences in STEM occupations within VET alongside more commonly studied outcomes (Jann and Hupka-Brunner 2020; Breda et al 2023), our approach allows us to better connect with existing research and directly examine within a single study how the explanatory power of common theoretical frameworks for gender gaps varies across different outcomes and between different groups of students (those on the VET route and the academic route).

Switzerland is an excellent case study to examine gender differences in STEM participation in VET. About two-thirds of compulsory school leavers choose VET over general education (BFS 2019), partly because it offers comparable wages to a university degree at labor market entry (Grønning et al 2020; Korber and Oesch 2019). Therefore, the VET system is less socially selective than in other countries with a strong VET system, such as Germany (Kriesi et al 2022). At the same time, gendered educational trajectories appear to be particularly pronounced in the Swiss context: a recent study showed that Switzerland has the largest gender gap in the intention to pursue a math-related career among OECD countries (Figure S1a,Breda and Napp 2019).

In the following, we briefly describe the Swiss VET system before presenting the state of research and our theoretical considerations. We then describe the data we used and the methods we applied. After presenting our results, we discuss them in the conclusion.

## The Swiss context

Switzerland has a highly stratified education system, which forces individuals to make career choices early in life, usually during adolescence (e.g.,Combet 2019; Nennstiel 2022a; Basler and Kriesi 2019). VET is part of the upper-secondary level, which students enter after leaving compulsory school at the end of ninth grade, typically at the age of around 15. Besides VET, students can choose to enter an academic track offering general education. The alternatives to these are interim solutions (e.g., preparatory courses, a gap year, or repeating ninth grade) or neither education nor employment (NEET) (Nennstiel 2022c). Access to these educational options depends on the lower-secondary school track and grades, although access to VET is possible regardless of the type of lower-secondary school attended (Basler and Kriesi 2019; Buchmann et al 2016; Nennstiel 2021).

VET is organized at the canton level and traditionally has a high value in Switzerland (Bonoli and Vorpe 2022). About two-thirds of compulsory school leavers choose VET, about 27% choose general education, and the remaining students choose an alternative pathway (BFS 2019). The share of school leavers choosing VET compared to general education at the upper-secondary level varies between the cantons and is particularly high in the German-speaking part of Switzerland (Imdorf et al 2014). The Swiss VET system offers both dual apprenticeship programs (company-based training combined with school-based education) and full-time school-based programs. The vast majority of students (90%) pursue a dual apprenticeship (BFS 2019). Students can choose between approximately 230 different training occupations. Most programs take three or four years, are highly standardized, and lead to nation-wide recognized federal diplomas (Grønning et al 2020; Imdorf et al 2014). Young men choose VET more often than women, with young women accounting for about 40% of VET graduates (BFS 2019). Furthermore, regarding the horizontal segregation in VET occupations, women are overrepresented in nursing and social work, whereas men are overrepresented in ICT, construction, engineering, and electricity (BFS 2019). Given the high standardization of the VET system in Switzerland and the young age at which students make these educational decisions (e.g.,Buchmann and Kriesi 2012), vocational choices likely have a long-lasting impact on occupational segregation.

## Theory and prior research

While women in many high-income countries have caught up with men in terms of educational attainment (Hadjar and Buchmann 2016), horizontal occupational gender segregation remains widespread (Charles and Bradley 2009). Several explanatory approaches have been put forward to explain the underrepresentation of women in STEM (Xie et al 2015; Wang and Degol 2017), which can be broadly divided into rational choice perspectives and cultural perspectives (for a detailed overview, see, Kriesi and Imdorf 2019; Hägglund and Lörz 2020).

### Rational choice perspectives

Rational choice perspectives on educational inequalities assume that individuals consider the costs and benefits of educational alternatives and choose the one with the highest perceived probability of success and lowest costs (e.g.,Becker 1993; Breen and Goldthorpe 1997). From this perspective, students may perceive their previous school performance in STEM-related subjects, such as mathematics, as an important signal of their future occupational prospects (e.g.,Gabay-Egozi et al 2015; Mann and DiPrete 2016; Hertweck and Lehner 2023). However, the extent of the gender achievement gap in mathematics has been debated, as it depends on how achievement is measured (e.g.,Buchmann et al 2008; Riegle-Crumb et al 2018). While, regarding standardized tests, boys often outperform girls in math and girls outperform boys in languages (e.g.,Else-Quest et al 2010; Nennstiel 2022b; Gutfleisch and Kogan 2022; Van Hek et al 2019), gender differences in math grades (i.e., teacher assessments) are small and often favor girls (e.g.,Voyer and Voyer 2014; Gutfleisch and Kogan 2024; Nennstiel and Gilgen 2024). Accordingly, the explanatory power of absolute math achievement for gender differences in occupational aspirations or tertiary participation in STEM has been considered small (e.g.,Riegle-Crumb et al 2012; Xie and Goyette 2003; Ochsenfeld 2016).

In contrast, scholars have highlighted the importance of comparative advantage—the relative strength in math versus reading—for educational and occupational preferences (e.g.,Hägglund and Lörz 2020; Beier et al 2023; van der Vleuten 2023). The underlying theoretical argument is that it is rational to choose the field of study for which one is academically best equipped (Jonsson 1999). Girls are relatively better in languages compared to math, whereas boys are relatively better in math compared to languages (Balducci et al 2024). Therefore, similar to previous research on aspirations and teritary education, gender differences in STEM participation in VET might be explained by intra-individual differences in math abilities and school grades in math and languages.

**Cultural perspectives**

Cultural perspectives emphasize the role of gender-specific socialization processes in shaping individual preferences, interests and work-related values of boys and girls (Kriesi and Imdorf 2019; Hägglund and Lörz 2020), as well as the evaluation of the benefits and costs of pursuing certain occupations (Eccles 2011; Combet 2024). Stereotypical beliefs about the traits, behaviors, and competencies of men and women persist despite an increase in gender-egalitarian ideology in many industrialized countries (Charles and Bradley 2009). Men are considered to be more naturally gifted in math and technical subjects, while women are considered to have better communication and nurturing skills (e.g., Starr et al 2022; Cheryan 2012; Garr-Schultz et al 2023). In line with patterns of occupational gender segregation (Cejka and Eagly 1999), these stereotypes are integrated into the images of study fields and occupations shaping adolescents' occupational preferences as well as potentially the expectations of significant others such as parents (Makarova et al 2019).

In line with these perspectives, scholars have emphasized the role of perceived abilities in math for gender differences in STEM participation (Weeden et al 2020). Girls tend to underestimate their abilities in mathematics and have lower math self-efficacy than boys, despite similar levels of performance (e.g., Correll 2001; Buchmann and Kriesi 2012; Jansen and Stanat 2015; Riegle-Crumb et al 2011). Similar patterns have been observed regarding self-efficacy in information technology (Cai et al 2017). In fact, perceived ability is considered more relevant than actual ability in STEM subjects in predicting gender differences in adolescents' occupational preferences (e.g., Lörz et al 2011; Thébaud and Maria 2018). Prior studies suggest that such beliefs at least partly explain students' occupational aspirations and choice of fields of study regarding STEM in higher education in Switzerland (Jann and Hupka-Brunner 2020) and other countries (e.g., Sax et al 2016; Perez-Felkner et al 2017; Seo et al 2019).

Another explanation rooted in cultural norms highlights that women may be more likely to prioritize family involvement, such as caregiving, which is often seen as difficult to reconcile with the demands of a STEM career (Weeden et al 2020; Busch-Heizmann 2015). Accordingly, and in line with a human capital or rational choice perspective, these culturally shaped expectations may lead girls to prefer occupations in which potential income losses due to employment interruptions, for example for childrearing, are less severe (Polachek 1981). Therefore, gender differences in family value orientation might explain part of the gender gap in STEM participation also in VET.

Similarly, prior research on STEM participation in tertiary education and gender segregation in occupational aspirations more broadly has identified gender differences in interest and work values as important factors (see e.g., Hägglund and Lörz 2020). Individuals tend to choose occupations with which they can sufficiently identify. Occupational choices thus reflect personal interests and personality traits (Holland 1973; Charles and Bradley 2009). This is also in line with expectancy value theory (Eccles and Wang 2016; Eccles 2011), which emphasizes that aligning one's interests with occupational choices can be a non-monetary benefit that enhances motivation and perceived task value. Gender differences in interests are often conceptualized along the people-things spectrum, with girls gravitating toward people-oriented fields and boys toward things-oriented ones, echoing traditional gender stereotypes (e.g., Kuhn and Wolter 2022; Busch-Heizmann 2015).

Another relevant set of gendered preferences that has been highlighted by previous research relate to competitiveness and risk aversion (e.g., Niederle and Vesterlund 2007; Buser et al 2017). Studies suggest that women tend to exhibit higher aversion to competition and risk, making women less likely to pursue highly competitive or male-typed fields, even when their actual performance is similar to men's (e.g., Niederle and Vesterlund 2007). A recent experimental study on gender differences in major choice among high school students in Switzerland suggests that gender differences in affinity for work tasks are more pronounced than differences in preferences for competitive environments or work-family compatibility, while no gender differences were found regarding instrumental values such as income or prestige (Combet 2024).

Overall, prior research—mostly in tertiary education—has identified a range of mechanisms that may help explain gender differences in STEM participation and in choosing gender-atypical fields more broadly, including differences in achievement, self-assessments, interests, and work values. The extent to which these explanatory approaches can account for gender differences in the pursuit of STEM occupations through VET pathways remains an open question.

## Data and methods

### Data

We used nationally representative data from the verification of the attainment of basic competencies (Überprüfung des Erreichens der Grundkompetenzen, ÜGK) study in 2016 to investigate ninth-graders' choices of VET occupations (i.e., apprenticeships), STEM career aspirations and math-related career aspirations (Nidegger 2019). For this study, 22,423 ninth-grade students were surveyed between April and June 2016. Besides information on students' competencies, the data provides information on students' socioeconomic and sociodemographic characteristics. The student sample was drawn using stratified random sampling. Within the participating cantons, first regions, then schools, and finally students within these schools were randomly selected. The participation rate was high, at over 90% of the selected students (Verner and Helbling 2019).

For our analyses, we draw on three analytical samples, which differ in size depending on the availability of the relevant dependent variable and the questionnaire version administered. First, we consider all students who have already (up until the time point of the survey) applied for an apprenticeship or a school-based VET program; labeled *Sample 1*. Furthermore, we include all students who provided a valid, classifiable response to the question regarding their ideal highest educational aspiration. These students were subdivided into two samples. One for those who indicated an educational qualification attainable through the VET system *Sample 2*, and another for those who indicated an educational qualification attainable through the academic education system *Sample 3*. This differentiation allows us to compare students who are already transitioning into VET (Sample 1), those who aspire to do so (Sample 2), and those aiming for an academic track (Sample 3), thereby enabling a more nuanced analysis of STEM-related orientations across educational pathways. While there is high overlap between *Samples 1* and *2*, *Sample 3* may also include students who already entered VET. This is because students may initially plan to complete a VET program, even if their highest educational aspiration refers to an academic degree.

Due to the survey design, not all students answered the same set of questions. Certain questions relating to some of the discussed theoretical mechanisms were included only in randomly assigned questionnaire modules. Therefore, within the three samples, we additionally differentiate whether we examine all students in the sample (*All*) or whether, due to the questionnaire design, we examine the *subsample A* or the *subsample B*. Subsample A were asked questions about general career expectations, family values, and personality traits. Subsample B were specifically asked about math-related values and preferences.

#### Operationalization

The first dependent variable under investigation is students' choice of a STEM occupation within VET (*Outcome 1*). The students were asked whether they had ever applied for or enrolled in VET (either company-based or school-based), and were then prompted to specify the particular program or apprenticeship. For some students with missing values for this question, we relied on another question related to the plans after the summer break to fill in gaps regarding the intended VET occupation. For individuals with data available for both their initial VET preference and the VET program planned for after the summer, we prioritized the information regarding the initially intended VET program. This approach was employed to minimize potential selection bias arising from matching processes (e.g., due to unobserved demand-side mechanisms). Accordingly, we operationalize this variable as the intention to pursue STEM in VET. However, we acknowledge that this outcome is itself subject to selection, as it includes only individuals who are pursuing or intending to pursue the VET pathway.

The classification of STEM fields or occupations varies across studies, partly due to differences in the outcomes under consideration (e.g., fields of study vs. occupations) and whether self-developed coding schemes or official classifications are used (see Stefani et al 2024, for a detailed discussion). To ensure consistency with current policy debates on women's underrepresentation in STEM and to allow for comparability across contexts (Stefani et al 2024), we followed the Eurostat classification based on the International Standard Classification of Education (ISCED-F 2013). This classification defines STEM as including apprenticeships in mathematics and natural sciences (ISCED-F category 5), engineering and construction (category 6), and information and communication technologies (category 7). Information on the ISCED-F codes of apprenticeships in 2016 was taken from the Federal Statistical Office (BFS) and merged with the occupational codes in the ÜGK data. Based on the data available, our classification includes only categories 6 and 7, as occupations classified under category 5 are rare in the VET system (in contrast to higher education, where they are more common). Despite this restriction, we use the general term STEM throughout the manuscript, as it reflects the broader conceptual and policy context and ensures consistency across outcomes.

The second dependent variable examined is the aspiration for a STEM occupation at age 30 (*Outcome 2*). For this, we utilized students' responses to a question regarding the profession they anticipate holding at age 30. This variable was generated by classifying occupations as either STEM or non-STEM based on the International Standard Classification of Occupations 2008 (ISCO-08). In contrast to our first outcome, this variable captures students' idealistic occupational aspirations, which are less likely to be shaped by immediate opportunity structures (i.e., the availability of VET occupations). This broader and less constrained perspective allows us to include a wider set of occupations under the STEM label, including science-related fields. Although we follow Gutfleisch and Kogan (2022) in including both high-skilled and middle-skilled professions, we deliberately exclude medical professions – unlike their approach – in order to align our STEM definition more closely with our VET-based classification and with official definitions. Consistent with other studies focusing on aspirations, it was observed that 20 percent of students could not yet formulate concrete occupational aspirations for age 30.

The third dependent variable, available only for a subsample of students (subsample B), is whether there is a future desire to pursue an occupation requiring mathematical skills and knowledge (*Outcome 3*). This subsample was randomly selected and received additional questions related to mathematics, including this variable. Based on responses to the question regarding their interest in later pursuing a math-intensive profession, we created a dummy variable with the categories 'no' (0, representing 'strongly disagree' and 'tend to disagree') and 'yes' (1, representing 'tend to agree' and 'strongly agree'). We include this outcome because it has been widely used in prior research on gender gaps in STEM participation based on international data (e.g., Breda et al 2023), and because many theoretical explanations for gendered patterns in STEM participation explicitly refer to attitudes toward mathematics.

In line with our theoretical framework, which integrates rational choice and cultural explanations, we further operationalize a set of explanatory variables that reflect key mechanisms from both perspectives. For our analyses, we measured *gender* as a binary variable (boys versus girls). To operationalize math achievement, we used both teacher assessments (i.e., *grades*), ranging from 1 (insufficient) to 6 (excellent), and standardized *test scores* (weighted likelihood estimates). We z-standardized the teacher assessments (the math grade), with positive values indicating above-average performance and negative values below-average performance. Teacher assessments result from multiple tests over time and are influenced by competencies, teacher perceptions, and student behavior. In contrast, test scores are based on assessments at one point in time and are thus considered a more objective measure of competencies. They therefore capture something different, which is why it is justifiable to include both measures. Additionally, we account for *comparative advantage* in mathematics grades relative to language grades (either German, French, or Italian, depending on the region) by subtracting the language grade from the mathematics grade. Positive values indicate an advantage in mathematics over the language grade, while negative values suggest an advantage in the language grade.

Furthermore, several variables aligning with cultural perspectives were included. *Math self-efficacy* refers to students' perceptions of their capacity to solve math-specific tasks. It is also provided as a standardized score in the data based on 16 items covering four domains: (1) general mathematics; (2) algebra; (3) geometry; and (4) probability. *Math self-concept* refers to students' perceptions of their math abilities. It is operationalized based on students' agreement to three items: (1) I get good marks in mathematics; (2) mathematics is one of my best subjects; and (3) I have always done well in mathematics. *Verbal self-concept* similarly assesses students' perceptions of their abilities in their test language. It is operationalized through students' responses to three items (ranging from 'strongly disagree' to 'strongly agree'): (1) In test language, I am a hopeless case; (2) In test language, I learn quickly; and (3) In test language, I get good marks. The data provides standardized scores for math and verbal self-concept, which we used in our analysis. *Instrumental motivation* reflects students' engagement in learning driven by future-oriented, practical benefits. It is assessed using a 4-point Likert scale (ranging from 'almost never' to 'almost always') based on three items: (1) I learn to improve my career opportunities; (2) I learn so that I will be financially secure in the future; and (3) I learn to get a good job. The data provides a standardized score for instrumental motivation, which was utilized in our analysis.

Whereas these variables are available for all students in our sample, the following variables were collected exclusively within subsample A. The *Big Five* personality traits neuroticism, extraversion, agreeableness, conscientiousness, and openness were assessed as multi-item composite scores. *Job value leisure time* was measured by students' rating of the importance of "A profession that allows me a lot of free time" on a 4-point scale (ranging from 'completely unimportant' to 'very important'). *Intrinsic job values* were measured by the importance of three items: (1) Having a job where I can always learn something new, (2) Having a profession where I can fully utilize my skills, and (3) Having a job that gives me the feeling of doing something meaningful. Responses for these items were collected on a 4-point scale (ranging from 'completely unimportant' to 'very important'). *Extrinsic job values* were assessed through the importance of three items: (1) Earning a lot of money, good salary, (2) Having a secure job, and (3) Having a job that is recognized and respected by others. These responses were also on a 4-point scale (ranging from 'completely unimportant' to 'very important'). *Family value orientation* was determined by the importance of two items: (1) Having children and (2) Getting married or living in a committed partnership, both rated on a 4-point scale (ranging from 'completely unimportant' to 'very important'). The data provides a standardized score for family value orientation, intrinsic and extrinsic job values, which we used in our analysis.

The following variables were collected exclusively within the subsample B. *Mother's importance of subject performance* was included, as it had fewer missing values compared to paternal expectations. This was assessed by asking "How important is it generally for your mother that you do well in the following subjects?" for mathematics, on a 4-point scale (ranging from 'not at all important' to 'very important'). *Instrumental motivation in math* was measured using a 4-point Likert scale (ranging from 'strongly disagree' to 'strongly agree') across four items: (1) I make an effort in mathematics because it will help me in my future job, (2) Mathematics is an important subject for me because I will need it later for my education, (3) It's worth it for me to try hard in mathematics class because it will be useful in my future profession, and (4) Learning mathematics is worthwhile because it improves my career prospects. The data provides a standardized score for instrumental motivation in math, which we used in our analysis.

We further included several student background characteristics as control variables in our analyses, such as age, migration background, highest parental education, parental

STEM occupation, and type of lower-secondary school track. *Age* was measured continuously in years. To operationalize the variable *migration background*, we differentiated between native-born students (at least one parent born in Switzerland), first-generation immigrants (student born abroad), second-generation immigrants (both parents born abroad), and students with missing information. We differentiated the variable lower-secondary *school track* as follows: schools with basic requirements (Realschule); schools with extended requirements (Sekundarschule); schools with academic requirements (Gymnasium); and schools with no selection that combine one or more types. The variable *highest parental education* was measured using the highest parental ISCED of the parents. We differentiated between the following categories: below tertiary level degree (ISCED 1 - ISCED 4), tertiary level degree (ISCED 5 or above), and students with missing information. We created a *parental STEM occupation* variable based on the jobs of the parents (following Gutfleisch and Kogan (2022)): no parents working in STEM, at least one parent working in STEM, and missing information on both parents' jobs. We again included both middle-skilled and high-skilled occupations, but excluded medical professions in order to algin with official statistical reports on STEM. As children are often unable or unwilling to answer questions about parental education and/or occupation (Hovestadt and Schneider 2021), we summarized the responses in which children did not provide information about their parents' education or job in a separate category.

#### Analytical sample selection

As outlined above, we analyze three distinct analytical samples: students with valid information on their intended VET occupation (*Sample 1*), and students who provided a valid, classifiable response to the question on their highest educational aspiration (*Samples 2* and *3*). Across these samples, we examine three outcome variables: STEM occuation in VET (*Outcome 1*), STEM career aspirations at age 30 (*Outcome 2*), and the intention to pursue a math-intensive occupation (*Outcome 3*). There is partial overlap between samples and outcomes: *Outcome 1* is only available for Sample 1, while *Outcomes 2* and *3* are observed for students in all three samples. Based on this structure, we conducted complete case analyses with respect to our key variables of interest in terms of theoretical mechanisms across outcomes and (sub)samples. This approach was employed, as the cumulative share of missing values for these variables remains below 5% in all (sub)samples. To retain as many observations as possible, we handled missing values on control variables (e.g., parental education or migration background) by including them as a separate category in the respective models (see operationalizations). Students from special needs schools were excluded from the analysis. Table 1 presents the case numbers for each sample, as well as the combinations of samples and outcomes. Our main analytical sample (Sample 1 (All students)) corresponds to roughly 10 percent of all ninth-grade students in the school year 2015/2016 in Switzerland (see Nennstiel 2022c, Table 1).

#### Methods

To answer our research questions, we performed the following analyses. For all possible combinations of outcomes and samples, we computed various logistic regression models and predicted the gender gap based on these. In order to enhance comparability of

**Table 1** Case numbers for the different samples, across outcomes and (questionnaire-related) subsamples

| | Outcome 1 | | | Outcome 2 | | | Outcome 3 |
|---|---|---|---|---|---|---|---|
| | STEM VET | | | STEM job at 30 | | | Math-intensive job |
| Sample 1 | All | A | B | All | A | B | B |
| *VET occupation* | | | | | | | |
| N | 9,909 | 4,983 | 4,858 | 8,132 | 4,115 | 3,962 | 4,858 |
| Sample 2 | | | | All | A | B | B |
| *VET aspirations* | | | | | | | |
| N | | | | 7,806 | 3,959 | 3,760 | 4,834 |
| Sample 3 | | | | All | A | B | B |
| *Academic aspirations* | | | | | | | |
| N | | | | 6,826 | 3,501 | 3,285 | 4,468 |

A = subsample A. B = subsample B. Source: ÜGK 2016; own calculations

effects across groups and models in logistic regressions (Mood 2010), we present these results as average marginal effects (AMEs). In Model 0 (M0), we included only gender as a predictor. This model provides the raw gender gap across the three outcome variables, which we subsequently use as a baseline to indicate the reduction of the gender gap across the models. In Model 1 (M1), we incorporated additional explanatory variables available for all subsamples, namely math grades, comparative grade advantage, math test scores, math self-efficacy, math self-concept, verbal self-concept, instrumental motivation, as well as our control variables, and re-estimated the gender gap based on these models. Model 2 (M2) was estimated only for the subsamples A and B, allowing us to include additional explanatory variables. In subsample A, we additionally control for variables related to family values, intrinsic and extrinsic future job values, leisure time job values, as well as the Big Five personality traits. In subsample B, we additionally control for instrumental math motivation and mothers' valuation of math performance. Based on these models, we re-estimated gender gaps in our three outcomes. We then related the predicted gender gaps from Models 1 and 2 to the raw gender gaps from Model 0 to illustrate the reduction of the gender gap across the models (i.e., subsamples; see Table 2). The average marginal effects predictions for all model variables are presented in the Appendix supplementary tables (see Tables A1-A5).

To take into account the sampling design of the study and the structure of our data (students nested within schools), we included sampling and balanced repeated replication (BRR) weights for all analyses (see also, Jann and Hupka-Brunner 2020).

## Results

Figure 1 graphically illustrates the variation in the size of the gender gap across models, outcomes, and subsamples. Table 2 presents the corresponding numerical results and provides additional information on the extent to which the gender gap is reduced from M0 to M1 and M0 to M2 across the outcome variables and samples.

Regarding *Outcome 1*, based on *Sample 1* (students who applied for VET), we observe a raw gender gap of approximately 48 percentage points. This gap is reduced by only 15.94 percentage points when key explanatory variables—namely, actual and perceived

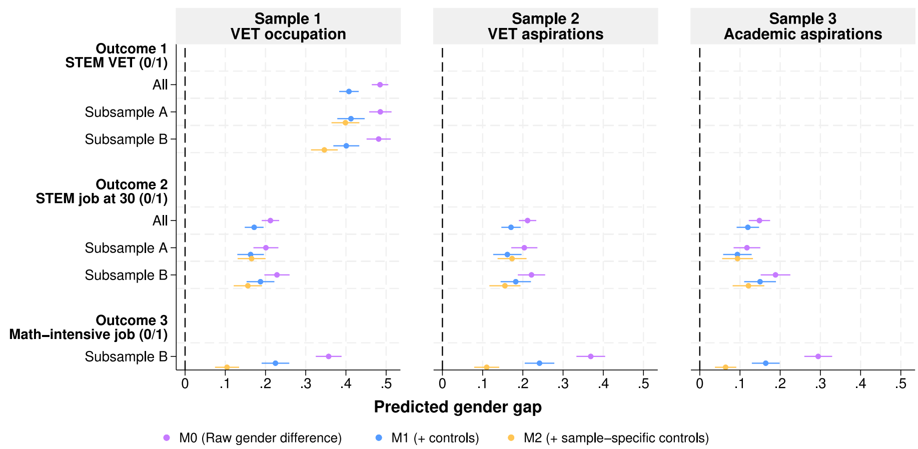


**Fig. 1** Predicted gender difference (boys compared to girls) for different outcomes (STEM VET, STEM job at 30, and Math-intensive job) across samples (in percentage points). *Note:* Predictive margins based on logistic regression models. Full models are displayed in Tables A1, A2, A3, A4, and A5 in the supplementary material. *Source:* ÜGK 2016; weighted data, own calculations

**Table 2** Gender gaps and percentage reduction in gender gaps across samples, outcomes, and statistical models Source: ÜGK 2016; weighted data, own calculations

| | **Outcome 1** | | | **Outcome 2** | | | **Outcome 3** |
|---|---|---|---|---|---|---|---|
| | **STEM VET** | | | **STEM job at 30** | | | **Math-intensive job** |
| Sample 1 | All | A | B | All | A | B | B |
| *Predicted gender gap* | | | | | | | |
| M0 | 0.48 | 0.49 | 0.48 | 0.21 | 0.20 | 0.23 | 0.36 |
| M1 | 0.41 | 0.41 | 0.40 | 0.17 | 0.16 | 0.19 | 0.22 |
| M2 | | 0.40 | 0.35 | | 0.17 | 0.16 | 0.10 |
| *Reduction in gender gap* | | | | | | | |
| % reduction M1 to M0 | 15.94 | 15.05 | 16.71 | 19.06 | 18.95 | 17.94 | 37.06 |
| % reduction M2 to M0 | | 17.89 | 28.05 | | 17.71 | 31.68 | 70.78 |
| Sample 2 | | | | All | A | B | B |
| *Predicted gender gap* | | | | | | | |
| M0 | | | | 0.21 | 0.20 | 0.22 | 0.37 |
| M1 | | | | 0.17 | 0.16 | 0.18 | 0.24 |
| M2 | | | | | 0.17 | 0.16 | 0.11 |
| *Reduction in gender gap* | | | | | | | |
| % reduction M1 to M0 | | | | 19.44 | 20.68 | 17.64 | 34.55 |
| % reduction M2 to M0 | | | | | 14.98 | 29.82 | 70.14 |
| Sample 3 | | | | All | A | B | B |
| *Predicted gender gap* | | | | | | | |
| M0 | | | | 0.15 | 0.12 | 0.19 | 0.29 |
| M1 | | | | 0.12 | 0.09 | 0.15 | 0.16 |
| M2 | | | | | 0.09 | 0.12 | 0.06 |
| *Reduction in gender gap* | | | | | | | |
| % reduction M1 to M0 | | | | 19.43 | 20.25 | 20.40 | 44.30 |
| % reduction M2 to M0 | | | | | 19.94 | 35.71 | 78.19 |

A = subsample A. B = subsample B

math abilities as well as instrumental values—are included in the model (M1). Similar patterns are observed across the two subsamples for M1: A (students for whom career values and family orientation are available), and B (students for whom intentions to pursue math-intensive fields as well as values related to math-intensive careers are available). When we additionally include personality traits, intrinsic and extrinsic jobs values, as well as family orientations in our model (M2, based on subsample A), the explained share of the gender gap in STEM participation in VET increases only slightly to 17.89 percentage points. In contrast, when we add mother's valuation of subject performance and instrumental motivation in math (M2, based on subsample B), the explained share increases substantially to 28.05 percentage points.

Different patterns are observed regarding the two other outcome variables, and when comparing the main sample *Sample 1* to the other two samples *Samples 2 and 3*. The raw gender gap in STEM participation is considerably smaller for *Outcome 2* (STEM job at age 30) compared to *Outcome 1* across all three samples. Regarding *Outcome 2*, the gap is slightly smaller in *Sample 3* (students aspiring to an academic degree) but does not differ substantially between *Samples 1* and *2* (students either pursuing or aspiring to a VET) based on M0. For our main sample (*Sample 1*), the explained share of the gender gap in STEM participation in *Outcome 2* is slightly higher than in *Outcome 1* when considering the full sample (regarding M1). However, when comparing samples within *Outcome 2*, considering the full range of theoretically relevant variables in Subsamples A and B, the explained gender gap in STEM participation is slightly higher in *Sample 3* (students aspiring to academic degrees) compared to the other two VET-focused samples. Among students in Subsample B, for example, roughly 36% of the gender gap in STEM job at 30 can be explained in *Sample 3*, as opposed to 30% in *Sample 2* and 32% in *Sample 1*.

For *Outcome 3* (intentions to pursue math-intensive careers), the raw gender gap is again smaller than for STEM in VET, although not as small as for aspirations at age 30. Importantly, more than 70% of the gender gap in intention to pursue math-intensive fields is explained by the theoretical mechanisms considered—namely, actual and perceived math ability, instrumental values, instrumental math motivation, and mother's valuation of subject performance. This proportion is highest in *Sample 3* (students aspiring to an academic degree; 78%).

Overall, the results show a consistent pattern: the gender gap in STEM participation is largest in relation to VET occupations, *Outcome 1,* and among students pursuing or intending to pursue VET, *Samples 1 and 2*, compared to the other two outcomes and *Sample 3*. Moreover, the theoretical mechanisms considered in our study explain a larger part of the gender gap in STEM participation among students aspiring to an academic degree and when considering math-intensive fields instead of STEM as outcome.

## Discussion and conclusion

Given growing labor shortages and concerns about social inequality, understanding the drivers of women's persistent underrepresentation in the STEM workforce is essential from both a policy and equity perspective (e.g., Stefani et al 2024). While prior research has offered valuable insights into the gender gap in STEM participation, particularly in general and tertiary education (for reviews, see Xie et al 2015; Yazilitas et al 2013; Wang and Degol 2017; Riegle-Crumb et al 2018), comparatively little attention has been paid to VET. Given the central role of VET in European labor markets (CEDEFOP 2024), this study examined the gender gap in STEM participation within VET. To assess whether the mechanisms identified in previous studies also apply to this context, we compared students pursuing or intending to pursue VET with those aspiring to an academic degree. Recognizing that the composition of available occupations differs across educational pathways, we further examined three different outcomes: actual or intended VET occupations, occupational aspirations at age 30, and intentions to pursue math-intensive careers.

Using nationally representative data from Switzerland, our findings reveal substantial variation in the size and explainability of the gender gap in STEM participation depending on the sample and outcome considered. The gender gap is largest—at 48 percentage points—for STEM-related VET occupations. In contrast, gender gaps are markedly smaller for idealistic aspirations to a STEM job at age 30 or pursuing a math-intensive career. Moreover, a larger share of these gender gaps can be explained by individual-level theoretical variables. This pattern is most pronounced among students aspiring to an academic degree, where 78% of the gender gap in math-related career intentions is accounted for.

These findings align with prior research on STEM aspirations and field of study choice in Switzerland (Jann and Hupka-Brunner 2020; Makarova et al 2019) and other countries (e.g., Beckmann and Fervers 2024; Beier et al 2023; van der Vleuten et al 2018; Mann and DiPrete 2013), which report gender gaps between approximately 20 and 30 percentage points. In contrast to earlier studies, however, our analysis compares multiple outcomes and groups (aspiring to VET or academic degree) within a unified analytical framework. Overall, our findings suggest that gendered sorting into STEM in the VET sector is only partially driven by widely studied individual-level mechanisms. Rather, these mechanisms seem to hold greater explanatory power when it comes to STEM aspirations, especially among students aspiring to an academic degree.

One possible explanation for the observed differences in the size and explainability of the gender gap across groups and outcomes lies in the nature of the explanatory variables themselves. Theoretical constructs such as math achievement, perceived ability, and instrumental values may align more closely with academic pathways and may therefore carry less explanatory weight in the context of VET. VET occupations differ from academic careers and aspirations in terms of the types of available jobs and their required skill profiles. For instance, many STEM occupations within VET are highly technical and are more manual in nature, suggesting the need to consider indicators of technical interest or hands-on skills in addition to math-related indicators or more general career values. This may also explain why the largest explained part was observed regarding the outcome of aspiring math-intensive jobs. Supporting this notion, a recent study finds only small or no gender differences in work values (e.g., work-family compatibility) or materialistic characteristics (e.g., income), but relatively large differences in affinity of work tasks (technical vs. social) (Combet 2024) . Therefore, commonly used explanatory variables may need to be expanded or adapted to better capture the specificities of the VET context.

Our study is not without limitations. First, the data used are cross-sectional, which limits our ability to assess how gender differences in STEM-related preferences and pathways evolve over time. While we compare students aspiring to either a VET or an academic track, we cannot observe their actual post-secondary field of study. This means our analysis is based on anticipated rather than realized pathways in terms of academic tracks, which may be shaped by distinct structural and temporal constraints. Second, some of our theoretical variables—such as personality traits, career values, and domain-specific motivations—were only available in questionnaire subsamples. However, because students were randomly assigned to different questionnaire modules, we do not expect systematic selection bias in this regard. Third, some relevant mechanisms identified in previous research could not be accounted for in our study, such as anticipated discrimination (e.g., Hägglund and Lörz 2020). A qualitative study has shown that gender is a crucial selection criterion among recruiters hiring apprentices in automobile mechanics in Switzerland (Imdorf 2013). Anticipated exclusion or physical demands in certain manual STEM fields may therefore deter girls from pursuing these pathways, contributing to the larger gender gaps observed in the VET context compared to occupational aspirations. Finally, our findings are based on data from Switzerland, a country with a well-developed, dual VET system. While this context is highly relevant for understanding STEM pathways in VET, generalizations to countries with less formalized VET systems should be made with caution.

Despite these limitations, our study contributes to prior research on gender gaps in STEM participation in several ways. We applied established individual-level explanations—such as math achievement, self-concept, and values-to the VET context, thereby extending previous research that has predominantly focused on institutional features of VET systems in explaining gender segregation (e.g., Smyth and Steinmetz 2015; Prix 2012). Our findings suggest that the mechanisms driving gendered STEM choices may differ between educational pathways. Specifically, the practical and technical orientation of VET programs may pose additional barriers for girls, which are not captured by theoretical models developed primarily for academic contexts. By comparing students who pursue or intend to pursue VET with those who aspire to academic education, and by examining three distinct STEM-related outcomes, we highlight that the magnitude and explainability of the gender gap vary depending on both the educational pathway and the type of outcome. This comprehensive approach helps refine our understanding of when and where gender disparities in STEM emerge. Future research should place greater emphasis on exploring the gender-specific dynamics of STEM participation not only in general and tertiary education but also in VET. Such inquiry will help to design effective measures to increase women's participation in STEM not only in the likelihood of aspiring to a STEM major in higher education (e.g., Fervers et al 2025; Barone et al 2020), but also for the VET context.

## Supplementary Information

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Supplementary material 1.

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**Author contributions**
TG contributed to the conceptualization, data analysis, statistical analyses, drafting of the initial manuscript, writing and rewriting of various sections, as well as providing supervision throughout the project.
RN contributed to the conceptualization, data analysis, statistical analyses, drafting of the initial manuscript, writing and rewriting of various sections, as well as providing supervision throughout the project.

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**Data availibility**
All data used is publicly available (after registration). As this is third-party data, we cannot make it publicly available. In the following, however, we make it clear which data we have used and where it can be obtained. The ÜGK/COFO/VECOF 2016: Competencies of Swiss pupils in mathematics data can be downloaded from the SWISSUbase website https://www.swissubase.ch/de/catalogue/studies/13413/19390/datasets/1004/1545/overview. Nidegger, C. (2019). ÜGK/COFO/VECOF 2016: Competencies of Swiss pupils in mathematics (Version 1.0.0) [Data set]. FORS data service. https://doi.org/10.23662/FORS-DS-1004-1.

**Code availability**
The syntax for our analysis is available here https://osf.io/wg4pt/.

**Materials availability**
Not applicable.

## Declarations

**Ethics approval and consent to participate**
Not applicable.

**Consent for publication**
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**Competing interests**
The authors declares that they have no Competing interests.

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**References**

Balducci M, Larose MP, Stoet G et al (2024) The gender-equality paradox in intraindividual academic strengths: a cross-temporal analysis. Psychol Sci 35(11):1246–1259. https://doi.org/10.1177/09567976241271330

Barone C (2011) Some things never change: gender segregation in higher education across eight nations and three decades. Sociol Educ 84(2):157–176. https://doi.org/10.1177/0038040711402099

Barone C, Schizzerotto A, Assirelli G et al (2020) Nudging gender desegregation: a field experiment on the causal effect of information barriers on gender inequalities in higher education. Eur Soc 21(1):356–377. https://doi.org/10.1080/14616696.2018.1442929

Basler A, Kriesi I (2019) Adolescents' development of occupational aspirations in a tracked and vocation-oriented educational system. J Vocat Behav 115:103330. https://doi.org/10.1016/j.jvb.2019.103330

Basler A, Kriesi I, Imdorf C (2021) The development of gendered occupational aspirations across adolescence: examining the role of different types of upper-secondary education. Longitud Life Course Stud 12(2):173–199. https://doi.org/10.1332/175795920X16015782777176

Becker GS (1993) Human capital: a theoretical and empirical analysis, with special reference to education. University of Chicago Press, Chicago

Beckmann J (2023) Why do they leave? Examining dropout behaviour in gender-atypical vocational education and training in Germany. J Vocat Educ Train 77(2):297–321. https://doi.org/10.1080/13636820.2023.2211546

Beckmann J, Fervers L (2024) Does study counselling foster STEM intentions and reduce the STEM gender gap? Evidence from a randomized controlled trial. Educ Res Eval 29(3–4):147–170. https://doi.org/10.1080/13803611.2024.2315283

Beckmann J, Wicht A, Siembab M (2023) Career compromises and dropout from vocational education and training in Germany. Soc Forces 102:658–680. https://doi.org/10.1093/sf/soad063

Beier L, Minello A, Uunk W et al (2023) The emergence of gender-specific competence patterns and decision making during the course of educational and job careers in Germany. Education, competence development and career trajectories. Methodology of educational measurement and assessment. Springer, Berlin, pp 59–86. https://doi.org/10.1007/978-3-031-27007-9_3

BFS (2019) Personen in Ausbildung. Ausgabe 2019. Bundesamt für Statistik (BFS), Neuchâtel.
Black SE, Muller C, Spitz-Oener A et al (2021) The importance of STEM: high school knowledge, skills and occupations in an era of growing inequality. Res Policy 50:104249. https://doi.org/10.1016/j.respol.2021.104249
Bol T, Heisig JP (2021) Explaining wage differentials by field of study among higher education graduates: evidence from a large-scale survey of adult skills. Soc Sci Res 99:102594. https://doi.org/10.1016/j.ssresearch.2021.102594
Bonoli L, Vorpe J (2022) Swiss VET between national framework and cantonal autonomy: a historical perspective. Educ Sci 12(2):114. https://doi.org/10.3390/educsci12020114
Breda T, Napp C (2019) Girls' comparative advantage in reading can largely explain the gender gap in math-related fields. Proc Natl Acad Sci USA 116(31):15435–15440. https://doi.org/10.1073/pnas.1905779116
Breda T, Jouini E, Napp C (2023) Gender differences in the intention to study math increase with math performance. Nat Commun 14:3664. https://doi.org/10.1038/s41467-023-39079-z
Breen R, Goldthorpe JH (1997) Explaining educational differentials. Towards a formal rational action theory. Ration Soc 9(3):275–305. https://doi.org/10.1177/104346397009003002
Buchmann M, Kriesi I (2012) Geschlechtstypische Berufswahl: Begabungszuschreibungen, Aspirationen und Institutionen. Kölner Zeitschrift für Soziologie und Sozialpsychologie 52:256–280. https://doi.org/10.1007/978-3-658-00120-9_11
Buchmann C, DiPrete TA, McDaniel A (2008) Gender inequalities in education. Ann Rev Sociol 34:319–337. https://doi.org/10.1146/annurev.soc.34.040507.134719
Buchmann M, Kriesi I, Koomen M et al (2016) Differentiation in secondary education and inequality in educational opportunities: the case of Switzerland. In: Blossfeld HP, Buchholz S, Skopek J (eds) Models of secondary education and social inequality. Edward Elgar, Cheltenham. https://doi.org/10.4337/9781785367267.00016
Busch F (2020) Gender segregation, occupational sorting, and growth of wage disparities between women. Demography 57(3):1063–1088. https://doi.org/10.1007/s13524-020-00887-3
Busch-Heizmann A (2015) Supply-side explanations for occupational gender segregation: adolescents' work values and gender-(a)typical occupational aspirations. Eur Sociol Rev 31(1):48–64. https://doi.org/10.1093/esr/jcu081
Buser T, Peter N, Wolter SC (2017) Gender, competitiveness, and study choices in high school: evidence from Switzerland. Am Econ Rev 107(5):125–130. https://doi.org/10.1257/aer.p20171017
Cai Z, Fan X, Du J (2017) Gender and attitudes toward technology use: a meta-analysis. Comput Educ 105:1–13. https://doi.org/10.1016/j.compedu.2016.11.003
CEDEFOP (2024) VET Occupations. Share of people with VET qualifications across broad occupations in EU in 2022. https://www.cedefop.europa.eu/en/tools/skills-intelligence/vet-occupations?year=2022. Accessed 05 May 2025.
Cejka MA, Eagly AH (1999) Gender-stereotypic images of occupations correspond to the sex segregation of employment. Pers Soc Psychol Bull 25(4):413–423. https://doi.org/10.1177/0146167299025004002
Charles M, Bradley K (2009) Indulging our gendered selves? Sex segregation by field of study in 44 countries. Am J Sociol 114(4):924–976. https://doi.org/10.1086/595942
Charles M, Grusky DB (2004) Occupational ghettos: the world-wide segregation of women. Stanford University Press, Stanford
Cheryan S (2012) Understanding the paradox in math-related fields: why do some gender gaps remain while others do not? Sex Roles 66(3–4):184–190. https://doi.org/10.1007/s11199-011-0060-z
Cheryan S, Ziegler SA, Montoya AK et al (2017) Why are some STEM fields more gender balanced than others? Psychol Bull 143(1):1–35. https://doi.org/10.1037/bul0000052
Combet B (2019) The Institutional Dimension of Class-based Educational Decision-making: Evidence from Regional Variation in Switzerland Institutionelle Dimensionen klassenbasierter Bildungsentscheidungen: Der Effekt regionaler Unterschiede in der Schweiz. Zeitschrift fur Soziologie 48(4):301–320. https://doi.org/10.1515/zfsoz-2019-0021
Combet B (2024) Women's aversion to majors that (seemingly) require systemizing skills causes gendered field of study choice. Eur Sociol Rev 40(2):242–257. https://doi.org/10.1093/esr/jcad021
Correll SJ (2001) Gender and the career choice process: the role of biased self-assessments. Am J Sociol 10(6):1691–1730. https://doi.org/10.1086/321299
Eccles JS (2011) Gendered educational and occupational choices: applying the Eccles et al. model of achievement-related choices. Int J Behav Dev 35(3):195–201. https://doi.org/10.1177/0165025411398185
Eccles JS, Wang MT (2016) What motivates females and males to pursue careers in mathematics and science? Int J Behav Dev 40(2):100–106. https://doi.org/10.1177/0165025415616201
Else-Quest NM, Hyde JS, Linn MC (2010) Cross-national patterns of gender differences in mathematics: a meta-analysis. Psychol Bull 136(1):103–127. https://doi.org/10.1037/a0018053
England P (1992) Comparable worth: theories and evidence. Routledge, New York
Fervers L, Jacob M, Beckmann J et al (2025) Risk-return preferences, gender inequalities and the moderating role of a counselling intervention on choice of major: evidence from a feld and survey experiment. High Educ 89:591–609. https://doi.org/10.1007/s10734-024-01237-7
Fischer-Browne M, Ahrens L, Kleinert C et al (2024) Compromises in occupational choice and premature termination of vocational education and training: gender type, prestige, and occupational interests in focus. Empir Res Vocat Educ Train 16:14. https://doi.org/10.1186/s40461-024-00168-y
Gabay-Egozi L, Shavit Y, Yaish M (2015) Gender differences in fields of study: the role of significant others and rational choice motivations. Eur Sociol Rev 31(3):284–297. https://doi.org/10.1093/esr/jcu090
Garr-Schultz A, Muragishi GA, Mortejo TA et al (2023) Masculine defaults in academic science, technology, engineering, and mathematics (STEM) fields. Psychol Sci Publ Interest 24(1):1–9. https://doi.org/10.1177/15291006231170829
Grønning M, Kriesi I, Sacchi S (2020) Income during the early career: do institutional characteristics of training occupations matter? Res Soc Stratif Mobil 67:100495. https://doi.org/10.1016/j.rssm.2020.100495
Gutfleisch T, Kogan I (2022) Parental occupation and students' STEM achievements by gender and ethnic origin: evidence from Germany. Res Soc Stratif Mobil 82:100735. https://doi.org/10.1016/j.rssm.2022.100735
Gutfleisch T, Kogan I (2024) Gender disparities in mathematics achievement by ethnic origin: evidence from Germany. Soziale Welt 75(2):198–246. https://doi.org/10.5771/0038-6073-2024-2-198

Hadjar A, Buchmann C (2016) Education systems and gender inequalities in educational attainment. In: Hadjar A, Gross C (eds) Education systems and inequalities: international comparisons. Policy Press, Bristol, pp 159–184. https://doi.org/10.56687/9781447326113-007
Hägglund AE, Leuze K (2021) Gender differences in STEM expectations across countries: how perceived labor market structures shape adolescents' preferences. J Youth Stud 24(5):634–654. https://doi.org/10.1080/13676261.2020.1755029
Hägglund AE, Lörz M (2020) Warum wählen Männer und Frauen unterschiedliche Studienfächer? Zeitschrift fur Soziologie 49(1):66–86. https://doi.org/10.1515/zfsoz-2020-0005
Hardie JH (2015) Women's work? Predictors of young men's aspirations for entering traditionally female-dominated occupations. Sex Roles 72(7–8):349–362. https://doi.org/10.1007/s11199-015-0449-1
Heiniger M, Imdorf C (2018) The role of vocational education in the transmission of gender segregation from education to employment: Switzerland and Bulgaria compared. J Labour Market Res 52:15. https://doi.org/10.1186/s12651-018-0248-6
Hertweck F, Lehner J (2023) The gender gap in STEM: (female) teenagers' ICT skills and subsequent career paths. Ruhr Econ Pap 1028:58. https://doi.org/10.4419/96973195
Holland JL (1973) Making vocational choices: a theory of careers. Prentice-Hall, Upper Saddle River
Hovestadt T, Schneider T (2021) Liefern Jugendliche valide Informationen zum Bildungsstand ihrer Eltern in standardisierten Erhebungen? Befunde zu Schülerinnen und Schülern der 9. Jahrgangsstufe in Deutschland. Zeitschrift für Erziehungswissenschaft 24(3):715–742. https://doi.org/10.1007/s11618-021-01016-5
Imdorf C (2013) Lorsque les entreprises formatrices sélectionnent en fonction du genre. Le recrutement des apprenti(e)s dans le secteur de la réparation automobile en Suisse. Revue française de pédagogie 183:9–70. https://doi.org/10.4000/rfp.4169
Imdorf C, Sacchi S, Wohlgemuth K et al (2014) How cantonal education systems in Switzerland promote gender-typical school-to-work transitions. Swiss J Sociol 40(2):175–196
Imdorf C, Hegna K, Eberhard V et al (2015) Educational systems and gender segregation in education: a three-country comparison of Germany, Norway and Canada. In: Imdorf C, Hegna K, Reisel L (eds) Gender segregation in vocational education. Emerald Insight, Bingley, pp 83–122. https://doi.org/10.1360/zd-2013-43-6-1064
Jacob M, Klein M (2019) Social origin, field of study and graduates' career progression: does social inequality vary across fields? Br J Sociol 70(5):18501873. https://doi.org/10.1111/1468-4446.12696
Jann B, Hupka-Brunner S (2020) Warum werden Frauen so selten MINT-Fachkräfte? Zur Bedeutung der Differenz zwischen mathematischen Kompetenzen und Selbstkonzept. Schweizerische Zeitschrift für Bildungswissenschaften 42(2):391–413. 10.25656/01
Jansen M, Stanat P (2015) Achievement and motivation in mathematics and science: the role of gender and immigration background. Int J Gend, Sci Technol 8(1):4–18
Jonsson JO (1999) Explaining sex differences in educational choice: an empirical assessment of a rational choice model. Eur Sociol Rev 15(4):391–404. https://doi.org/10.1093/oxfordjournals.esr.a018272
Kleinert C, Leuze K, Bächmann AC et al (2023) Occupational sex segregation and its consequences for the (Re-) production of gender inequalities in the German labour market. Methodol Educ Meas Assess. https://doi.org/10.1007/978-3-031-27007-9_13
Korber M, Oesch D (2019) Vocational versus general education: employment and earnings over the life course in Switzerland. Adv Life Course Res 40:1–13. https://doi.org/10.1016/j.alcr.2019.03.003
Kriesi I, Imdorf C (2019) Gender segregation in education. In: Becker R (ed) Research handbook on the sociology of education. Edward Elgar Publishing, Cheltenham, pp 193–212
Kriesi I, Bonoli L, Grønning M, et al (2022) Areas of tension in vocational education and training in switzerland and other countries – developments, challenges and potential. Fifth OBS SFUVET Trend Report. Zollikofen: Swiss Federal University for Vocational Education and Training SFUVET
Kuhn A, Wolter SC (2022) Things versus people: gender differences in vocational interests and in occupational preferences. J Econ Behav Organ 203:210–234. https://doi.org/10.1016/j.jebo.2022.09.003
Leemann RJ, Keck A (2005) Der Übergang von der Ausbildung in den Beruf. Die Bedeutung von Qualifikation, Generation und Geschlecht. Bundesamt für Statistik (BFS), Neuchâtel
Lörz M, Schindler S, Walter JG (2011) Gender inequalities in higher education: extent, development and mechanisms of gender differences in enrolment and field of study choice. Irish Educ Stud 30:179–198. https://doi.org/10.1080/03323315.2011.569139
Makarova E, Aeschlimann B, Herzog W (2016) Why is the pipeline leaking? Experiences of young women in STEM vocational education and training and their adjustment strategies. Empir Res Vocat Educ Train 8(1):1–18. https://doi.org/10.1186/s40461-016-0027-y
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. Front Educ. https://doi.org/10.3389/feduc.2019.00060
Mann A, DiPrete TA (2013) Trends in gender segregation in the choice of science and engineering majors. Soc Sci Res 42(6):1519–1541. https://doi.org/10.1016/j.ssresearch.2013.07.002
Mann A, DiPrete TA (2016) The consequences of the national math and science performance environment for gender differences in STEM aspirations. Sociol Sci 3(2001):568–603. https://doi.org/10.15195/v3.a25
McDaniel A (2016) The role of cultural contexts in explaining cross-national gender gaps in STEM expectations. Eur Sociol Rev 32(1):122–133. https://doi.org/10.1093/esr/jcv078
Mood C (2010) Logistic regression: why we cannot do what we think we can do, and what we can do about it. Eur Sociol Rev 26(1):67–82. https://doi.org/10.1093/esr/jcp006
Nennstiel R (2021) Do more demanding lower secondary school certificates for minority students pay off? A comparison of VET access between Germany and German-speaking Switzerland. Soziale Welt 72(3):313–342. https://doi.org/10.5771/0038-6073-2021-3-313
Nennstiel R (2022) Explaining ethnic differences in access to VET in German-speaking Switzerland: the effects of application behavior and resources. Z Soziol 50(6):396–414. https://doi.org/10.1515/zfsoz-2021-0024

Nennstiel R (2022) No Matthew effects and stable SES gaps in math and language achievement growth throughout schooling: evidence from Germany. Eur Sociol Rev. https://doi.org/10.1093/esr/jcac062
Nennstiel R (2022) Positive ethnic choice effects are persistent over time but not across minority generations: evidence from Switzerland. Kolner Zeitschrift fur Soziologie und Sozialpsychologie 74(4):499–524. https://doi.org/10.1007/s11577-022-00865-0
Nennstiel R, Gilgen S (2024) Does chubby can get lower grades than skinny sophie? using an intersectional approach to uncover grading bias in german secondary schools. PLoS ONE 19(7):e0305703. https://doi.org/10.1371/journal.pone.0305703
Nidegger C (2019) ÜGK / COFO / VECOF 2016: Competencies of Swiss pupils in mathematics (Version 1.0.0) [Data set]. FORS data service., https://doi.org/10.23662/FORS-DS-1004-1
Niederle M, Vesterlund L (2007) Do Women shy away from competition? Do men compete too much? Int J Behav Dev 122:1067–1101. https://doi.org/10.1162/qjec.122.3.1067
Ochsenfeld F (2016) Preferences, constraints, and the process of sex segregation in college majors: a choice analysis. Soc Sci Res 56:117–132. https://doi.org/10.1016/j.ssresearch.2015.12.008
OECD (2017) OECD science, technology and industry scoreboard 2017: the digital transformation. OECD Publishing, Paris
Perez-Felkner L, Nix S, Thomas K et al (2017) Gendered pathways: how mathematics ability beliefs shape secondary and postsecondary course and degree field choices. Front Psychol 8:1–11. https://doi.org/10.3389/fpsyg.2017.00386
Polachek SW (1981) Occupational self-selection: a human capital approach to sex differences in occupational structure. Rev Econ Stat 63(1):60–69. https://doi.org/10.2307/1924218
Prix I (2012) Gender segregation within different educational levels: Austrian and finnish trends in the light of educational reform, 1981–2005. Scand J Educ Res 56(6):637–657. https://doi.org/10.1080/00313831.2011.621136
Riegle-Crumb C, Moore C, Ramos-Wada A (2011) Who wants to have a career in science or math? Exploring adolescents' future aspirations by gender and race/ethnicity. Sci Educ 95(3):458–476. https://doi.org/10.1002/sce.20431
Riegle-Crumb C, King B, Grodsky E et al (2012) The more things change, the more they stay the same? Prior achievement fails to explain gender inequality in entry into STEM college majors over time. Am Educ Res J 49(6):1048–1073. https://doi.org/10.3102/0002831211435229
Riegle-Crumb C, Kyte SB, Morton K (2018) Gender and racial/ethnic differences in educational outcomes: Examining patterns, explanations, and new directions for research. In: Schneider B (ed) Handbook of the sociology of education in the 21st century. Springer International Publishing, Cham, pp 131–152
Sax LJ, Allison Kanny M, Jacobs JA et al (2016) Understanding the changing dynamics of the gender gap in undergraduate engineering majors: 1971–2011. Springer, Netherlands, Berlin. https://doi.org/10.1007/s11162-015-9396-5
Seo E, Shen Y, Alfaro EC (2019) Adolescents' beliefs about math ability and their relations to STEM career attainment: joint consideration of race/ethnicity and gender. J Youth Adolesc 2017:306–325. https://doi.org/10.1007/s10964-018-0911-9
Sikora J (2019) Is it all about early occupational expectations? How the gender gap in two science domains reproduces itself at subsequent stages of education: evidence from longitudinal PISA in Australia. Int J Sci Educ 41(16):2347–2368. https://doi.org/10.1080/09500693.2019.1676933
Smyth E, Steinmetz S (2008) Field of study and gender segregation in European labour markets. Int J Comp Sociol 49(4–5):257–281. https://doi.org/10.1177/0020715208093077
Smyth E, Steinmetz S (2015) Vocational training and gender segregation across Europe. Comp Soc Res 31:53–81. https://doi.org/10.1108/S0195-631020150000031003
Starr CR, Gao Y, Lee G et al (2022) Parents' math gender stereotypes and their correlates: an examination of the similarities and differences over the past 25 years. Sex Roles 87:603–619. https://doi.org/10.1007/s11199-022-01337-7
Stefani A, Minor R, Leuze K et al (2024) Empirical challenges in assessing the eaky STEM pipeline:how the research design afects the measurement of women's underrepresentation in STEM. Int J STEM Educ 11:54. https://doi.org/10.1186/s40594-024-00512-4
Thébaud S, Maria C (2018) Segregation, stereotypes, and STEM. Proc Natl Acad Sci USA 7(7):111. https://doi.org/10.3390/socsci7070111
Valentino L (2020) The segregation premium: how gender shapes the symbolic valuation process of occupational prestige judgments. Soc Forces 99(1):31–58. https://doi.org/10.1093/sf/soz145
Van De Werfhorst HG (2017) Gender segregation across fields of study in post-secondary education: trends and social differentials. Eur Sociol Rev 33(3):449–464. https://doi.org/10.1093/esr/jcx040
Van De Werfhorst HG, Sullivan A, Cheung SY (2003) Social class, ability and choice of subject in secondary and tertiary education in Britain. Br Edu Res J 29(1):41–62. https://doi.org/10.1080/0141192032000057366
van der Vleuten M (2023) Gender differences in fields of study: the role of comparative advantage for trajectory choices in upper secondary education. J Educ 203(2):331–342. https://doi.org/10.1177/00220574211032344
van der Vleuten M, Steinmetz S, van de Werfhorst H (2018) Gender norms and STEM: the importance of friends for stopping leakage from the STEM pipeline. Educ Res Eval 24(6–7):417–436. https://doi.org/10.1080/13803611.2019.1589525
Van Hek M, Buchmann C, Kraaykamp G (2019) Educational systems and gender differences in reading: a comparative multilevel analysis. Eur Sociol Rev 35(2):169–186. https://doi.org/10.1093/esr/jcy054
Verner M, Helbling L (2019) Sampling ÜGK2016. Technischer Bericht zu Stichprobendesign, Gewichtung und Varianzschätzung bei der Überprüfung des Erreichens der Grundkompetenzen 2016. Institut für Bildungsevaluation, Universität Zürich, Zürich, https://www.uegk-schweiz.ch/wp-content/uploads/2023/10/UeGK2016_Verner_Helbling_2019_-Sampling-UeGK-2016.pdf
Voyer D, Voyer SD (2014) Gender differences in scholastic achievement: a meta-analysis. Psychol Bull 140(4):1174–1204. https://doi.org/10.1037/a0036620

Wang MT, Degol JL (2017) Gender gap in science, technology, engineering, and mathematics (STEM): current knowledge, implications for practice, policy, and future directions. Educ Psychol Rev 29(1):119–140. https://doi.org/10.1007/s10648-015-9355-x
Weeden KA, Gelbgiser D, Morgan SL (2020) Pipeline dreams: occupational plans and gender differences in STEM major persistence and completion. Sociol Educ 93(4):297–314. https://doi.org/10.1177/0038040720928484
Xie Y, Goyette K (2003) Social mobility and the educational choices of Asian Americans. Soc Sci Res 32(3):467–498. https://doi.org/10.1016/S0049-089X(03)00018-8
Xie Y, Fang M, Shauman K (2015) STEM education. Ann Rev Sociol 41:331–357. https://doi.org/10.1146/annurev-soc-071312-145659
Yazilitas D, Svensson J, de Vries G et al (2013) Gendered study choice: a literature review. A review of theory and research into the unequal representation of male and female students in mathematics, science, and technology. Educ Res Eval 19(6):525–545. https://doi.org/10.1080/13803611.2013.803931

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