

Can vocational role models change the gendered perception of STEM VET occupations? Results from an intervention study in Germany

Janina Beckmann, Ermioni Athanasiadi, Mona Granato



PII: S0276-5624(26)00047-8

DOI: <https://doi.org/10.1016/j.rssm.2026.101166>

Reference: RSSM101166

To appear in: *Research in Social Stratification and Mobility*

Received date: 15 April 2025

Revised date: 17 June 2026

Accepted date: 17 June 2026

Please cite this article as: Janina Beckmann, Ermioni Athanasiadi and Mona Granato, Can vocational role models change the gendered perception of STEM VET occupations? Results from an intervention study in Germany, *Research in Social Stratification and Mobility*, (2026)
doi:<https://doi.org/10.1016/j.rssm.2026.101166>

This is a PDF of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability. This version will undergo additional copyediting, typesetting and review before it is published in its final form. As such, this version is no longer the Accepted Manuscript, but it is not yet the definitive Version of Record; we are providing this early version to give early visibility of the article. Please note that Elsevier's sharing policy for the Published Journal Article applies to this version, see: <https://www.elsevier.com/about/policies-and-standards/sharing#4-published-journal-article>. Please also note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Can vocational role models change the gendered perception of STEM VET occupations? Results from an intervention study in Germany

Author names and affiliations:

Janina Beckmann ¹, Ermioni Athanasiadi ¹², and Mona Granato ¹

¹ VET Research and Monitoring Department, Federal Institute for Vocational Education and Training, Germany

² University of Siegen

Corresponding author:

Janina Beckmann

Federal Institute for Vocational Education and Training (BIBB)

Friedrich-Ebert-Allee 114-116

53113 Bonn

Germany

E-Mail: janina.beckmann@bibb.de

Abstract

In the German vocational education and training (VET) system, female apprentices are strongly underrepresented in STEM professions, where there is also a general shortage of skilled workers. In this study, we look at whether a vocational role model intervention of apprentices visiting schools could reduce gender differences in students' aspirations toward VET STEM professions and change their gendered perception of these occupations in terms of their occupational knowledge, self-efficacy, and perception of tasks as interesting. Based on a regional sample of male and female secondary school students in Germany surveyed in 2022 and 2023, our results indicate that students still hold gendered career aspirations, self-efficacy, and knowledge with

respect to STEM VET occupations. Based on a non-equivalent control group design, we find that the role model intervention with mainly male role models can reduce these gendered perceptions to some extent, with female students developing greater occupational knowledge and higher career aspirations. These findings suggest that real-life vocational role models can serve as a promising career orientation approach in the context of VET to reduce gendered perceptions and aspirations in the career choice process.

Keywords: STEM, career orientation, intervention, gender, vocational education and training, role model

1 Introduction

Gender differences in career choices are for the most part stable and persistent across industrialised countries: despite tendencies of equalisation in some fields, gender segregation still characterises choices of fields of study in higher education (Barone, 2011) and especially career choices in the vocational education and training (VET) systems (e.g., Kroll, 2021; Smyth & Steinmetz, 2015). In Germany, gender segregation in the VET system has persisted for decades, with men overrepresented in technical information technology occupations and in skilled crafts and trades. Women, on the other hand, are overrepresented, e.g., in social and care occupations. Gender differences in young people's occupational aspirations carry over into gendered career choices (Hillmert, 2015; Weeden et al., 2020), which has long-term consequences and translates into vertical dimensions of gender inequality such as future employment prospects and earnings (e.g., Blackburn et al., 2014; Leuze & Strauß, 2016).

Looking at gendered participation in VET STEM fields is particularly relevant from an inequality perspective. The gender gap in science, technology, engineering and mathematics (STEM) fields is significantly larger in VET than in higher education, 'with women representing only 16,1% of enrolment in medium-level VET STEM fields' while they made up 31% of students enrolled in STEM tertiary fields in 2022 (European Commission, 2025: 5). Furthermore, we can observe a general lack of middle-skilled workers across European countries, which is particularly evident in STEM fields (European Commission, 2025; for Germany, see, e.g., Hickmann & Koneberg, 2022).

Given this, a range of educational policies have been implemented across Europe and worldwide in past decades aimed at increasing women's participation in STEM and at reducing gender segregation in career aspirations and choices (e.g., European Commission 2025). One strand of these policies focuses on providing girls and boys with work and learning experiences in gender-atypical professions during secondary education (e.g., initiatives such as 'Girls' and Boys' Day' in Germany, Wentzel & Funk, 2014). The few experimental studies on these policies provide some indication that hands-on learning and outreach programs can effectively increase the motivation and skills of female students in STEM fields (e.g., Denner et al., 2012; Fernández-César et al., 2020). Another policy strand consists of short-term informational guidance, providing students with information about the expected income of graduates from different fields of study (Barone et al., 2019; Finger et al., 2020; Peter et al., 2023) or on the demand of STEM occupations (Ikkatai et al., 2021). These experimental studies, however, only address some of the processes driving gender-segregated career choices, showing for example that although women shifted toward financially more rewarding fields in response to income information, they did not gravitate toward less

gender-typical majors such as those in technical fields (Barone et al., 2019; Peter et al., 2023).

Providing vocational role models has been suggested as another fruitful approach in career guidance, since the lack of role models has been discussed to be one of the reasons why girls don't choose STEM occupations as often as do boys (Solga & Pfahl, 2009). Female professionals have repeatedly been used in career guidance policies as identifiable role models to increase women's representation in (academic) STEM fields (e.g., Germany: Wentzel, 2013; Austria: Drescher et al., 2020; the Netherlands: Jansen & Joukes, 2013). Although the empirical evidence points to the effectiveness of STEM role models in increasing female students' academic performance and motivation (for a review see, e.g., Lawner et al., 2019) as well as in shifting their aspirations and choices toward STEM careers (for reviews, see Gioannis et al., 2023; Olsson & Martiny, 2018), the state of research is limited in three regards, all of which we address with our study.

First, the majority of STEM role model research focusses on role models representing STEM fields in higher education, which considerably differ from STEM VET occupations, e.g., in terms of educational pathway, tasks, and required skills, prestige and gender composition, as well as in terms of the explanatory variables for gendered sorting (Gutfleisch & Nennstil, 2025). However, to date, the very few studies that have investigated role modelling in the VET context mainly consist of small-scale qualitative investigations (Bridges et al., 2020; Sevilla et al., 2023). It is therefore an open question whether STEM role model interventions could be as effective in the context of VET, also given potentially younger target audiences in comparison to role models from tertiary fields.

Second, previous experimental research has overwhelmingly focused on media-based role models (Gioannis et al., 2023), i.e., with students reading sometimes fictional biographies (Dasgupta & Asgari, 2004; van Camp et al., 2019), interacting with computer-animated characters (e.g., Krämer et al., 2016), or watching videos (Davis-Hall et al., 2023; Steinke et al., 2021). Intervention studies that use real-life role models are scarce (for exceptions, see, e.g., Breda et al., 2023; Drescher et al., 2020). Evidence of the impact of real-life role models is needed, as they might provide particularly strong grounds for social identification as well as authentic and credible insights as compared to media-based role models.

Third, empirical evidence of the effectiveness of role models in reducing gender differences in STEM aspirations and choices has mainly focused on exclusively *female* role models, arguing that they are more effective than male role models in disrupting stereotypes depicting STEM fields as masculine (e.g., Breda et al., 2023; Chhaochharia et al., 2022; Lawner et al., 2019). Few intervention studies have also included male role models, with inconsistent results (for a review, see Gioannis et al., 2023). On a related note, there is little research comparing role modelling effects for male and female students, partly because studies often employ exclusively female student samples (e.g., Bamberger, 2014; Cheryan et al., 2013; Cheryan et al., 2011; González-Pérez et al., 2020; Merritt et al., 2021).

Our study addresses these three research gaps and investigates whether real-life vocational STEM role models, with a sample of mainly *male* role models, can reduce gender differences in students' perceptions of STEM VET professions and their aspirations to these occupations. We examine role modelling effects on four key dimensions that are relevant in students' career choice process: students' occupational

aspirations to and perceptions of STEM VET occupations, including occupation-specific knowledge, occupation-specific self-efficacy, and the assessment of these occupations as involving interesting tasks (task perceptions). Importantly, we focus on gender-specific effects, examining whether female and male students are affected differently by STEM vocational role models, thereby contributing to a better understanding of how gender inequalities are reproduced or may be reduced.

We draw on an existing real-life role model approach, with apprentices visiting school classes and presenting their occupations as ‘VET ambassadors.’ This intervention is implemented in Germany in order to increase the visibility of VET occupations for students and to enlarge their occupational aspirations (Athanasidi et al., 2020). Our study is an intervention study, with pre-post comparisons of a treatment group and a control group among a regional sample of 1,041 secondary school students.

2 Theoretical Framework

2.1 Gender segregation in occupational aspirations and choices

Based on expectancy-value theory (Eccles, 2011), gendered career aspirations and choices can be explained by gender differences in the subjective value and expectancies of success associated with career alternatives. In the context of STEM, a robust finding is that girls hold lower success expectancies for male-dominated tasks at the same level of performance, hence systematically underestimating their skills in mathematics, science, and technology in comparison to boys (e.g., Correll, 2001).

According to Eccles (2011), subjective values can be conceptualised as interest, attainment, utility, and relative cost value. Regarding the interest value attributed to academic STEM occupations, previous research has shown that occupational interest

is an important predictor of gendered career choices, with women being less interested in mathematics and technology (e.g., Su & Rounds, 2015; Volodina & Nagy, 2016), which can be attributed to gender-typical socialisation processes in families and peer groups. Attainment values reflect 'subjective importance,' i.e., the extent to which a task is tied to an individual's core identity and values, and, according to Eccles (2011), also play a role in predicting occupational choices. STEM domains are likely to be perceived as incongruent with female gender identities. Even if female youth express STEM-related interests, they tend to exclude these occupations from further consideration, due to anticipated gender incongruence and essentialist notions of gendered occupational tasks and skills (Gottfredson, 1981), reflecting the perceived (social) costs of choosing a gender-atypical occupation. At the same time, utility values such as income preferences seem to be a less important explanatory factor for gendered career choices (e.g., Weeden et al., 2020).

Knowledge about occupations can be considered another important factor in the development of values and expectations about occupations as well as in the formation of occupational aspirations (Matthes, 2019). According to Eccles (2011), occupational choices are not only influenced by the effect of individual gender roles on expectations and subjective task values, but also on the perceived field of possible options. Congruent with Gottfredson (1981), this field is limited by missing or inaccurate information about occupational alternatives. Studies indicate that while occupational knowledge does not differ by gender among young children, gender differences in occupational knowledge increase as children grow older, with youth being better informed about occupations that they perceive as gender-congruent (Miller & Hayward, 2006; Rohlfsing et al., 2012). The higher level of information about gender-typical career

paths may be related to young people's gender-segregated social networks, which makes informational flows more likely for gender-typical career options.

2.2 The relevance of STEM role models

Our study is based on vocational role models that have unique and short-term encounters with students in classrooms (Athanasiasi et al., 2020). This approach thus differs from mentors or guides that foster long-term relationships with students involving a high degree of personal interaction on a regular basis. Role models can be presented in different ways. On the one hand, role models may be presented through media-based interventions, such as written biographies (Bagès et al., 2016; Stout et al., 2011; van Camp et al., 2019), fictional or animated characters (Rosenberg-Kima et al., 2008), or videos (Lewis et al., 2019; Steinke et al., 2021). On the other hand, role models may be encountered directly through presentations or talks, which constitute the focus of the present study. Since research findings on real-life role models remain scarce (Gioannis et al., 2023), we draw on international evidence from both real-life and media-based role model interventions in our literature review.

In light of the complexity and diversity of the German VET system (see Section 4), school leavers can face difficulties during their career choice about occupational pathways. Vocational role models may serve as an important source of guidance in students' career orientation processes by means of different mechanisms, including motivation. The motivational function of role models is reflected in the definition provided by Morgenroth et al. (2015, p. 4) as 'individuals who influence role aspirants' achievements, motivation, and goals by acting as behavioural models, representations of the possible, and/or inspirations' and by J. Gladstone and Cimpian (2021, p. 1), who

define role models as ‘individuals who can positively shape a student’s motivation by acting as a successful exemplar.’

In Morgenroth’s role model-framework, which draws upon expectancy-value theories (Eccles, 1983), role models are thought to influence both the expectancies and values of role aspirants. Motivational effects described by Morgenroth are based on Bandura’s (1977) social learning theory, according to which role models can increase self-efficacy through observational learning. Similar to success expectancy, self-efficacy describes the confidence an individual has in their ability to successfully perform a task or exhibit a particular behaviour. It has been conceptualised as a core component of goal-related expectations and plays a crucial role in social learning processes, which are assumed to be the primary mechanisms of role model effects, as they can ‘increase one’s confidence in being able to successfully complete the task oneself’ (Morgenroth et al., 2015, p.7). According to Morgenroth (2015), role models can influence the perception of values and expectancies surrounding occupational goals through a range of possible processes based on learning experiences, identification, and social influence. These processes can reduce stereotypes and increase identification, which, in turn, enhances individuals’ motivation to pursue these goals. Similarly, role models may decrease perceived social costs by altering the salience of social norms surrounding career choices (see e.g. Beckmann 2021): encountering counter-stereotypical role models — such as successful women in STEM — may lead to these careers being perceived as more attainable and socially acceptable.

The positive motivational effects of female role models on STEM-specific academic performance, motivation, and self-efficacy in the classroom have been plentifully documented (Bagès et al., 2016; Breda et al., 2020; Conner & Danielson, 2016; J.

Gladstone & Cimpian, 2020; Stout et al., 2011). Higher math-related self-efficacy in college students is associated with exposure to female professors in some literature (e.g., Stout et al., 2011), while in other studies, young women's self-efficacy was not significantly increased by female role model interventions (e.g., Drescher et al., 2020; Guenaga et al., 2022). In a study with college students, reading biographies of STEM role models positively impacted the academic self-efficacy of students already enrolled in STEM, but not that of non-STEM students (Shin et al., 2016). Role models can also promote students' attitudes and beliefs about the possibilities of success and their abilities in STEM (e.g., Asgari et al., 2010; Betz & Sekaquaptewa, 2012; Cheryan et al., 2011; Drescher et al., 2020; González-Pérez et al., 2020; Rosenberg-Kima et al., 2008).

In addition to their motivational function, role models fulfil an informational function by providing knowledge about the world of work and enhancing students' labour market literacy (e.g., Higgins et al., 2010). Although the informational function of role modelling might be straightforward, only few studies include measures on occupational knowledge transmitted through role model interventions. Some literature suggests that while students' subjectively perceived occupational knowledge increases after being exposed to a role model (Masters & Barth, 2022), there seems to be no change in their actual knowledge (e.g., Ferrari et al., 2015). In addition to transmitting occupational knowledge, role models represent the social identities and characteristics of employees, thus refuting or confirming prevailing stereotypes associated with STEM occupations. Empirical evidence shows that vocational role models can disrupt negative stereotypes associated with occupations that are based on misinformation or

unquestioned ideas by challenging students' implicit beliefs about STEM persons (e.g., Bamberger, 2014; Drescher et al., 2020; van Camp et al., 2019).

Ultimately, both the motivational and the informational function of role modelling may lead to an increased interest in and aspirations to STEM subjects or careers. Observational studies on real-life role models generally support this assumption (e.g., Conner & Danielson, 2016; González-Pérez et al., 2020; Zhang et al., 2023). For example, speed-dating with role models in secondary education was related to an increase of young men and women choosing STEM subjects in higher education in the Netherlands (Jansen & Joukes, 2013). Experimental studies yield mixed effects. For example, some studies show that exposure to role models increases aspirations to and choices for STEM subjects and professions (real-life role models: Bamert, 2024; Breda et al., 2020, 2023, media-based role models: Shin et al., 2016; Wyss et al., 2012). The role modelling workshops reported by Bamberger (2014) and Drescher et al. (2020), however, did not increase participants' aspirations.

As shown in the literature analyses of this section, the overwhelming majority of role model intervention studies in STEM is in an academic context, with most role models either targeting college students (e.g., Asgari et al., 2010; Cheryan et al., 2013; Lewis et al., 2019) or representing academic STEM careers that require a college degree (e.g., Porter & Serra, 2020; Merritt et al., 2021; Marx et al., 2013).

2.3 The relevance of role model gender and students' gender

We can have different theoretical expectations regarding gendered differences in role modelling effects, whether it be the gender of role models or of students. First, from the perspective of social identity theory (Turner & Oakes, 1986), the social influence effects of role modelling are assumed to be stronger when role models provide higher

grounds for identification and similarity (see also J. R. Gladstone & Cimpian, 2021). As gender is a major dimension of social identity, it is suggested that the gender match between role model and role aspirant is a highly important factor in role modelling effects (Lockwood, 2006). Accordingly, students may be expected, on average, to benefit more from same-gender than from opposite-gender role models. Second, from the perspective of stereotype theory (e.g., Dasgupta, 2011), the gender of the role model may become relevant in the transmission or disruption of gender-specific stereotypes related to the occupation in question. Male vocational STEM role models may confirm male-typed values and stereotypes of those occupations being male-dominated, and thereby discourage female students from pursuing these occupations. Female role models, on the other hand, may disrupt stereotypes of masculinity related to STEM fields as a positive example.

The present strand of empirical research does not provide a clear answer to the question whether role modelling effects are structured by the gender of role models and students. This is due to two limitations. First, given that existing role model interventions applied in the field of STEM typically follow the aim of strengthening the presence of women in STEM fields, most studies have used an exclusively female student sample (e.g., Gladstone & Cimpian, 2021; Lawner et al., 2019; Olsson & Martiny, 2018; Stout et al., 2011). Studies comparing the effects of female role models on male versus female students yield mixed results. Some studies find that female students benefit more from female role models than do male students (e.g., Breda et al., 2020, 2023; Porter & Serra, 2020). For example, Guenaga et al. (2022) find that participating in six workshop sessions with female STEM role models was related to greater increases in positive attitudes toward STEM for girls than for boys. On the

contrary, Drescher et al. (2020) find that workshops with mainly female role models can reduce stereotypes related to technical occupations similarly for both male and female students, but did not change students' interest in technical occupations nor their self-efficacy. Interacting with female scientists changed the self-concept and attitudes towards STEM equally in boys and girls (Conner & Danielson, 2016). Evidence on whether role models affect male and female students differently remains inconclusive. Interpreting gender differences is further complicated by preexisting differences between boys and girls in STEM-related interest and potential ceiling effects.

Second, the existing literature has mainly employed female role models, based on the premise that female role models act as ingroup role models for female students and may disrupt stereotypes of masculinity related to STEM fields (e.g., Dasgupta, 2011; O'Brien et al., 2017; Rosenberg-Kima et al., 2008; Stout et al., 2011). The few existing experimental studies suggest that workshops with female role models in secondary education can increase female students' educational aspirations and choices toward STEM, comprising their undergraduate choices (Breda et al., 2023) and enrolment in STEM in higher education in France (Breda et al., 2020). Only a minor number of studies includes both female and male role models. Reading biographies of successful male and female scientists increased the STEM interest of college students (Shin et al., 2016). In another study, both male and female students showed an increased interest in science after watching videos of interviews with male and female scientists (Wyss et al., 2012).

Even fewer studies have directly compared whether the gender of the role model is a relevant moderator for role model effects on student-related outcome variables (Gioannis et al., 2023). Bamert (2024) found that exposure to male and female

academic STEM speakers increased both male and female students' STEM enrolment and completion in higher education in Switzerland, with female speakers being overall even more effective for both male and female students than male speakers. The authors suggest that the greater degree of interactivity of women's presentations could be an explanation for this. Stout et al. (2011) compared reading biographies of male versus female engineering role models on a female student sample and found that exposure to male engineers was related to negative attitudes toward math while exposure to female engineers was related to an increase in positive attitudes, but not to STEM identification. Some of these studies demonstrate a greater benefit of female role models for female students in the field of academic STEM than of male role models (e.g., O'Brien et al., 2017; Olsson & Martiny, 2018; Rosenberg-Kima et al., 2008; Stout et al., 2011), while others report no effect of role model gender on female student academic outcomes (e.g., Cheryan et al., 2013; Cheryan et al., 2011; Lockwood & Kunda, 1997).

While women working in non-traditional middle-skill STEM occupations point out the importance of female role models in their professions, such as in skilled trades (Stewart, 2009), welding, plumbing, or electrical (Hall, 2016), the potential of male role models in VET has received very little attention. Observational studies demonstrate the positive influence of role models on VET career choices of students in general (Neuenschwander et al., 2018) and in STEM (Sevilla et al., 2023). To date there are still no systematic or experimental investigations of whether and how vocational role models influence students' motivation for and knowledge about STEM careers in VET.

3 Research questions and hypotheses

In the present study, we examine the effect of apprentices ('VET-ambassadors') from different STEM VET-occupations as real-life role-models on STEM-specific perceptions and career aspirations of secondary school students. Our intervention study is based on a sample of mainly male STEM role models, considering their effects on both female and male students. We ask the following research questions (RQ):

RQ 1: Does exposure to real-life vocational (mainly male) VET STEM role models lead to more positive perceptions of VET STEM occupations (including greater knowledge, greater self-efficacy, and the perception of VET STEM tasks as interesting) and increase students' career aspirations for the occupations presented by the role models, as compared to the control group?

According to the theories of role modelling outlined in section 2.2, we expect that vocational STEM role models will, on average, increase students' perceived knowledge about the presented VET STEM occupations (informational function) and their self-efficacy to successfully attain and complete STEM vocational education and training (motivational function). We also expect that vocational STEM role models will increase students' perception of tasks typical of the presented VET STEM occupation as interesting and that their aspirations to the presented VET STEM occupations will increase. *Vocational STEM role models lead to more positive student perceptions (i.e., knowledge, self-efficacy, and task perception) and increase their career aspirations to VET STEM occupations presented by the role models (H1: general role modelling effect).*

RQ 2: Are there gender differences in the effect of real-life vocational (mainly male) VET STEM role models on students' VET STEM perceptions and aspirations?

Based on social identification theory and stereotype theory, as presented in section 2.3, we can expect that male students will, on average, profit more from vocational STEM role models who are themselves mainly male, providing higher grounds for identification and perceived similarity. As outlined above, male STEM role models may furthermore embody male-typed values and stereotypes of those occupations being male-dominated, which is expected to increase the positive effects on male, but not on female students. However, male role models may still be encouraging for female students due to general role model mechanisms (such as perceived attractiveness, likeability, intelligence, etc.). We thus expect that, for male students, the (mainly male) role models will have positive effects. We expect that the (mainly male) role models will have less of an effect on female than on male students. This could mean either weakly positive, no effect, or even negative effects (e.g., due to reinforcing gender stereotypes), depending on the magnitude of the mechanisms at work. *Male STEM role models lead to more positive perceptions among male students and increase their career aspirations for the presented VET STEM occupations more strongly for male students than for female students (H2: gender-specific role modelling effects).*

With our sample of VET ambassadors dominated by male role models, we contribute to the scarce research on the relevance of male, and hence gender-typical, role models in the context of VET STEM on both female and male students. Due to the very small number of female role models, our sample does not allow for a systematic comparison of female vs. male role models, but we present and discuss additional descriptive analyses, stratifying our results by role model gender in section 7.4. Before turning to the empirical analyses, we first provide a brief overview of the German education and VET system, the context of the intervention.

4 The institutional context in Germany

The role model intervention presented in this study targets students from different general education school types. The German general education system is characterised by early and selective tracking into different educational pathways. In the federal state of North Rhine-Westphalia, where this study was conducted, students are tracked into different school types after completing the first four years of primary education, leading to different school-leaving qualifications: the lower secondary school (*Hauptschule*) leads to a lower secondary school-leaving certificate and the intermediate school (*Realschule*) leads to an intermediate secondary school-leaving certificate. The higher education entrance qualification is typically obtained upon completion of upper secondary education at the *Gymnasium* or *Gesamtschule*. For many students, completing general education after grade 9 or 10 marks a key transition point at which they must decide whether to enter the VET system or continue in general education. The VET ambassador intervention targets students in preparation for this transition.

The VET system is a common pathway for school leavers in Germany. In 2022, a total of 682,400 young people in Germany entered the VET system, corresponding to 36% of all individuals transitioning into post-school pathways. The German VET system comprises two main tracks: the full-time school-based VET track and the larger company-based dual VET track, comprising 65% of apprentices entering VET in 2022 (Dionisus & Illiger, 2023). Although the dual VET system is formally accessible to graduates of all school types, access to different occupations is strongly structured by students' school-leaving certificates and additional selection criteria: it is ultimately companies that decide whether to recruit a young person, reflecting a 'market-based'

access mechanism (Granato & Ulrich, 2017). The large number of different VET occupations, the dual structure, and the selective admission practices make the system complex for students navigating the school-to-work transition, highlighting the importance of early guidance and information about vocational pathways and the potentially crucial impact of vocational role models.

Within dual VET, the field of STEM VET is one of the largest, with around 480,000 apprentices (39.5%) (BIBB, 2024). Young women were strongly underrepresented in dual VET STEM occupations in 2023: while 34.7% of all dual VET apprentices are female, only around one in ten apprentices in STEM VET occupations is a young woman (11.2%). The gender gap is particularly pronounced in technical and IT professions (10.3%) – representing by far the largest field of STEM apprenticeships (463,000 apprentices, 96%). Only in the comparatively small field of mathematical and scientific dual VET professions – representing 4% of all STEM apprenticeships – are young women more strongly represented, making up approximately one third of apprentices (34.4%). These disparities highlight the need to encourage STEM participation, especially among female students.

5 The vocational role model intervention

The present study uses data from the BIBB-TUDa career orientation study, which is based on the ‘VET ambassadors’ (German: *Ausbildungsbotschafter*), a career orientation approach involving real-life vocational role models (see, e.g., Athanasiadi et al., 2020). The ‘VET-ambassador’ intervention targets secondary school students from grade 9 onwards and is incorporated into the school-based career orientation process. The approach was established to address the policy need of increasing young

people's interest in dual VET occupations. It is implemented by the regional chambers of industry and commerce and the chambers of crafts in Germany, as well as other bodies.

In the present study, we focus on VET ambassadors in a specific region of North Rhine-Westphalia. Typically, two VET ambassadors, one apprentice in a non-STEM (e.g., commercial) and one in a STEM (e.g., craft or technical) dual VET occupation, visited school classes during lessons and gave presentation talks about their apprenticeship and about themselves. The school visit commonly lasted about 45 to 60 minutes. The presentations contained information and personal insights about their VET occupation, the tasks involved, their daily (work) routine, their learning opportunities, as well as information about their career choice and application process. There was also an opportunity for students to ask questions.

The role models included in our sample are apprentices from nine different STEM occupations, especially IT and technical professions (e.g., electricians, automotive mechatronics technicians, plasterers) (Table A1). The VET ambassadors were introduced in class as role models for dual VET occupations, and exhibited the characteristics commonly stated in the literature as leading them to be perceived as role models by the students: they are similar to students in age, social and educational background, and, having been trained for giving the presentation, they are able to confidently present their apprenticeship experiences. All of this can contribute to positive student outcomes (Gladstone & Cimpian, 2020).

Table 1 provides a descriptive overview of student perception of vocational STEM role models at t_2 , the survey that took place immediately after the intervention (see section 6.1). Results show that male and female students of the treatment group evaluated the

VET ambassadors overwhelmingly positively, with a mean ranging between 3.8 to 4.2 on a scale from 1 to 5 for the attributes listed. Thus about 80% of students found the presenter to be 'likeable.' Students' identification with the vocational role model was overall a bit lower, and significantly higher for male students on all three items used, which could be due to the role models being mostly male, hence providing a higher degree of identification for male students.

Table 1. Perception of and identification with vocational STEM role models at t_2 by gender.

Variable	M (male students)	M (female students)	Difference in means	t	p
Perception					
The presentation was interesting.	3.925	3.799	.126	1.548	0.122
The ambassador was intelligent.	3.916	3.860	.056	0.763	0.446
The ambassador was educated.	3.899	3.900	-.001	-0.016	0.987
The ambassador was likeable.	4.242	4.140	.102	1.383	0.167
Identification					
The ambassador has similar interests and hobbies.	3.149	2.541	.608	6.814	0.000
The ambassador has a similar way of talking.	3.284	3.029	.255	2.920	0.004
The ambassador looks like me (e.g., clothing).	2.892	2.362	.531	5.626	0.000

Note: Results from unpaired t-tests. Displayed is the mean (M) of students agreeing with the statements, on a scale from 1 to 5 (1: does not apply at all, 2: does not apply, 3: neither nor, 4: applies, 5: completely applies), $n=614$ person $\times$ occupation units of the treatment group with valid responses on all variables.

6 Methodology

6.1 The career orientation study

To assess the effectiveness of the role model intervention, we conducted an intervention study with a non-equivalent control group design (Cambell & Stanley,

2015), in which a total of 2,396 students who were exposed to VET ambassadors in the school years 2021/22 or 2022/23 were repeatedly surveyed (see Figure 1). The non-representative sample was recruited from schools already taking part in the VET ambassadors project as organised by the chambers of industry and commerce and the chambers of crafts in one region. Chambers were responsible for recruiting the schools willing to participate in the career orientation study. A total of 25 secondary schools agreed to participate.

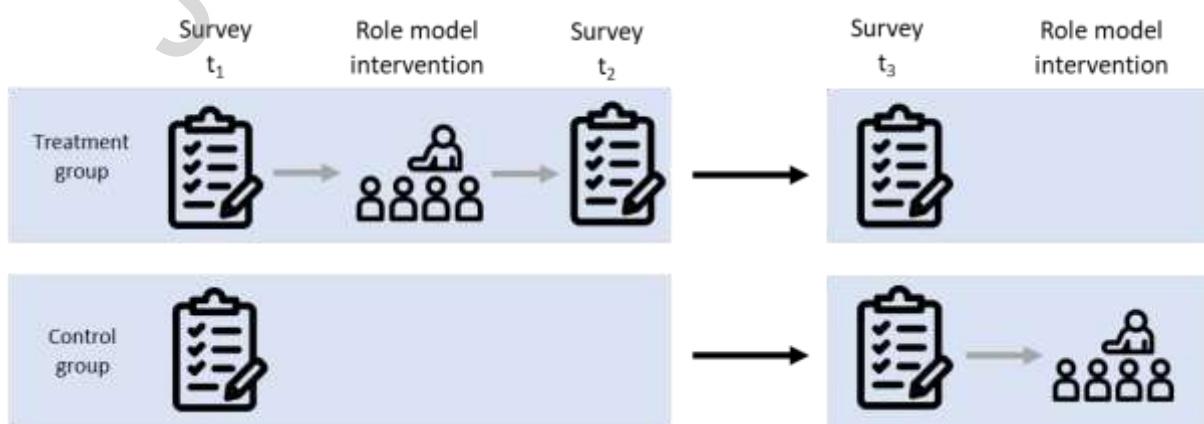
Assignment to the treatment and control condition happened at the school level and was stratified by school track to ensure an equal distribution across different school tracks. The assignment was primarily based on organisational criteria to ensure the implementation of the VET ambassadors in accordance with the chambers and the schools. For the sake of efficiency, it was mostly based on the scheduled date for the ambassador visits, with schools with earlier visits selected as intervention schools and schools with later visits as control schools. This way, data collection in control schools could be completed before the control group was given the opportunity to participate in the role model intervention after the last follow-up survey ('waitlist control group'). Furthermore, treatment schools were oversampled in early stages of the data collection period. This approach ensured that we could include control schools that were surveyed on the same occupations as presented in the treatment group.

Students were in grade 9 or 10 (for lower and intermediate school tracks and comprehensive schools) or in the upper secondary track (for comprehensive schools or *Gymnasium*). Students in the treatment group were surveyed three different times, before and after participating in the role model intervention; students in the control group were surveyed twice. Both treated and control group were surveyed at the

baseline survey (t_1). For the treatment group, the baseline survey took place immediately before the role model presentations (usually in the lesson before). For the control group, the baseline survey was conducted at the start of a regular school lesson. For the treatment group, students completed a second survey (t_2) in the lesson immediately following the role model presentations, in which they evaluated the presentation. Both treated and control group were surveyed at the last follow-up survey t_3 that took place about eight weeks after the baseline survey (distance in weeks: $M=8.56$ weeks; $SD=4.01$). The control group was surveyed on average after eight weeks and the treatment group after nine weeks, corresponding to a statistically significant difference of 1.14 weeks between the two groups.

All surveys took place in the classroom context and were conducted via paper and pencil or online with tablets or smartphones. The questionnaire included questions about students' career aspirations, their perception of occupations, their career orientation process, and socio-demographic characteristics. Responses from the different survey waves were linked using self-generated identification codes (SGIC).

Figure 1. Research design of the BIBB-TUDa Career Orientation Study.



Source: own illustration.

6.2 Sample description

The data were collected as part of a larger study that surveyed students attending role model interventions of VET apprentices in both STEM and non-STEM occupations. In total, 2,396 students participated at t_1 , of which 1,614 students (67.36%) were surveyed at both t_1 and t_3 . 32.35% of panel attrition was attributable to schools not participating in t_3 , and 67.65% were attributable to participants not matching with their self-generated identification codes (SGIC). Attrition was evenly distributed within treatment and control group and did not correlate with treatment status.

In the treatment group, we restricted our sample to students who attended presentations of at least one apprentice in STEM occupations, hence excluding $n=777$ students who participated in interventions with only non-STEM role models. 82% of the students in our analysis sample attended presentations with one STEM and one non-STEM apprentice (commercial professions), 8% of students attended presentations of one STEM apprentice only, and 2% of students were treated with one STEM apprentice and two non-STEM apprentices.

In our analysis sample, we included only those students of the control group who were surveyed for the same STEM occupations as in the treatment group. We defined STEM occupations according to the definition of the Federal Employment Agency (2022) (see also Kroll, 2024), as occupations that require a high level of knowledge and competency in the fields of mathematics, computer science, natural sciences, or technology. Table A1 (appendix) gives an overview of the nine STEM VET occupations presented by role models included in our sample.

Due to our study's focus on gender-specific effects, the few students who indicated a non-binary gender category or with missing gender information (n=14) were excluded. These sample restrictions led to an effective sample size of n=1,041 students from 19 schools and 26 school visits¹ in 60 classes (see Table 2).

Table 2. Stepwise sample restrictions (number of individuals in the sample).

Full sample (t_1)	n=2,396
Participation in t_1 and t_3 (panel attrition)	n=1,614
Focus on VET STEM occupations in both treatment and control group	n=1,053
Exclusion of individuals with missing or non-binary gender	n=1,041

Three classes of the treatment group were visited by two STEM VET ambassadors, each presenting their occupation, and one class of the control group was surveyed on two STEM occupations. Due to this, some students are included twice in the sample, yielding n=1,134 person×occupation units used for analysis.

6.3 Measures

¹ The majority of schools participated with one school visit (corresponding to one intervention conducted in two to three school classes). Note that n=5 schools participated as treatment or control schools more than once, but in different school years.

6.3.1 Outcome variables

The outcome variables measure students' occupation-specific aspirations and their occupation-specific knowledge, their self-efficacy, and their task perceptions of the VET STEM occupations presented by the vocational role models. The students of both groups were briefly informed by the research team about the surveyed occupation before filling out the questionnaire at baseline to ensure a common basic understanding of the occupational titles used.

The VET occupation accounts for the specific occupations surveyed in the occupation-specific questions, which correspond to the nine VET STEM occupations presented by the role models for the treatment group, which were also surveyed in the control group (see Table A1).

STEM-specific occupational aspirations were measured using student responses to two items on a five-point scale from 1 'not at all true' to 5 'completely true': 'I would like to do an apprenticeship in this *VET STEM occupation*' and 'I would like to work in this *VET STEM occupation*.' The average score of these two items was computed to render an overall score of the individual's aspiration to this occupation. There is a high internal consistency between the two items (Cronbachs $\alpha=.92$)

STEM-specific self-perceived knowledge about the presented VET STEM occupation was measured with two items: 'I know this *VET STEM occupation* well' and 'I can imagine what a VET specialist in this *STEM occupation* does' (Cronbachs $\alpha=.75$).

STEM-specific self-efficacy was measured with two items, capturing students' 'internal' and 'external' self-efficacy for the occupations presented by vocational ambassadors: 'I believe that I have the ability to complete the training required for this

STEM occupation' and 'I would have good chances of getting an apprenticeship in this *STEM occupation'* (Cronbachs $\alpha=.86$).

STEM-specific task perception reflects students' perception of interesting tasks as being typical of the presented VET STEM occupation. It was measured with one item asking students to rate 'how typical' they thought 'interesting tasks' were for the presented VET STEM occupation using a five-point scale (1 = 'not at all typical' to 5 = 'very typical').

6.3.2 Socio-structural variables

The following socio-structural variables were obtained:

Students' gender refers to students' self-reported gender (female students coded as 1, male students coded as 0). The few students who responded to the non-binary gender category 'diverse' were excluded from the sample (see Table 2).

Students' language spoken at home was obtained through their self-reported language acquisition in the family (German as only language coded as 0, other language(s) coded as 1). This measure approximates students' migration background, but it should be noted that not all students with a migration background speak languages other than German at home.

Academic family background was measured through students' self-reporting of their parents' academic degree (0: no parent with a higher education degree, 1: only one parent with a higher education degree, 2: both parents with higher education degrees).

School type differentiates between lower secondary schools (*Hauptschule*), intermediate secondary schools (*Realschule*), comprehensive schools (*Gesamtschule*), and upper secondary schools (*Gymnasium*), coded from 1-4.

School grade differentiates between grade 9 coded as 1, grade 10 coded as 2, and grade 11 coded as 3.

Verbal and mathematics academic self-concepts were measured with two items capturing students' subjective estimation of their success in maths and German ('I obtain good marks in German/maths') using a five-point scale (1 = 'not at all' to 5 = 'totally agree').

General VET aspiration was measured by students' self-reported response to the question 'How well can you imagine pursuing a VET degree?' using a five-point scale (1 = 'not at all' to 5 = 'very well').

The aspired educational degree differentiates between a lower (*Hauptschulabschluss*) or intermediate (*Realschulabschluss*) school-leaving certificate and a higher education entrance qualification degree (*Abitur* or *Fachabitur*), as indicated by the students as their intended degree at the end of schooling.

The timing of t_1 is a dummy variable indicating the timing of the first survey, i.e., at the end of school year 2021/2022 or at the beginning of the subsequent school year 2022/2023.

Descriptives of the dependent and socio-structural variables are presented in Table A2 (see panel 'before IPTW').

6.3.3 Treatment group variables

For the treatment group (1: treatment group, 0: control group), the following role model characteristics were obtained at t_2 :

The gender of the role model was documented by the research team during the intervention. 13.4% of students in the treatment group participated in presentations by a female role model in seven classroom interventions. Combining the gender of the role model and students' gender resulted in another variable of whether the role model was **same-sex or opposite-sex**.

Perception of the role model was obtained through students' subjective ratings using four statements (e.g., 'The apprentice in this STEM profession seemed likeable') on a five-point scale (1 = 'does not apply at all' to 5 = 'completely applies') (see Figure 1).

Identification with the role model was measured through students' ratings using three statements (e.g., 'The apprentice in this STEM profession talks like I do') on a five-point scale (1 = 'does not apply at all' to 5 = 'completely applies') (see Figure 1).

6.4 Statistical Analyses

Before analyzing intervention effects, we examined gender differences in students' VET STEM perceptions and aspirations at baseline. To this end, we ran OLS regressions of the four continuous outcome variables on students' gender, controlling for socio-structural variables and the surveyed VET STEM occupations.

To evaluate the effects of the role model intervention (RQ1 and RQ2), we first inspected the equivalence between the treatment and control group on theoretically relevant covariates at baseline. Imbalances were observed for occupational

aspirations and knowledge as well as for students' verbal self-concept, school track, and the timing of the t_1 survey (standardised difference $> .10$). To account for these imbalances, we applied Inverse Probability of Treatment Weights (IPTW), a method assigning individual weights to the treated and the control group based on the estimated propensity score such that the covariates are balanced across both groups (for details see Chesnaye et al., 2022). We used weights of $1/p_i$ for treated units and $1/(1-p_i)$ for control units, where p_i denotes the propensity score which was calculated based on the outcome variables at baseline and further covariates. The balance of treatment and control group before and after matching is displayed in Table A2 (appendix).

To address RQ1, we estimated difference-in-difference (DiD) estimates comparing the change from t_1 to t_3 between the treatment and control group. We specified a fixed effects (FE) panel regression with time fixed effects, in which the unit of analysis is the person $\times$ occupation combination (for individuals surveyed on two occupations). This specification exploits within-unit variation over time and controls for all time-invariant, unobserved characteristics of each person $\times$ occupation unit (Angrist & Pischke, 2009). The DiD specification can be written as

$$Y_{jt} = \alpha_j + \gamma_t Post_t + \beta (Treat_j \times Post_t) + \varepsilon_{jt},$$

where Y_{jt} denotes the outcome of the person $\times$ occupation unit j at time t . The coefficient β captures the difference-in-difference estimate, that is, the differential change from t_1 to t_3 to between the treatment and control group. α_j denotes unit fixed effects that capture all time-invariant observed and unobserved characteristics of each person–occupation unit, and γ_t is the coefficient for change over time in the control group. Because treatment status is time-invariant at the person–occupation level, its main

effect is absorbed by the unit fixed effects and is therefore not estimated separately. Under the application of the IPTW weights and assuming that the parallel trends assumption holds, the DiD estimator identifies the average treatment effect (ATE). To account for within-school dependence, we report cluster-robust standard errors at the level of school visits. All outcome variables were z-standardised.

To address RQ2, we investigated effect heterogeneities in treatment effects by students' gender by adding a three-way interaction term between treatment status, time, and gender, reporting the gender-specific marginal effects.

Missing values were present in four outcome variables and six socio-structural covariates (missingness rate between 0.35 - 3.3%). Missing values were imputed using Multivariate Imputation by Chained Equations (MICE) via Stata's `mi impute` command with $n=25$ imputation samples (Royston, 2004). In addition to the incomplete variables, treatment status, person ID, wave, school track, school grade, surveyed occupation, timing of t_1 , and gender were also included in the imputation models to make the Missing at Random (MAR) assumption more reasonable. Predictive mean matching was used for all (continuous) outcome variables ($k=5$ donor pool size); linear regression, logistic regression, or multinomial regression were used as imputation methods for covariates. All statistical analyses were conducted with Stata, version 18.0.

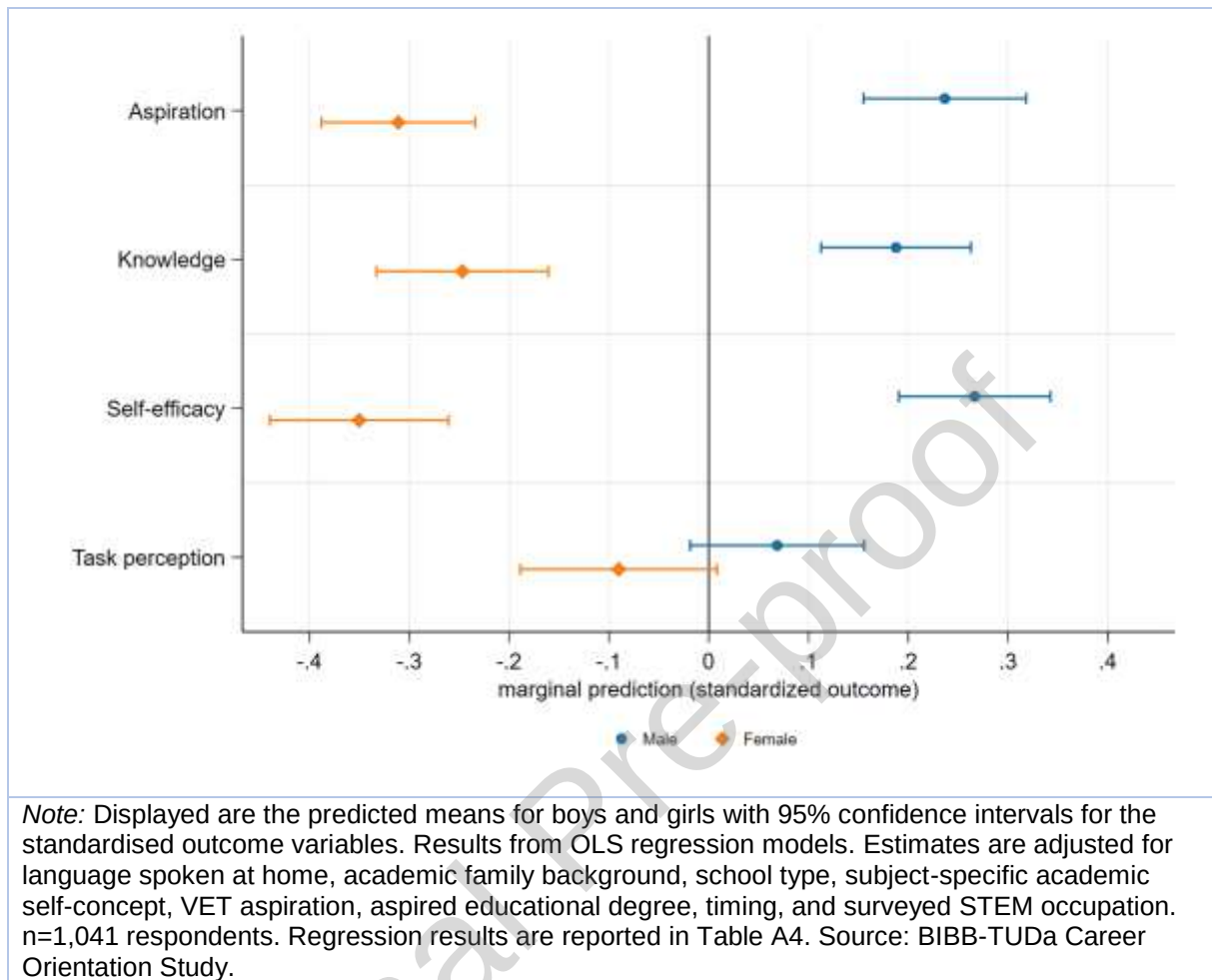
7 Results

7.1 Gender differences in the perception of VET STEM occupations at baseline

First, we inspected gender differences in students' perceptions of and aspirations to VET STEM occupations at baseline. Figure 3 shows the differences in means between

male and female students, controlling for socio-structural differences. In our sample, the largest gender difference is visible for STEM-specific self-efficacy, with girls reporting a predicted mean of 2.44 scale points and boys a predicted mean of 3.10 scale points, corresponding to a statistically significant difference between the genders of about 0.61 standard deviations ($p < .001$). Gender differences in favour of boys are also visible for STEM-specific aspirations (0.536 standard deviations with $p < .001$), followed by STEM-specific occupational knowledge (0.429 standard deviations difference with $p < .001$). Boys and girls differ only slightly in their evaluation of VET STEM occupations containing interesting tasks ($SD = 0.169$ [$p = .05$]).

Figure 3. Gender differences in the perception of and aspirations to VET STEM occupations at baseline t_1 .

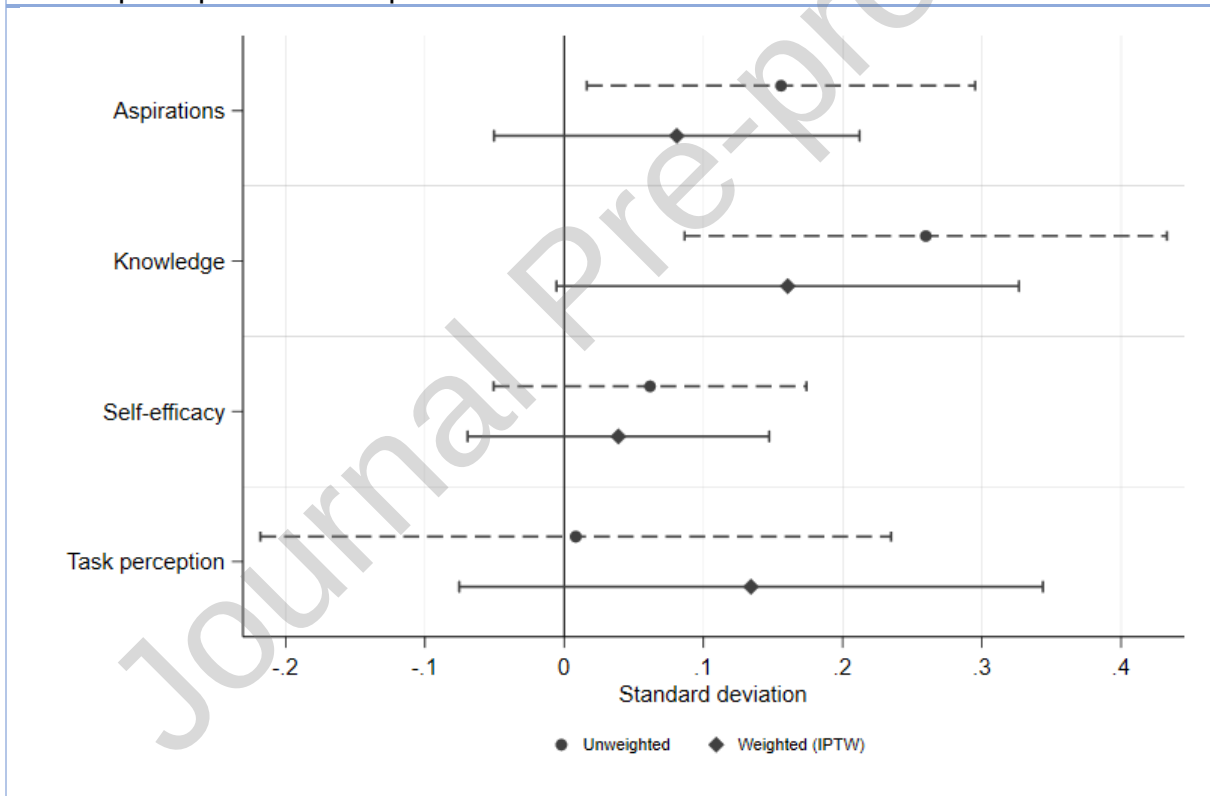


7.2 Can vocational role models change students' VET STEM perceptions and aspirations?

Results of the weighted and unweighted difference-in-difference (DiD) estimates of the role model intervention on the perception of VET STEM occupations and occupational aspirations are reported in Figure 4. On average, participating in the role model intervention slightly increased students' aspirations to VET STEM occupations presented by the role models by 0.16 standard deviations (SD) (with $p < .05$) compared to the control group based on the unweighted model. This effect shrinks to 0.08 SD in the weighted sample and no longer reaches statistical significance. The results also show that students' knowledge about the presented VET STEM occupations increased by 0.26 SD (with $p < .01$) in the unweighted model, and by 0.16 SD with $p = .057$ in the

weighted model. In line with recent recommendations, this effect can be described as a small effect size above the threshold of 0.1 (Gignac & Szodorai, 2016). From a substantial perspective, these results are in line with H1, the general role modelling effect. Effect sizes for occupational self-efficacy and perception of tasks as interesting remain below 0.1 in both the unweighted and weighted models and do not reach statistical significance, refuting H1 for these two outcomes.

Figure 4. Difference-in-difference estimates of the role model intervention on VET-STEM perceptions and aspirations.



Note: Displayed are the difference-in-difference estimates based on the interaction between treatment and wave, with 95% confidence intervals. Results from OLS fixed effects (FE) panel regressions. Cluster-robust standard errors at the school level. n=1,041 respondents. Regression results are reported in Table A5. Source: BIBB-TUDa Career Orientation Study.

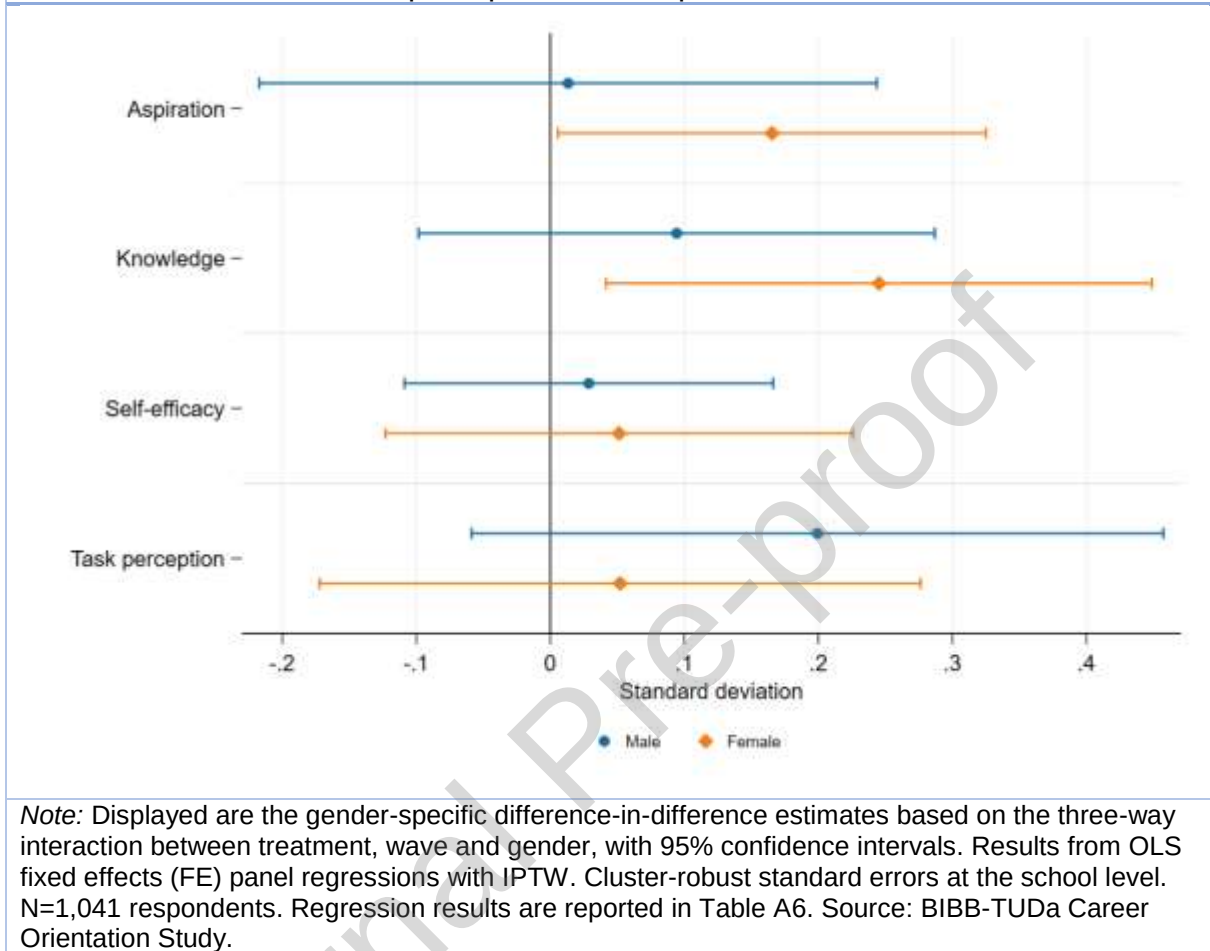
We also assessed whether the DiD-estimates differed across the distribution of the outcome at baseline to test for potential ceiling effects, specifying an interaction term between the wave, treatment, and baseline value. We found that students with initially

lower levels of knowledge had significantly higher intervention effects, whereas such ceiling effects did not emerge for the other outcomes (see Table A7, Model A).

7.3 Do role modelling effects differ by students' gender?

According to the gender-specific treatment effects displayed in Figure 5, the positive intervention effects on students' occupational aspirations and occupational knowledge were mainly driven by female students. Female students showed an increase in their aspirations by $SD=0.165$ (with $p<.05$), whereas for boys we observe a point estimate near zero. These gender-specific effects imply that the initial gender gap in aspirations of $SD=0.565$ was reduced by the intervention to overall $SD=0.413$. The largest treatment effect occurs on girls' self-reported occupational knowledge ($SD=0.243$ with $p<.021$), which can be considered a small to medium effect based on recommendations on interpreting effect sizes (Gignac & Szodorai, 2016). In comparison, a substantially lesser increase in knowledge is observed for boys that does not reach statistical significance ($SD=0.102$). Taken together, the gender gap at baseline in knowledge of $SD=0.447$ was reduced to $SD=0.306$. It should be noted that the difference in treatment effects by gender is not statistically significant based on the interaction term between the treatment, wave, and gender. Regarding the other outcomes, male and female students do not show statistically significant intervention effects on their self-efficacy and perception of tasks as interesting, although male students experienced a larger increase in their perception of tasks as interesting based on the point estimate of $SD=0.2$. Overall, these results clearly contradict our theoretical expectation that role modelling effects would be greater for male than for female students, pointing in the opposite direction of H2.

Figure 5. Gender-specific difference-in-difference estimates of the role model intervention on VET STEM perceptions and aspirations.



We also looked at whether the gender-specific treatment effects differed by students' baseline levels (see Table A7). Male students with a lower prior knowledge displayed significantly higher intervention effects on their knowledge, whereas for male students with high levels of knowledge at baseline, intervention effects were smaller. For example, male students with 1.5 SD below the mean experienced an increase of 0.33 ($p < .05$). For female students, however, intervention effects on knowledge shrank only slightly at higher baseline levels. Furthermore, the intervention effects on aspirations increased for female students with higher baseline aspirations. For example, female students with baseline aspirations at the mean had a treatment effect of 0.188 ($p < .05$),

which increased to 0.285 ($p < .05$) for female students with 1.5 SD above the mean at baseline.

7.4 Does the gender of the role model make a difference?

The large majority of vocational role models in our intervention study was male. We cannot directly compare male and female role models since the female role models in our sample were concentrated in the occupation 'IT Specialists' (see Table A1). Although the research design of this study does not allow us to assess differences by role models' gender in a causal framework, we can put forward descriptive analyses of differences in treatment effects associated with role model gender.

First, we assessed whether same-sex and opposite-sex role models were differently perceived by students at t_2 in terms of positive attributes and identification (Table A3). Statistically significant mean differences with $p < .05$ between same-sex and opposite-sex role models emerged for students' reported identification with the vocational role model, with same-sex role models yielding a higher degree of identification on two of three items, with differences in mean ranging between 0.17 and 0.41 scale points. No substantial differences between same-sex and opposite-sex role models emerged for the perception of positive attributes such as 'educated.'

Second, in Table 3 we present the results of gender-specific DiD estimates, differentiating the treatment variable into male and female role models. Due to the small number of observations in the subgroup with female role models, the standard errors and confidence intervals are larger overall. In terms of gender-specific treatment effects, female students experienced substantial intervention effects from both male and female role models on their STEM aspirations and STEM knowledge. For example,

female students' self-perceived knowledge increased by $SD=0.29$ (with $p<.05$) after participating in male role model interventions, which is twice the effect size of the DiD from female role models. These results refute potential concerns that the effects for female students reported in Figure 5 are exclusively driven by same-sex role models.

For male students, no substantial treatment effects emerged on their aspirations, knowledge, or self-efficacy based on the gender of the role model. Interestingly, the positive treatment effect on male students' perception of tasks as interesting was mainly driven by male role models, involving an increase by $SD=0.236$ ($p<.1$). Overall, results should be interpreted cautiously due to the small sample size of female role models, as also reflected by the weak significance levels of effect estimates.

Table 3. Gender-specific difference-in-difference (DiD) estimates of the average treatment effect (ATE) for male and female role models

	STEM-specific occupational aspiration		STEM-specific self-perceived knowledge		STEM-specific self-efficacy		STEM-specific task perception	
	b	SE	b	SE	b	SE	b	SE
Female students								
ref. control group								
male role model	0.154 ⁺	0.084	0.290 [*]	0.113	0.097	0.098	0.105	0.116
female role model	0.192 ⁺	0.110	0.138	0.135	-0.058	0.063	-0.075	0.111
Male students								
ref. control group								
male role model	0.016	0.133	0.091	0.107	0.027	0.082	0.236 ⁺	0.127
female role model	0.005	0.109	0.103	0.091	0.034	0.060	0.100	0.142

Notes: ⁺ $p<.1$, ^{*} $p<.05$; ^{**} $p<.01$; ^{***} $p<.001$; b: Standardised coefficient, SE: standard error. Results based on OLS fixed effects (FE) panel regressions with an interaction term between treatment (coded as 0: control group, 1: male role model, 2: female role model), wave, and gender. Cluster-robust standard errors at the school level. Shown are the weighted results (IPTW). N=1,041 respondents. Male role models: n=515, female role models: n=152. Source: BIBB-TUDa Career Orientation Study.

8 Discussion

This study expands the limited body of empirical evidence on role modelling in career guidance by using an intervention study with a non-equivalent control group design in the field of VET STEM. Importantly, our study is based on a male-dominated sample of real-life vocational VET STEM role models, while previous interventions have mostly used female role models (e.g., Breda et al., 2020). Our study makes another important contribution by focussing on VET role models, which, to our knowledge, have not been as widely studied as academic role models. This is highly relevant from a national and international policy perspective, given the overall magnitude of work-based learning across European countries, the pressing shortage of skilled workers in VET STEM occupations (European Commission, 2025), as well as the extensive gender gap in VET systems which is even greater than in higher education (see also Gutfleisch & Nennstiel, 2025). Furthermore, unlike many previous interventions that used text-based or video-based role models, our study is based on real-life interactions with role models, offering a more personal and authentic approach to role model theory (Gioannis et al., 2023).

Examining how intervention effects differ for male and female students, we build upon previous intervention studies that have tested for the gender-specific effects of informational guidance and career interventions (Barone et al., 2019; Finger et al., 2020; Ikkatai et al., 2021; Peter et al., 2023). In contrast to these studies, descriptively, female students showed slightly larger gains in STEM aspirations and occupational knowledge (but not self-efficacy) than male students in response to the intervention, though the gender difference in treatment effects did not reach statistical significance. Our results are promising in this regard, suggesting that role modelling interventions

may be better suited for targeting gendered career aspirations compared to purely informational interventions. This is because, as is argued in the literature, role modelling not only provides information, but is strongly based on processes of social identification and motivation (Morgenroth et al., 2015). Contrary to our expectations, the intervention did not increase male or female students' self-efficacy, a result which contradicts key theoretical predictions about role modelling (Bandura, 1977; Morgenroth et al., 2015).

Another unexpected result of our study is that real-life *male* vocational role models succeeded in substantially increasing the occupational knowledge and aspirations of female students. Thus, our results contradict both theoretical arguments based on social identity and stereotype theory that male students would profit more than female students from a male role model. Although we find that students overall identify slightly more with same-sex vocational role models (see section 7.4), our results suggest that this greater identification does not lead to substantially larger role modelling effects. Instead, we find that female students can develop greater STEM aspirations even when gender stereotypes are confirmed, such as when the occupation is portrayed by male role models.

The interpretation of these gender-specific effects are not straightforward, and leaves us with the puzzle of why female students adjust their aspirations and knowledge more than do male students in response to male VET STEM role models. Possibly, girls are overall more susceptible to being influenced by role modelling than are boys, perhaps because they have less contact with STEM professions within their socialisation and gendered spheres of life. This argumentation is supported by the descriptive results from our study, with female students reporting less knowledge of STEM VET

professions than male students at baseline. Furthermore, the male VET ambassadors included in our treatment and their presentation in the classroom were perceived positively by most of the students, whether male or female. Presumably, perceiving the role model in a positive way (in terms of being educated, intelligent, and likeable) may be more important than the gender of the role model. This interpretation is also consistent with previous research suggesting that role model gender may be less influential than other characteristics of role modelling, such as the beliefs role models convey about ability and talent (e.g., Bagès & Martinot, 2011; 2016), the embodiment of stereotypes related to clothing, hobbies and preferences (Cheryan et al. 2011), or their presentation style (Bamert, 2024).

The second surprising finding of our study is that male role models did not substantially increase male students' aspirations for VET STEM occupations. Possibly, boys are already more in contact with and socialised in STEM subjects in their everyday lives, so that male students have already had the possibility of developing STEM aspirations before the intervention occurred and are thus already 'saturated.' Such ceiling effects would make further increases in their level of knowledge, self-efficacy, and aspiration to VET STEM occupations unlikely. Indeed, further analyses showed larger intervention effects for boys with lower knowledge at baseline compared to boys whose knowledge was higher at the outset. Furthermore, male role models that are positively selected on a range of attributes, as is likely the case in our intervention, may induce negative backfiring effects. Marx et al. (2013), for example, showed that talented male role models negatively affected male students' math performance. They suggest that male students compared their ability to that of the talented role model. According to

the authors, men might feel threatened and perceive pressure to live up to the positive, high-achieving stereotype of a talented male person working in STEM.

9 Limitations

Several shortcomings of our study can be identified. First, role modelling may involve more processes than we were able to consider in our study. We took into account four key outcome dimensions discussed in role modelling theories and gender-specific career choice theories. Future studies could investigate further dimensions of how STEM VET occupations are perceived, e.g., related to the concrete stereotypical content of these occupations such as (personal) attributes of people working in VET STEM occupations (e.g. 'nerdiness' or 'social awkwardness' Breda et al., 2020). Although we did show that female students increased their self-reported knowledge about these occupations, a fruitful avenue for future research could be to directly assess students' knowledge about occupations, for example regarding expected income or other occupational features. It would also be beneficial to examine students' specific interest in different tasks rather than general task perceptions in order to identify more precisely their significance and effect in the process of VET role modelling.

Second, the overall study design should be considered when interpreting our results. Our data is based on a non-representative, selective regional sample of secondary schools in Germany that were surveyed during and at the outset of the Covid-19 pandemic, when students spent more time than usual with their families and when there were hardly any career guidance programmes available to students in the school context. Future research with a representative sample of schools is warranted.

Due to additional organisational constraints during the pandemic, students in our study were not randomly assigned to the treatment group, nor to a real-life role model of a specific gender. In the absence of randomisation, the estimation of the causal effect of our intervention is based on the untestable assumption that all confounders are observed. Since timing of the intervention may correlate with the career orientation process of students as well as with period effects during the Covid pandemic, it was included as a covariate. We attempted to eliminate as many confounding sources as possible by applying IPTW to remove preexisting differences between treatment and control groups in relevant observed covariates at baseline.

Furthermore, the studied intervention was not solely designed to address gender differences in STEM-specific VET occupations, but was part of a larger career orientation study broadly aiming to improve career competencies of students with regard to VET careers. As a result, the variety of different VET occupations in our sample was imbalanced in terms of role model gender, with female role models being highly underrepresented. The accordingly small sample size of female role models limits the reliability of our findings. This should be considered when interpreting the results of role model gender.

Our findings on gender-specific vocational role model effects in VET STEM occupations thus provide first valuable insights into how student gender and vocational STEM role model gender may interact. We encourage future researchers to set up a research design that randomly varies the gender of the role model students are assigned to so that the relevance of both student and role model gender – as well as other characteristics – can be studied causally.

Lastly, the research design of our intervention study allowed us to assess short-term role modelling effects after a few weeks. Our study focussed on psychological outcomes, but not on behavioural outcomes such as internship decisions, post-school pathways, or other career choices. Since career orientation represents a long term process and continues until students make their career choices and possibly adjust them, it would be desirable for future studies to consider such behavioural outcomes and to follow up on the long-term effects of role modelling interventions on students' career choices and trajectories (for notable exceptions, see, e.g., Breda et al., 2020 and Bamert, 2024).

10 Conclusion

The results of the present study provide important insights into the relevance of real-life VET STEM role models in career guidance, especially for female students. Our results suggest that unique encounters with mainly male role models can contribute to changing how female students perceive VET STEM occupations in terms of occupational knowledge and aspirations, but not regarding their perception of tasks as interesting nor their self-efficacy. Although standard guidance activities such as vocational interest tests or information platforms may also increase students' occupational knowledge, our results empirically confirm that real-life role models have both an informational and a motivational function, as suggested by Morgenroth et al. (2015).

From a policy perspective, our results suggest strengthening social guidance approaches by employing real-life personal testimonials, which provide grounds for identification and more personal and comprehensive insights. Vocational role models like the 'VET ambassadors' can thus contribute to diminishing gender inequalities in

vocational knowledge about and aspiration to VET STEM occupations, which is a key prerequisite for girls pursuing STEM careers and constitutes an important building block in supporting young women's entry into these male-dominated occupational pathways. At the same time, different policy interventions should be considered to target the large gender gap in self-efficacy that was observed at baseline and was not affected by the role model intervention.

Since vocational role models have also been shown to increase students' long-term persistence within STEM (Bamert, 2024), concerns regarding potentially negative role modelling effects, such as producing misled or too ambitious choices, may be unfounded, but should be taken into account in future research. Overall, the observed treatment effects on especially female students' knowledge about and aspirations to STEM VET occupations by (male) vocational role models contribute to some extent to reducing existing gender gaps in students' STEM VET aspirations, and potentially reducing gendered career choices in the long-term that are connected to further gender inequalities in labour-market opportunities.

Appendix

Table A1. Overview of STEM vocational education and training occupations.

Occupation (German)	Occupation (English)	Control group (n)	Treatment group (n)	
			Male role model	Female role model
Elektroniker*in	Electronics Technician	82	83	0
Fachinformatiker*in	IT Specialist	80	50	152
Fachkraft für Kreislauf- und Abfallwirtschaft	Environmental Technologist for Recycling and Waste Management	31	36	0
Feinwerkmechaniker*in	Precision Machinist	35	38	0
Fluggerätemechaniker*in	Aircraft Mechanic	23	39	0
Kfz-Mechatroniker*in	Motor Vehicle Mechatronics Technician	95	101	0
Mechatroniker*in für Kältetechnik	Mechatronics Engineer for Refrigeration Technology	55	90	0
Technische*r Produktdesigner*in	Technical Product Designer	34	24	0
Verfahrensmechaniker*in	Process Mechanic	32	54	0
Total		467	982	152

Note: displayed is the number of respondents. Source: BIBB-TUDa Career Orientation Study.

Table A2. Balance statistics.

Variable	Before IPTW						After IPTW					
	Treated		Control				Treated		Control			
	M	Var.	M	Var.	Std. diff.	Var. Ratio	M	Var.	M	Var.	Std. diff.	Var. Ratio
Outcome variables (baseline): STEM specific												
Aspirations	1.92	0.98	2.12	1.14	0.20	0.86	2.00	1.06	1.98	1.05	0.02	1.01
Knowledge	2.54	0.93	2.72	0.93	0.19	0.99	2.63	0.97	2.59	0.96	0.04	1.00
Self-efficacy	2.78	1.13	2.86	1.09	0.08	1.03	2.80	1.16	2.80	1.12	0.01	1.03
Task perception	3.10	0.69	3.03	0.80	0.08	0.86	3.04	0.71	3.08	0.81	- 0.05	0.88
Covariates												
Gender	0.44	0.25	0.42	0.24	0.04	1.01	0.44	0.25	0.46	0.25	- 0.04	0.99
Language spoken at home	0.55	0.25	0.58	0.24	0.06	1.01	0.55	0.25	0.54	0.25	0.02	0.99

Family background:												
Non-academic	0.12	0.11	0.09	0.08	0.06	1.28	0.11	0.09	0.11	0.10	-	0.93
Academic: one parent	0.21	0.16	0.21	0.16	0.00	0.99	0.21	0.16	0.22	0.17	-	0.95
Academic: both parents	0.67	0.22	0.70	0.21	0.09	1.05	0.69	0.22	0.66	0.22	0.05	0.96
Math self-concept	3.51	1.16	3.55	1.28	0.03	0.91	3.52	1.20	3.57	1.23	-	0.97
Verbal self-concept	3.34	0.84	3.46	0.77	0.14	1.09	3.38	0.82	3.41	0.82	-	1.00
VET aspiration	3.53	1.28	3.62	1.23	0.08	1.04	3.56	1.33	3.59	1.22	-	1.09
Educational degree aspiration	0.66	0.22	0.64	0.23	0.04	0.98	0.65	0.23	0.67	0.22	-	1.03
School type: low	0.11	0.09	0.10	0.09	0.03	1.09	0.12	0.11	0.08	0.08	0.13	1.40
medium	0.67	0.22	0.42	0.24	0.51	0.91	0.56	0.25	0.56	0.25	0.02	1.00
high	0.09	0.08	0.32	0.22	0.60	0.38	0.18	0.15	0.19	0.15	-	0.97
Timing of t ₁	0.34	0.23	0.73	0.20	0.84	1.14					0.02	

Note: bold font indicates an absolute standardized difference above the threshold of 0.10 (Normand et al., 2001) and variance ratios above the threshold of 2.0 or below 0.5 (Rubin, 2001). N=1,041 respondents. M=mean, Var.=variance, Std. diff=standardized difference. Statistics computed based on Stata-command covbal (Linden, 2020). Source: BIBB-TUDa Career Orientation Study.

Table A3. Perception of and identification with role models by gender-match between role model and students (at t₂).

Variable	Same-sex role model (M)	Opposite-sex role model (M)	Difference in means	t	p
Perception					
The presentation was interesting.	3.87	3.87	0.00	0.01	.996
The ambassador was intelligent.	3.88	3.90	0.02	0.33	.744
The ambassador was educated.	3.87	3.93	0.06	0.86	.388
The ambassador was likeable.	4.23	4.16	-0.06	-0.88	.378
Identification					
The ambassador has similar interests and hobbies as I do.	3.04	2.68	-0.36	-3.97	<.001
The ambassador has a similar way of talking as I do.	3.24	3.08	-0.16	-1.81	.071
The ambassador looks like me (e.g., the way they dress).	2.84	2.43	-0.41	-4.35	<.001

Results from paired t-tests. n=614 person×occupation units of the treatment group with valid responses on all variables. Source: BIBB-TUDa Career Orientation Study.

Table A4. OLS regression results of gender differences in outcome variables at baseline t_1 .

	STEM-specific occupational aspiration		STEM-specific self-perceived knowledge		STEM-specific self-efficacy		STEM-specific task perception	
Female (ref. male):	b	SE	b	SE	b	SE	b	SE
unadjusted	-.595***	.056	-.441***	.057	-.640***	.059	-.192**	.065
adjusted	-.548***	.059	-.435***	.060	-.617***	.062	-.159*	.070
Number of observations	1,134							
Number of individuals	1,041							

Notes: * $p < .05$; ** $p < .01$; *** $p < .001$; b: coefficient, SE: standard error. The adjusted models contain the following covariates: migration background, academic family background, mathematic and verbal self-concept, VET aspiration, educational degree aspiration, school track, survey date and surveyed occupation. Cluster-robust standard errors at the level of schools. Source: BIBB-TUDa Career Orientation Study.

Table A5. Difference-in-difference (DiD) estimates of the average treatment effect (ATE).

	STEM-specific occupational aspiration		STEM-specific self-perceived knowledge		STEM-specific self-efficacy		STEM-specific task perception	
	b	SE	b	SE	b	SE	b	SE
<i>DiD estimates of the average treatment effect (displayed in Figure 4)</i>								
Model 1 (unweighted):	0.155*	0.067	0.260**	0.083	0.062	0.054	0.008	0.109
Model 2 (weighted):	0.081	0.063	0.161+	0.080	0.039	0.053	0.135	0.101
N	1,134							
<i>Robustness check (I): sample with two ambassadors (STEM and non-STEM)</i>								
Model 3 (unweighted):	0.141	0.082	0.283**	0.098	0.068	0.064	0.110	0.097
Model 4 (weighted):	0.065	0.073	0.172+	0.091	0.043	0.061	0.218*	0.094
N	959							
<i>Robustness check (II): sample with only male ambassadors</i>								
Model 5 (unweighted)	0.158+	0.085	0.276**	0.096	0.077	0.061	0.057	0.106
Model 6 (weighted):	0.078	0.084	0.176+	0.095	0.057	0.063	0.179+	0.103

N	982
Notes: +p<.1, *p<.05; **p<.01; ***p<.001; b: coefficient, SE: standard error. Results based on OLS fixed effects (FE) panel regressions with an interaction term between treatment and wave. Cluster-robust standard errors at the school level. Weighted results are based on inverse probability of treatment weights (IPTW). Source: BIBB-TUDa Career Orientation Study.	

Table A6. Gender-specific difference-in-difference (DiD) estimates of the average treatment effect (ATE), weighted results.

	STEM-specific occupational aspiration		STEM-specific self-perceived knowledge		STEM-specific self-efficacy		STEM-specific task perception	
	b	SE	b	SE	b	SE	b	SE
<i>DiD estimates of the gender-specific average treatment effect (displayed in Figure 5)</i>								
Male students:	0.013	0.112	0.102	0.091	0.029	0.067	0.200	0.126
Female students:	0.165*	0.078	0.243*	0.099	0.051	0.085	0.052	0.109

Notes: +p<.1, *p<.05; **p<.01; ***p<.001; b: coefficient, SE: standard error. Results based on OLS fixed effects (FE) panel regressions with an interaction term between treatment, wave, and gender. Cluster-robust standard errors at the school level. Shown are the weighted results (IPTW). N=1,041 respondents. Source: BIBB-TUDa Career Orientation Study.

Table A7. Difference-in-difference (DiD) estimates of the average treatment effect (ATE) by the baseline outcome measure.

	STEM-specific occupational aspiration		STEM-specific self-perceived knowledge		STEM-specific self-efficacy		STEM-specific task perception	
	b	SE	b	SE	b	SE	b	SE
Full sample								
1.5 SD below the mean	0.130	0.09	0.371**	0.117	0.154	0.095	0.036	0.300
mean	0.077	0.06	0.164*	0.068	0.039	0.049	0.121	1.11
1.5 SD above the mean	0.024	0.08	-0.043	0.130	-0.075	0.081	0.205	1.11
N (obs):	1,134							
Male students								
1.5 SD below the mean	0.087	0.60	0.328*	2.35	0.124	1.07	-0.030	-0.20
mean	0.016	0.18	0.078	0.96	-0.009	-0.15	0.148	1.04
1.5 SD above the mean	-0.056	-0.50	-0.172	-1.21	-0.141	-1.80	0.326	1.48
N (obs):	644							
Female students								
1.5 SD below the mean	0.090	1.01	0.344*	2.28	0.046	0.41	0.110	0.64

mean	0.189*	2.61	0.299*	2.54	0.152	1.93	0.067	0.62
1.5 SD above the mean	0.287*	2.18	0.255	0.96	0.258	1.82	0.025	0.10
N (obs):	490							

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$; b: coefficient, SE: standard error. Results based on OLS fixed effects (FE) panel regressions with an interaction term between treatment, wave, and the respective baseline outcome measure. Cluster-robust standard errors at the school level. Shown are the weighted results (IPTW). Source: BIBB-TUDa Career Orientation Study.

References

- Asgari, S., Dasgupta, N., & Gilbert Cote, N. (2010). When Does Contact with Successful Ingroup Members Change Self-Stereotypes? *Social Psychology*, 41(3), 203–211. <https://doi.org/10.1027/1864-9335/a000028>
- Athanasidi, E., Schare, T., & Ulrich, J. G. (2020). Ausbildungsbotschafterbesuche als Instrument der Berufsorientierung: Wege zum Beruf aufzeigen, Identifikationspotenziale erschließen. *Berufsbildung in Wissenschaft Und Praxis (BWP)*, 49(4), 40–44.
- Bagès, C., & Martinot, D. (2011). What is the best model for girls and boys faced with a standardized mathematics evaluation situation: A hardworking role model or a gifted role model? *The British Journal of Social Psychology*, 50(3), 536–543. <https://doi.org/10.1111/j.2044-8309.2010.02017.x>
- Bagès, C., Verniers, C., & Martinot, D. (2016). Virtues of a Hardworking Role Model to Improve Girls' Mathematics Performance. *Psychology of Women Quarterly*, 40(1), 55–64. <https://doi.org/10.1177/0361684315608842>
- Bamberger, Y. M. (2014). Encouraging Girls into Science and Technology with Feminine Role Model: Does This Work? *Journal of Science Education and Technology*, 23(4), 549–561. <https://doi.org/10.1007/s10956-014-9487-7>
- Bamert, J. (2024). *Does Exposure to Female STEM Professionals Reduce the Gender Gap in STEM Participation?* (Job Market Paper).
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191–215. <https://doi.org/10.1037/0033-295X.84.2.191>
- Barone, C. (2011). Some Things Never Change. *Sociology of Education*, 84(2), 157–176. <https://doi.org/10.1177/0038040711402099>
- Barone, C., Schizzerotto, A., Assirelli, G., & Abbiati, G. (2019). Nudging gender desegregation: a field experiment on the causal effect of information barriers on gender inequalities in higher education. *European Societies*, 21(3), 356–377. <https://doi.org/10.1080/14616696.2018.1442929>
- Betz, D. E., & Sekaquaptewa, D. (2012). My Fair Physicist? Feminine Math and Science Role Models Demotivate Young Girls. *Social Psychological and Personality Science*, 3(6), 738–746. <https://doi.org/10.1177/1948550612440735>
- BIBB. (2024). „Datenbank Auszubildende“ des Bundesinstituts für Berufsbildung (BIBB) auf Basis der Daten der Berufsbildungsstatistik der statistischen Ämter des Bundes und der Länder (Erhebung zum 31. Dezember).

- Blackburn, R. M., Jarman, J., & Racko, G. (2014). Occupational Segregation. In G. Razzu (Ed.), *Gender Inequality in the Labour Market in the UK* (pp. 101–121). Oxford University Press.
<https://doi.org/10.1093/acprof:oso/9780199686483.003.0005>
- Breda, T., Grenet, J., Monnet, M., & van Effenterre, C. (2020). Do Female Role Models Reduce the Gender Gap in Science? Evidence from French High Schools. *SSRN Electronic Journal*. Advance online publication. <https://doi.org/10.2139/ssrn.3584926>
- Breda, T., Grenet, J., Monnet, M., & van Effenterre, C. (2023). How Effective are Female Role Models in Steering Girls Towards STEM? Evidence from French High Schools. *The Economic Journal*, 133(653), 1773–1809. <https://doi.org/10.1093/ej/uead019>
- Bridges, D., Wulff, E., Bamberry, L., Krivokapic-Skoko, B., & Jenkins, S. (2020). Negotiating gender in the male-dominated skilled trades: a systematic literature review. *Construction Management and Economics*, 38(10), 894–916. <https://doi.org/10.1080/01446193.2020.1762906>
- Cheryan, S., Drury, B. J., & Vichayapai, M. (2013). Enduring Influence of Stereotypical Computer Science Role Models on Women’s Academic Aspirations. *Psychology of Women Quarterly*, 37(1), 72–79. <https://doi.org/10.1177/0361684312459328>
- 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>
- Chesnaye, N. C., Stel, V. S., Tripepi, G., Dekker, F. W., Fu, E. L., Zoccali, C., & Jager, K. J. (2022). An introduction to inverse probability of treatment weighting in observational research. *Clinical Kidney Journal*, 15(1), 14–20. <https://doi.org/10.1093/ckj/sfab158>
- Chhaochharia, V., Du, M., & Niessen-Ruenzi, A. (2022). Counter-stereotypical female role models and women’s occupational choices. *Journal of Economic Behavior & Organization*, 196, 501–523.
<https://doi.org/10.1016/j.jebo.2022.02.009>
- Conner, L. D. C., & Danielson, J. (2016). Scientist role models in the classroom: how important is gender matching? *International Journal of Science Education*, 38(15), 2414–2430.
<https://doi.org/10.1080/09500693.2016.1246780>
- Correll, S. J. (2001). Gender and the Career Choice Process: The Role of Biased Self-Assessments. *American Journal of Sociology*, 106(6), 1691–1730. <https://doi.org/10.1086/321299>
- Dasgupta, N. (2011). Ingroup Experts and Peers as Social Vaccines Who Inoculate the Self-Concept: The Stereotype Inoculation Model. *Psychological Inquiry*, 22(4), 231–246.
<https://doi.org/10.1080/1047840X.2011.607313>
- Dasgupta, N., & Asgari, S. (2004). Seeing is believing: Exposure to counterstereotypic women leaders and its effect on the malleability of automatic gender stereotyping. *Journal of Experimental Social Psychology*, 40(5), 642–658. <https://doi.org/10.1016/j.jesp.2004.02.003>
- Davis-Hall, D., Farrelly, L., Risteff, M., & Magin, C. M. (2023). Evaluating How Exposure to Scientific Role Models and Work-Based Microbadging Influences STEM Career Mindsets in Underrepresented Groups. *Biomedical Engineering Education*, 3(1), 23–38.
<https://doi.org/10.1007/s43683-022-00096-x>
- Denner, J., Werner, L., Martinez, J., & Bean, S. (2012). Computing Goals, Values, and Expectations: Results from an After-School Program for Girls. *Journal of Women and Minorities in Science and Engineering*, 18(3), 199–213.
<https://doi.org/10.1615/JWomenMinorScienEng.2013002075>
- Dionisius, R., & Illiger, A. (2023). Das (Aus)Bildungsgeschehen in Deutschland. *Datenreport Zum Berufsbildungsbericht*, 71–86.

- Drescher, K., Häckl, S., & Schmieder, J. (2020). *MINT-Berufe: Workshops mit Rollenvorbildern können Geschlechterstereotype abbauen*. DIW - Deutsches Institut für Wirtschaftsforschung. https://doi.org/10.18723/diw_wb:2020-13-1
- Eccles, J. S. (1983). Expectancies, values and academic behaviors. *Achievement and Achievement Motives*. <https://cir.nii.ac.jp/crid/1570291225622639232>
- Eccles, J. S. (2011). Gendered educational and occupational choices: Applying the Eccles et al. Model of achievement-related choices. *International Journal of Behavioral Development*, 35(3), 195–201. <https://doi.org/10.1177/0165025411398185>
- European Commission. (2025). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A STEM Education Strategic Plan: skills for competitiveness and innovation*. Publications Office of the European Union. https://education.ec.europa.eu/sites/default/files/2025-03/STEM_Education_Strategic_Plan_COM_2025_89_1_EN_0.pdf
- Fernández-César, R., Garrido, D., & Solano-Pinto, N. (2020). Do Science, Technology, Engineering and Mathematics (STEM) Experimentation Outreach Programs Affect Attitudes towards Mathematics and Science? A Quasi-Experiment in Primary Education. *Mathematics*, 8(9), 1490. <https://doi.org/10.3390/math8091490>
- Ferrari, L., Ginevra, M. C., Santilli, S., Nota, L., Sgaramella, T. M., & Soresi, S. (2015). Career exploration and occupational knowledge in Italian children. *International Journal for Educational and Vocational Guidance*, 15(2), 113–130. <https://doi.org/10.1007/s10775-015-9299-1>
- Finger, C., Solga, H., Ehlert, M., & Rusconi, A. (2020). Gender differences in the choice of field of study and the relevance of income information. Insights from a field experiment. *Research in Social Stratification and Mobility*, 65, 100457. <https://doi.org/10.1016/j.rssm.2019.100457>
- Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences*, 102, 74–78. <https://doi.org/10.1016/j.paid.2016.06.069>
- Gioannis, E. de, Pasin, G. L., & Squazzoni, F. (2023). Empowering women in STEM: a scoping review of interventions with role models. *International Journal of Science Education, Part B*, 45, 1–15. <https://doi.org/10.1080/21548455.2022.2162832> (Part B).
- Gladstone, J., & Cimpian, A. (2020). *Role Models Can Help Make the Mathematics Classroom More Inclusive*. Center for Open Science. <https://doi.org/10.31219/osf.io/ktjy4>
- Gladstone, J. R., & Cimpian, A. (2021). Which role models are effective for which students? A systematic review and four recommendations for maximizing the effectiveness of role models in STEM. *International Journal of STEM Education*, 8(1), 59. <https://doi.org/10.1186/s40594-021-00315-x>
- González-Pérez, S., Mateos de Cabo, R., & Sáinz, M. (2020). Girls in STEM: Is It a Female Role-Model Thing? *Frontiers in Psychology*, 11, 2204. <https://doi.org/10.3389/fpsyg.2020.02204>
- Gottfredson, L. S. (1981). Circumscription and compromise: A developmental theory of occupational aspirations. *Journal of Counseling Psychology*, 28(6), 545–579. <https://doi.org/10.1037/0022-0167.28.6.545>
- Granato, M., & Ulrich, J. G. (2017). L’alternance, une voie de réussite pour tous ? L’impact de l’origine ethnique en Allemagne. *Formation Emploi*(139), 119–146. <https://doi.org/10.4000/formationemploi.5168>
- Guenaga, M., Eguíluz, A., Garaizar, P., & Mimenza, A. (2022). The Impact of Female Role Models Leading a Group Mentoring Program to Promote STEM Vocations among Young Girls. *Sustainability*, 14(3), 1420. <https://doi.org/10.3390/su14031420>

- Gutfleisch, T., & Nennstiel, R. (2025). Bridging the gap: Gender-specific preferences in STEM occupations in vocational education and training. *Empirical Research in Vocational Education and Training*, 17(1), 12. <https://doi.org/10.1186/s40461-025-00187-3>
- Härpfer, J., & Neuhauser, P. (2022). *Anpassung des spezifischen Berufsaggregats MINT-Berufe*. Bundesagentur für Arbeit.
- Hickmann, H., & Koneberg, F. (2022). *Die Berufe mit den aktuell größten Fachkräftelücken*. IW-Kurzbericht 67/2022. IW-Kurzbericht: 67/2022. IW. <https://www.iwkoeln.de/studien/helen-hickmann-filiz-koneberg-die-berufe-mit-den-aktuell-groessten-fachkraefteluecken.html>
- Higgins, J., Nairn, K., & Sligo, J. (2010). Vocational imagination and labour market literacy: Young New Zealanders making education–employment linkages. *Journal of Vocational Education & Training*, 62(1), 13–25. <https://doi.org/10.1080/13636820903491716>
- Hillmert, S. (2015). Gender Segregation in Occupational Expectations and in the Labour Market: International Variation and the Role of Education and Training Systems. In M. Triventi, J. Skopek, Y. Kosyakova, S. Buchholz, & H. P. Blossfeld (Eds.), *Comparative social research. Gender inequalities at labor market entry : A comparative view from eduLIFE project* (Vol. 31, pp. 123–148). Emerald Group Publishing Limited. <https://doi.org/10.1108/S0195-631020150000031005>
- Ikkatai, Y., Inoue, A., Minamizaki, A., Kano, K., McKay, E., & Yokoyama, H. M. (2021). Effect of providing gender equality information on students' motivations to choose STEM. *PloS One*, 16(6), e0252710. <https://doi.org/10.1371/journal.pone.0252710>
- Jansen, N., & Joukes, G. (2013). Long Term, Interrelated Interventions to Increase Women's Participation in STEM in the Netherlands. *International Journal of Gender, Science and Technology*, 5(3), 305–316. <https://genderandset.open.ac.uk/index.php/genderandset/article/view/314>
- Krämer, N. C., Karacora, B., Lucas, G., Dehghani, M., Rütther, G., & Gratch, J. (2016). Closing the gender gap in STEM with friendly male instructors? On the effects of rapport behavior and gender of a virtual agent in an instructional interaction. *Computers & Education*, 99, 1–13. <https://doi.org/10.1016/j.compedu.2016.04.002>
- Kroll, S. (2021). Allein unter Männern, allein unter Frauen. Geschlechtsspezifische Entwicklungen in dualen Männer- und Frauenberufen und Unterschiede im Ausbildungsverlauf. *Berufsbildung in Wissenschaft Und Praxis. Zeitschrift Des Bundesinstituts Für Berufsbildung*(4). <https://www.bwp-zeitschrift.de/dienst/veroeffentlichungen/de/bwp.php/de/publication/download/17519>
- Kroll, S. (2024). *MINT-Berufe im dualen System (BBiG bzw. HwO), Deutschland 2023*. https://www.bibb.de/dokumente/xls/dazubi_berufsliste-mint_2023.xlsx
- Lawner, E. K., Quinn, D. M., Camacho, G., Johnson, B. T., & Pan-Weisz, B. (2019). Ingroup role models and underrepresented students' performance and interest in STEM: A meta-analysis of lab and field studies. *Social Psychology of Education*, 22(5), 1169–1195. <https://doi.org/10.1007/s11218-019-09518-1>
- 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>
- Lewis, N. A., Sekaquaptewa, D., & Meadows, L. A. (2019). Modeling gender counter-stereotypic group behavior: A brief video intervention reduces participation gender gaps on STEM teams. *Social Psychology of Education*, 22(3), 557–577. <https://doi.org/10.1007/s11218-019-09489-3>

- Liben, L. S., & Coyle, E. F. (2014). Developmental interventions to address the STEM gender gap: Exploring intended and unintended consequences. *Advances in Child Development and Behavior*, 47, 77–115. <https://doi.org/10.1016/bs.acdb.2014.06.001>
- Lockwood, P. (2006). “Someone Like Me can be Successful”: Do College Students Need Same-Gender Role Models? *Psychology of Women Quarterly*, 30(1), 36–46. <https://doi.org/10.1111/j.1471-6402.2006.00260.x>
- Lockwood, P., & Kunda, Z. (1997). Superstars and me: Predicting the impact of role models on the self. *Journal of Personality and Social Psychology*, 73(1), 91–103. <https://doi.org/10.1037/0022-3514.73.1.91>
- Marx, D. M., Monroe, A. H., Cole, C. E., & Gilbert, P. N. (2013). No doubt about it: When doubtful role models undermine men’s and women’s math performance under threat. *The Journal of Social Psychology*, 153(5), 542–559. <https://doi.org/10.1080/00224545.2013.778811>
- Masters, S., & Barth, J. (2022). Do Gender Conformity Pressure and Occupational Knowledge Influence Stereotypical Occupation Preferences in Middle Childhood? *Frontiers in Education*, 6, Article 780815, 780815. <https://doi.org/10.3389/educ.2021.780815>
- Matthes, S. (2019). *Warum werden Berufe nicht gewählt? Die Relevanz von Attraktions- und Aversionsfaktoren in der Berufsfindung* (1. Auflage). *Berichte zur beruflichen Bildung*. Bundesinstitut für Berufsbildung. <https://www.econstor.eu/handle/10419/206793>
- Merritt, S. K., Hitti, A., van Camp, A. R., Shaffer, E., Sanchez, M. H., & O’Brien, L. T. (2021). Maximizing the impact of exposure to scientific role models: Testing an intervention to increase science identity among adolescent girls. *Journal of Applied Social Psychology*, 51(7), 667–682. <https://doi.org/10.1111/jasp.12774>
- Miller, L., & Hayward, R. (2006). New jobs, old occupational stereotypes: gender and jobs in the new economy. *Journal of Education and Work*, 19(1), 67–93. <https://doi.org/10.1080/13639080500523000>
- Morgenroth, T., Ryan, M. K., & Peters, K. (2015). The Motivational Theory of Role Modeling: How Role Models Influence Role Aspirants’ Goals. *Review of General Psychology*, 19(4), 465–483. <https://doi.org/10.1037/gpr0000059>
- Neuenschwander, M. P., Hofmann, J., Jüttler, A., & Schumann, S. (2018). Professional Desires and Career Decisions: Effects of Professional Interests, Role Models, and Internship in Lower Secondary School. *International Journal for Research in Vocational Education and Training*, 5(3), 226–243. <https://doi.org/10.13152/IJRVET.5.3.5>
- O’Brien, L. T., Hitti, A., Shaffer, E., van Camp, A. R., Henry, D., & Gilbert, P. N. (2017). Improving Girls’ Sense of Fit in Science. *Social Psychological and Personality Science*, 8(3), 301–309. <https://doi.org/10.1177/1948550616671997>
- Olsson, M., & Martiny, S. E. (2018). Does Exposure to Counterstereotypical Role Models Influence Girls’ and Women’s Gender Stereotypes and Career Choices? A Review of Social Psychological Research. *Frontiers in Psychology*, 9, 2264. <https://doi.org/10.3389/fpsyg.2018.02264>
- Peter, F., Schober, P., & Spiess, C. K. (2023). Information intervention on long-term earnings prospects and the gender gap in major choice. *European Sociological Review*, Article jcad055. Advance online publication. <https://doi.org/10.1093/esr/jcad055>
- Porter, C., & Serra, D. (2020). Gender Differences in the Choice of Major: The Importance of Female Role Models. *American Economic Journal: Applied Economics*, 12(3), 226–254. <https://doi.org/10.1257/app.20180426>

- Prieto-Rodriguez, E., Sincock, K., & Blackmore, K. (2020). STEM initiatives matter: results from a systematic review of secondary school interventions for girls. *International Journal of Science Education*, 42(7), 1144–1161. <https://doi.org/10.1080/09500693.2020.1749909>
- Rohlfing, J. E., Nota, L., Ferrari, L., Soresi, S., & Tracey, T. J. (2012). Relation of occupational knowledge to career interests and competence perceptions in Italian children. *Journal of Vocational Behavior*, 81(3), 330–337. <https://doi.org/10.1016/j.jvb.2012.08.001>
- Rosenberg-Kima, R. B., Baylor, A. L., Plant, E. A., & Doerr, C. E. (2008). Interface agents as social models for female students: The effects of agent visual presence and appearance on female students' attitudes and beliefs. *Computers in Human Behavior*, 24(6), 2741–2756. <https://doi.org/10.1016/j.chb.2008.03.017>
- Royston, P. (2004). Multiple Imputation of Missing Values. *The Stata Journal: Promoting Communications on Statistics and Stata*, 4(3), 227–241. <https://doi.org/10.1177/1536867X0400400301>
- Sevilla, M. P., Bordón, P., & Ramirez-Espinoza, F. (2023). Reinforcing the STEM pipeline in vocational-technical high schools: The effect of female teachers. *Economics of Education Review*, 95, 102428. <https://doi.org/10.1016/j.econedurev.2023.102428>
- Shin, J. E. L., Levy, S. R., & London, B. (2016). Effects of role model exposure on STEM and non-STEM student engagement. *Journal of Applied Social Psychology*, 46(7), 410–427. <https://doi.org/10.1111/jasp.12371>
- Smyth, E., & Steinmetz, S. (2015). Vocational Training and Gender Segregation Across Europe. In M. Triventi, J. Skopek, Y. Kosyakova, S. Buchholz, & H. P. Blossfeld (Eds.), *Comparative social research. Gender inequalities at labor market entry : A comparative view from eduLIFE project* (Vol. 31, pp. 53–81). Emerald Group Publishing Limited. <https://doi.org/10.1108/S0195-631020150000031003>
- Solga, H., & Pfahl, L. (2009). Doing Gender im Technisch-Naturwissen-Schaftlichen Bereich. In J. Milberg (Ed.), *Acatech Diskutiert. Förderung des Nachwuchses In Technik und Naturwissenschaft: Beiträge Zu Den Zentralen Handlungsfeldern* (pp. 155–218). Springer. https://doi.org/10.1007/978-3-642-01123-8_4
- Steinke, J., Applegate, B., Penny, J. R., & Merlino, S. (2021). Effects of Diverse STEM Role Model Videos in Promoting Adolescents' Identification. *International Journal of Science and Mathematics Education*, 20(2), 255–276. <https://doi.org/10.1007/s10763-021-10168-z>
- Stewart, L. (2009). *Increasing women's participation in industrial trades*. University of Northern British Columbia. <https://doi.org/10.24124/2009/bpgub1397>
- Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). Stemming the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology*, 100(2), 255–270. <https://doi.org/10.1037/a0021385>
- Su, R., & Rounds, J. (2015). All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields. *1664-1078*, 6, 189. <https://doi.org/10.3389/fpsyg.2015.00189>
- Turner, J. C., & Oakes, P. J. (1986). The significance of the social identity concept for social psychology with reference to individualism, interactionism and social influence. *British Journal of Social Psychology*, 25(3), 237–252. <https://doi.org/10.1111/j.2044-8309.1986.tb00732.x>
- van Camp, A. R., Gilbert, P. N., & O'Brien, L. T. (2019). Testing the effects of a role model intervention on women's STEM outcomes. *Social Psychology of Education*, 22(3), 649–671. <https://doi.org/10.1007/s11218-019-09498-2>

- Volodina, A., & Nagy, G. (2016). Vocational choices in adolescence: The role of gender, school achievement, self-concepts, and vocational interests. *Journal of Vocational Behavior*, 95-96, 58–73. <https://doi.org/10.1016/j.jvb.2016.07.005>
- Weeden, K. A., Gelbgiser, D., & Morgan, S. L. (2020). Pipeline Dreams: Occupational Plans and Gender Differences in STEM Major Persistence and Completion. *Sociology of Education*, 93(4), 297–314.
- Wentzel, W. (2013). *Weibliche Rollenvorbilder in MINT-Berufsorientierungsprojekten für Mädchen – unverzichtbar oder überschätzt? Der Einfluss weiblicher Betreuungspersonen am Girls' ...*
- Wentzel, W., & Funk, L. (2014). *Mädchen auf dem Weg ins Erwerbsleben: Wünsche, Werte, Berufsbilder; Forschungsergebnisse zum Girls'day*. Verlag Barbara Budrich. <https://doi.org/10.3224/86388055>
- Wyss, V. L., Heulskamp, D., & Siebert, C. J. (2012). Increasing Middle School Student Interest in STEM Careers with Videos of Scientists. *International Journal of Environmental and Science Education*, 7(4), 501–522. <https://eric.ed.gov/?id=ej997137>
- Zhang, H., Couch, S., Estabrooks, L., Perry, A., & Kalainoff, M. (2023). Role models' influence on student interest in and awareness of career opportunities in life sciences. *International Journal of Science Education, Part B*, 13(4), 381–399. <https://doi.org/10.1080/21548455.2023.2180333>

Funding:

This article was written as part of the BIBB-TUDa Career Orientation Study (German: BIBB-TUDa-Berufsorientierungsstudie) funded by the Federal Institute for Vocational Education and Training (BIBB) within the research project “Forschungsprojekt Bildungsorientierungen und- entscheidungen” and by the Technical University of Darmstadt.

Competing interests statement

Declarations of interest: none.

Declaration of generative AI in scientific writing

During the preparation of this work the authors used generative AI (IconCreator) in order to create the graphical presentation in Figure 1 (Research design). After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Submission declaration and verification

The article has not been previously published elsewhere and is not under consideration for publication elsewhere. The publication is approved by all authors.

CRedit authorship contribution statement

JB: Conceptualisation, methodology, formal analysis, writing - original draft, review & editing

EA: Conceptualisation, methodology, writing - original draft, review & editing

MG: Conceptualisation, writing - original draft, review & editing

All authors approved the final version of the manuscript.

Acknowledgements

We thank the two anonymous reviewers and the editor for their valuable feedback on earlier versions of this manuscript. We are also grateful to Stephan Kroll for his valuable advice regarding the classification of STEM VET occupations, and to Isabelle Le Mouillour for her valuable support regarding the analysis of gender disparities in Europe.

Declarations of interest

none.