Research in Social Stratification and Mobility 82 (2022) 100735

Contents lists available at ScienceDirect

Research in Social Stratification and Mobility

journal homepage: www.elsevier.com/locate/rssm

Parental occupation and students' STEM achievements by gender and ethnic origin: Evidence from Germany

Tamara Gutfleisch [a,*], Irena Kogan [a,b]

[a] *Mannheim Centre for European Social Research (MZES), University of Mannheim, 68131 Mannheim, Germany*
[b] *School of Social Sciences, University of Mannheim, 68131 Mannheim, Germany*

ARTICLE INFO

Keywords:
STEM achievement
Parental occupation
Gender
Generation status
Ethnic origin
Germany

ABSTRACT

Research has documented a positive association between parents' background in science, technology, engineering, and mathematics (STEM) and children's achievement and participation in STEM. Yet it is unclear whether girls and boys with and without migration background benefit equally from having STEM-affiliated parents, and whether this relationship varies depending on the educational stage. Using nationally representative data from standardized assessment tests, we explore gender and ethnic differences in the association of parental STEM occupation and students' achievement in STEM at two educational stages (fourth and ninth grade) in Germany. Results show that parents' STEM occupation is associated only with girls' math competencies in fourth grade and boys' math and science competencies in ninth grade. After controlling for parental socioeconomic status, no significant variation in this relationship can be reported by migrant generation status and ethnic origin. Eastern European students (irrespective of parents' background) perform better in STEM fields than other immigrant groups at both educational stages.

1. Introduction

Due to the challenges of demographic change and globalization, the demand for a scientifically and technologically literate population willing to pursue careers in science, technology, engineering and mathematics (STEM) has increased in European as well as other developed economies (OECD, 2017a). Women in particular, but also ethnic minorities, seem to be an untapped resource given the gender and ethnic gaps in achievement and participation in STEM in many industrialized countries (Kao & Thompson, 2003; Yazilitas, Svensson, de Vries, & Saharso, 2013). In Germany, the proportion of qualified women and immigrants in STEM fields has increased in recent years, but these groups still represent a minority compared to native men in many STEM fields (Anger, Kohlisch, Koppel, & Plünnecke, 2021).

Family background such as parents' social class and educational level is considered one of the most influential factors in explaining gender and ethnic differences in STEM achievement and participation (Xie, Fang, & Shauman, 2015). In recent years, scholars have placed more emphasis on the role of horizontal differences (i.e., parents' educational and occupational field) in shaping children's STEM outcomes (e.g., Ertl & Hartmann, 2019; Holmes, Gore, Smith, & Lloyd, 2018; Moakler & Kim, 2014; Plasman, Gottfried, & Williams, 2021; Shoraka, Arnold, Kim, Salinitri, & Kromrey, 2015; Tilbrook & Shifrer, 2022). Focusing primarily on the U.S. context, this research has linked parental occupation in STEM fields to choosing and persisting in STEM in higher education (Anaya, Stafford, & Zamarro, 2022; Chise, Fort, & Monfardini, 2021; Leslie, McClure, & Oaxaca, 1998; Oguzoglu & Ozbeklik, 2016), STEM-related occupational aspirations and choices (Cheng, Kopotic, & Zamarro, 2019; Holmes et al., 2018; Sikora & Pokropek, 2012b), and achievement in STEM (Bowden, Bartkowski, Xu, & Lewis, 2017; Mues, Birtwistle, Wirth, & Niklas, 2021). The key theoretical argument promoted in this research is that parents transmit occupation-specific capital (e.g., knowledge, social networks, and values) to their offspring, which translates into the latter's educational advantages and career choices comparable to those of their parents (Jonsson, Grusky, Di Carlo, Pollak, & Brinton, 2009).

However, while some studies have examined gender differences in the intergenerational transmission of STEM-related capital regarding aspirations and choices (e.g., Anaya et al., 2022; Oguzoglu & Ozbeklik, 2016; Sikora & Pokropek, 2012b) as well as achievement (Bowden et al., 2017), it remains unclear whether having parents with occupational STEM backgrounds is equally relevant for the STEM outcomes of boys and girls

* Corresponding author.
E-mail address: tamara.gutfleisch@uni-mannheim.de (T. Gutfleisch).

https://doi.org/10.1016/j.rssm.2022.100735
Received 25 May 2022; Received in revised form 13 October 2022; Accepted 13 October 2022
Available online 17 October 2022

Table 1
Overview of the operationalization of control variables.

	IQB NAS (2011 and 2016)	German PISA study (2003, 2006, 2009, 2012, 2015, and 2018)
Age	continuous, mean centered	
Use of the German language at home	Three categories: 1. Always (reference category) 2. Sometimes German, sometimes other language 3. Never	German spoken at home (yes versus no)
Type of school	General school (including “Waldorfschule”) versus special needs school	“Gymnasium” (i.e., highest school track leading to university entry qualification) versus other schools
Special educational needs	Yes versus no	*Not available*
Highest parental education in the family	Three different categories of the International Standard Classification of Education (ISCED): 1. Max ISCED 1–2 (reference category) 2. ISCED 3–4 3. ISCED 5–6	
Highest occupational status in the family	ISEI score	
Study year	2016 versus 2011	2003 versus 2006–2018

with and without migration background and minorities of different ethnic origins (but see, e.g., Chachashvili-Bolotin, Lissitsa, & Milner-Bolotin, 2019; Leslie et al., 1998; Lissitsa & Chachashvili-Bolotin, 2019). Furthermore, prior research about the intergenerational transmission of STEM outcomes has focused mostly on adolescents. This may be due to the fact that most studies focused on aspirations and choices, which become more relevant during adolescence. As a result, we know very little about the influence of parents’ occupational field on students’ STEM outcomes (e.g., interest and achievement) in early education (an exception being, e.g., Mues et al., 2021).

Against this background, we explore gender and ethnic differences in the association of parental STEM occupation and students’ achievement in STEM at two educational stages–the end of primary (fourth grade) and the end of lower secondary school (ninth grade)–in Germany. Considering both vertical and horizontal dimensions of the intergenerational transmission of STEM achievement is important to better understand the role of family background for educational inequality in STEM fields. This is particularly the case in a country like Germany, with a vocational and educational training system characterized by strong school-to-work linkages (Knoll, Riedel, & Schlenker, 2017). Moreover, given that disparities in achievements at the start of the educational career often persist or widen over time (e.g., Leahey & Guo, 2001; Wei, Liu, & Barnard-Brak, 2015), it is crucial to obtain a more comprehensive account of intersectional patterns in the intergenerational transmission of STEM-related capital over the life course.

Our analytical focus is on achievement in STEM for two reasons. First, research has documented gender and ethnic gaps in STEM subjects in Germany, whereas immigrant girls perform worst in standardized tests (e.g., Becker & Schmidt, 2013; Gottburgsen & Gross, 2012). Yet, achievement (measured by grades or standardized tests) is considered an essential component for students’ pursuit of STEM careers and is positively associated with other outcomes such as interest in STEM (e.g., Holmes et al., 2018; Hübner et al., 2017; Simpkins, Davis-Kean, & Eccles, 2006). Second, in societies where technology and science are becoming increasingly important not only economically but also politically (e.g., as a salient topic in the media), gaining competencies in STEM is crucial for the social and cultural participation of children and adolescents.

Our contribution addresses the following questions: (1) Is parental STEM occupation associated with higher achievement in STEM among both boys and girls? (2) Does this relationship vary by migration background and ethnic origin? In other words, can girls and immigrants with parental background in STEM narrow or even close the achievement gap in STEM fields? (3) Are similar patterns of association observed at different stages of the educational system? To answer our research questions, we rely on nationally representative data of large-scale assessment studies on the results of standardized tests in STEM subjects. Such tests provide a more objective measure for students’ STEM

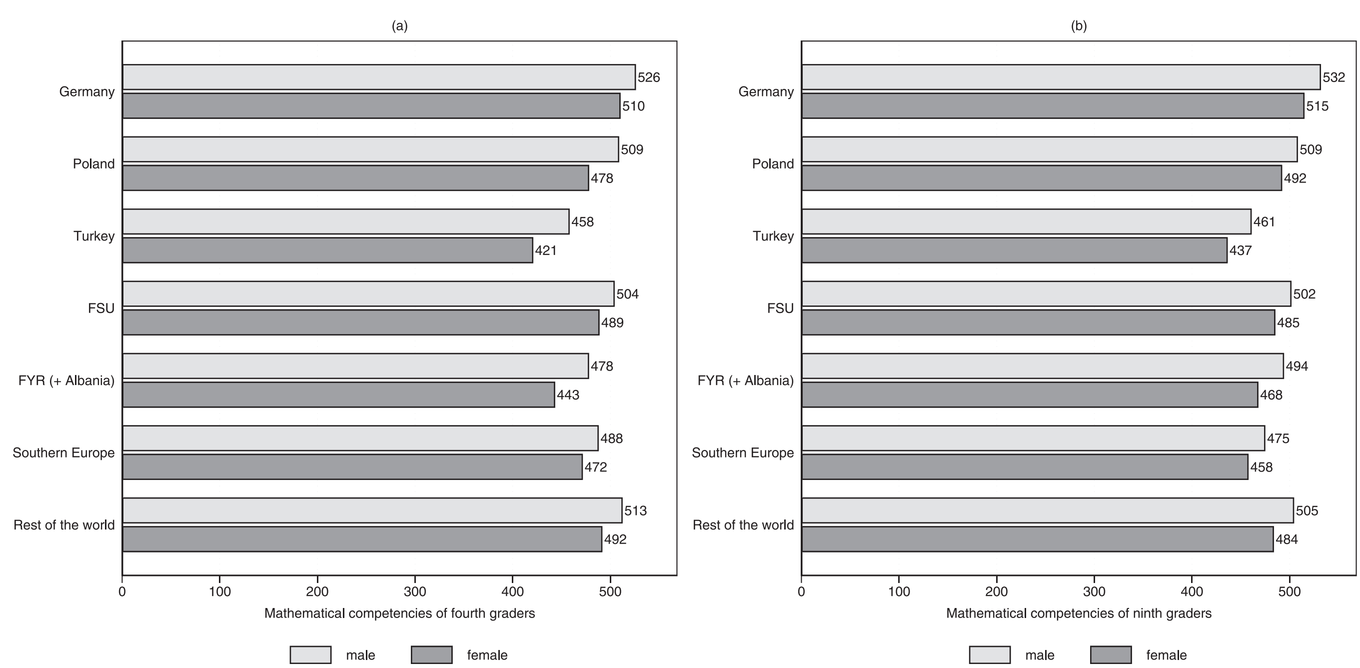

Fig. 1. ab. Unadjusted test scores of mathematical competencies of fourth and ninth graders. (a) IQB NAS waves 2011, 2016, N = 16,737 boys, N = 16,601 girls; (b) PISA (German extension) 2003–2018, N = 13,762 boys, N = 15,019 girls; FSU=Former Soviet Union, FYR=Former Yugoslav Republic.

Table 2
Results of linear regression analysis predicting student's test scores of mathematical competencies; full sample.

	Model without interaction effects				Model with interaction effects			
	Fourth Grade[a]		Ninth Grade[b]		Fourth Grade[a]		Ninth Grade[b]	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
At least one parent with STEM background (ref.: both parents non-STEM)	0.84	4.37*	3.65 *	2.19	0.51	4.60*	3.56*	2.32
Migration background (ref.: no migration background)								
One foreign-born parent	−15.26***	−19.77***	−9.81***	−14.08***	−14.73**	−18.93***	−9.86*	−10.65**
Second generation	−8.50	−13.59***	−9.55**	−23.01***	−10.62	−14.89**	−9.65	−23.91***
First generation	−19.65 *	−8.88	−21.39***	−21.04***	−18.71	0.18	−22.80***	−24.08***
Interaction effect								
Parent(s) in STEM × One foreign-born parent					−1.19	−1.76	−0.30	−7.02
Parent(s) in STEM × Second generation					4.41	2.57	0.09	1.62
Parent(s) in STEM × First generation					−2.47	−20.49	2.61	5.91
Control variables	YES				YES			
Constant	461.66***	438.11***	431.79***	421.53***	461.85***	437.95***	432.13***	421.49***
R2	0.27	0.21	0.39	0.40	0.27	0.21	0.39	0.40

Notes: Results of linear regression analysis, data are weighted. Full models are shown in Tables A1 and A3 in Appendix A. Italics used for headings of categorical variables.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
[a] IQB NAS waves 2011, 2016, N = 16,737 boys, N = 16,601 girls.
[b] PISA (German extension) 2003—2018, N = 13,762 boys, N = 15,019 girls.

competencies than grades, which depend more strongly on student behavior and teachers' subjective assessments. Furthermore, competency measures are of value to the study of inequality because they can indirectly influence teachers' grading (e.g., Gentrup, Lorenz, Kristen, & Kogan, 2020) as well as students' and their families' decisions regarding later educational choices (e.g., in-depth courses) and career plans (e.g., Sikora & Pokropek, 2012a). At the primary school level, we used pooled data from the 2011 and 2016 National Assessment Study (NAS) on the mathematics competencies of fourth-grade students. At the secondary school level, we used pooled data from six waves (2003, 2006, 2009, 2012, 2015, 2018) of the German extension study of the Programme of International Student Assessment (PISA) on ninth graders' competencies in mathematics and science.

We proceed as follows. In Section 2, we discuss our theoretical background. Our data and method are described in Section 3, before presenting our results in Section 4. Section 5 includes a discussion of the results and our key conclusions.

2. Theoretical and empirical background

2.1. Parental transmission of STEM competencies

A theoretical link between parents' occupational background in STEM and their children's achievement in STEM is provided by the micro class mobility model (MMM). Building on Bourdieu's (1984) concept of "occupational habitus", the micro class mobility approach postulates that parents transmit occupation-specific social, cultural, and human capital to their children, which makes it more likely that they invest in similar careers (e.g., Jonsson et al., 2009; Weeden & Grusky, 2004). Accordingly, children may "inherit" occupation-specific tastes and values (e.g., perceived relevance of certain occupational careers), social networks (e.g., information channels), and behaviors that impact their educational and occupational choices (e.g., aspiring for the same occupation as their parents).

Following the MMM logic, a successful intergenerational transmission of STEM-related capital is likely to lead to educational advantages in STEM. Parents with an occupational STEM background may directly shape children's investment in acquiring STEM competencies by sharing knowledge and interests, providing support and encouragement, and exposing their children to STEM outside of school (e.g., Chakraverty & Tai, 2013; Dabney, Chakraverty, & Tai, 2013; Sjaastad, 2012). Furthermore, parents with a STEM background may cultivate positive attitudes towards STEM more successfully than parents working in non-STEM occupations, with potentially positive effects on children's "STEM identity" and motivation to do well in STEM (Hazari, Sadler, & Sonnert, 2013; see also Plasman, Gottfried, Williams, Ippolito, & Owens, 2021). Parents may also indirectly shape their children's achievement in STEM by acting as role models in potential careers. It has been shown that adolescents often use their parents' occupations as orientation when forming occupational preferences and aspirations (e.g., Buchmann & Kriesi, 2012; Kaiser & Schels, 2016; Knoll et al., 2017; Law & Schober, 2021), which also likely affects children's investment in achieving these goals (i.e., acquiring competencies).

The MMM differs from traditional "big class" mobility models, which state that parental class background impacts children's career outcomes regardless of their parents' actual occupations (e.g., Breen & Goldthorpe, 1997; Erikson, Goldthorpe, & Hällsten, 2012; Erikson & Goldthorpe, 2002). Children from higher socio-economic backgrounds tend to have higher achievements in STEM fields and are more likely to choose STEM in higher education (e.g., Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016; OECD, 2014; Xie et al., 2015). Based on narrative interviews with Israeli parents from boys who entered STEM fields in higher education (Lissitsa & Chachashvili-Bolotin, 2021), a recent study found that most parents in the sample (with and without STEM background) put more emphasis on the educational attainment of their sons than them pursing the same occupation. Nevertheless, the

Table 3
Results of linear regression analysis predicting student's test scores of mathematical competencies; migrant subsample.

	Fourth Grade[a]		Ninth Grade[b]	
	Boys	Girls	Boys	Girls
At least one parent with STEM background (ref.: both parents non-STEM)	−5.97	5.44	−3.11	1.89
Country of origin (ref.: Turkey)				
Poland	28.80*	45.75***	23.24	25.08**
FSU	28.90**	56.38***	27.04**	39.71***
FYR (+ Albania)	14.37	24.08	10.85	34.71**
Southern Europe	23.03	18.40	4.85	11.08
Rest of the world	38.03***	50.22***	15.86	28.37***
Interaction effect				
Parent(s) in STEM × Poland	24.67	−3.02	11.66	16.32
Parent(s) in STEM × FSU	18.46	2.24	12.68	1.23
Parent(s) in STEM × FYR (+ Albania)	12.09	−5.88	20.24	−10.24
Parent(s) in STEM × Southern Europe	14.99	30.47	−3.11	1.54
Parent(s) in STEM × Rest of the world	3.39	−3.99	9.03	−1.28
Control variables (including generation status)	YES			
Constant	439.79***	390.15***	422.0***	394.49***
R2	0.20	0.22	0.38	0.42

Notes: Results of linear regression analysis, data are weighted. Full models are shown in Tables A2 and A4 in Appendix A. Italics used for headings of categorical variables. FSU=Former Soviet Union, FYR=Former Yugoslav Republic.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
[a] IQB NAS waves 2011, 2016, N = 3,435 boys, N = 3,446 girls.
[b] PISA (German extension) 200332018, N = 2,501 boys, N = 2,832 girls.

study also suggested that sons might still choose the same career path as their parents even when parents do not actively push their children towards pursuing similar paths (Lissitsa & Chachashvili-Bolotin, 2021). Overall, these studies emphasize the importance of taking socio-economic status differences into account when investigating the intergenerational transmission of STEM-related capital.

2.2. Variation by gender, migration background, and ethnic origin

Although the MMM does not necessarily predict gender differences, it has been suggested that the intergenerational transmission of occupation-specific capital varies along gender lines (Erikson et al., 2012). Gendered patterns in the intergenerational transmission of STEM outcomes can be explained by gender-specific socialization processes within the family and wider society (e.g., Eccles, Freedman-Doan, Frome, Jacobs, & Yoon, 2000; Ridgeway, 2011). Parents transmit gender stereotypes and norms about "appropriate" behavior and skills either directly, for example through discouraging their daughters to pursue STEM or undermining their ability in mathematics and science (e.g., Frome & Eccles, 1998; Jacobs & Bleeker, 2004; Muller, 1998), or indirectly through gender-typical occupations (e.g., Law & Schober, 2021; Polavieja & Platt, 2014; van der Vleuten, Jaspers et al., 2018).

Regarding STEM outcomes, it could be argued that girls might be more susceptible to their parents' influence than boys, because they have fewer role models in STEM careers outside of the family and thus less opportunities to acquire STEM-related cultural capital. Since STEM fields are stereotypically associated with male personality traits and behavior (Cheryan, Ziegler, Montoya, & Jiang, 2017), parents' occupation in STEM might therefore matter more for girls' STEM achievement. However, prior research focusing on the intergenerational transmission of STEM achievement and participation has produced mixed results as to whether boys or girls benefit more from having parents work in STEM and whether the mother's or father's occupation is more important (e.g., Anaya et al., 2022; Bowden et al., 2017; Cheng et al., 2019; Leslie et al., 1998; Oguzoglu & Ozbeklik, 2016; Sikora & Pokropek, 2012b), albeit this may partly be due to differences in outcomes, definitions of STEM fields, and study contexts. We cannot consider the mother's and father's occupation separately in this study, but we test whether having at least one parent with an occupational STEM background is associated equally with girls' and boys' competencies in STEM.

Furthermore, structural inequalities and cultural differences in gender ideology may restrict the intergenerational transmission of STEM-related capital to boys and girls in immigrant families. Language barriers, lack of access to host country-specific social networks, and lower human capital endowments pose obstacles to the successful social, cultural, and economic integration of immigrant families into the host country (Chiswick & Miller, 2007; Portes & Rumbaut, 2001). In particular, structural and cultural differences between sending and receiving countries limit the transferability of immigrants' country-specific resources to the host society, which is also the case for highly skilled immigrants (e.g., Chiswick, Cohen, & Zach, 1997; Friedberg, 2000; Kogan, Kalter, Liebau, & Cohen, 2011). STEM skills are more universal since they are, for example, less dependent on language skills and therefore more easily transferable across countries than other types of knowledge (Han, 2016). This might make it easier for immigrant parents with a STEM background to transmit STEM-specific knowledge and skills to their children compared to other immigrant families. On the other hand, it is unlikely that immigrant families with a STEM background dispose of the same resources as comparable native families in order to transmit STEM-specific capital to their children (e.g., due to a lack of knowledge about the school system).

However, this assumption might not hold equally for all immigrant groups. Although both first- and second-generation migrants tend to lag behind natives regarding educational and labor market outcomes, penalties tend to be greater for first-generation immigrants (Heath, Rothon, & Kilpi, 2008). Second-generation parents have generally been living in the host country for a longer period and are therefore more likely to have acquired host country-specific knowledge than first-generation parents. In such families, as well as families where only one parent is born abroad, second-generation students likely dispose of similar resources as native children due to their socialization in the host country. This demonstrates that while first-generation families may have a lower transmission of STEM-related capital compared to native families, this is not necessarily the case for the second generation.

Moreover, the broader literature on social mobility suggests gender differences in the intergenerational transmission of parents' labor market position between natives and immigrants (e.g., Abada & Tenkorang, 2009; Aydemir, Chen, & Corak, 2013; Bauer & Riphahn, 2006; Schneebaum, Rumplmaier, & Altzinger, 2016). Conditional on status differences, such patterns might also be observed regarding the intergenerational transmission of both STEM participation and achievement.

Whereas past decades have seen a shift towards more gender egalitarian attitudes in Germany and other Western industrialized countries (Inglehart, Norris, & Welzel, 2002), migrants and their descendants–particularly from non-Western countries–tend to hold more conservative views on gender roles than natives in Western countries (e.g., Diehl, Koenig, & Ruckdeschel, 2009; Idema & Phalet, 2007). These differences are also evident in the context of social origin (Lühe, Becker, & Maaz, 2018). This can largely be explained by an intergenerational transmission of gender ideology from migrant parents to their offspring (Kretschmer, 2018). At the same time, intra-family interdependence and parental authority has been suggested to be stronger in non-Western countries of origin compared to Western countries of destination (e.g., Inglehart & Norris, 2003; Phalet & Schönpflug, 2001). Although cultural differences may diminish over time due to assimilation processes (Röder & Mühlau, 2014), the integration of second-generation girls in particular is likely to be influenced by conflicts between the values of their country of origin and host country (see e.g., Bayrakdar & Guveli, 2021).

Hence, there might be different patterns of the association between parents' STEM occupation and students' STEM achievement between immigrant girls and boys and comparable natives. Independent from generation status, however, there might also be differences between migrants of different ethnic origins. Due to cultural differences in gender ideology, immigrant parents may hold different beliefs about the appropriateness of STEM for girls depending on the country of origin, which moderates the intergenerational transmission of STEM competencies. However, whereas migrants from more traditional backgrounds might invest less in the STEM-related educational outcomes of their daughters than their sons, parents may also adjust their expectations and support their daughters in their educational career (Qin, 2006).

As far as we can judge, ethnic differences in the intergenerational transmission of STEM-related capital to boys and girls have rarely been addressed empirically. Moreover, the existing evidence focuses on STEM aspirations and participation rather than achievement. A Swedish study investigated the transmission of self-employment among native and immigrant men and women using register data (Andersson & Hammarstedt, 2011). The authors found that second-generation men and natives tend to become self-employed in the same business sector as their fathers, whereas female immigrants and natives are less likely to be self-employed in the same sector as their parents and view both their parents as role models. Van der Vleuten et al. (2018) found for the Netherlands that non-Western immigrants were more likely to pursue gender-atypical career choices than natives, particularly if the mother had a gender-atypical occupation. The authors hypothesized that non-traditional behavior of parents may induce non-traditional behavior in children (van der Vleuten, Jaspers et al., 2018, p. 310). Lissitsa and Chachashvili-Bolotin (2019) as well as Chachashvili-Bolotin et al. (2019) found that second-generation immigrants in Israel with parents originating from the former Soviet Union (FSU) do better in STEM subjects and are more likely to choose STEM courses than other immigrants. The authors linked these results to the higher share of parents in STEM occupations in this group but did not account for parental occupation in their analyses. More closely related to our study, Leslie et al. (1998) found that in the U.S., parental STEM occupation was more relevant for boys'–particularly for Hispanic boys'–choices to study science and engineering than females'. Regarding the field of biology, Afro-American men and women exhibited the largest positive effects of having parents working in a STEM-related field. However, migration history as well as the composition of migrants in Germany and other European countries deviates from the U.S.

Against this background, the following analyses will address several open questions regarding gender and ethnic differences in the intergenerational transmission of parents' STEM-related capital. Is the effect of parental STEM occupation weaker in immigrant families than in native families? Are these patterns different for boys and girls? What is the role of ethnic origin in the intergenerational transmission of STEM-related capital regarding boys' and girls' STEM achievement? Although the patterns of associations to be explored in the empirical analyses are primarily of descriptive nature, addressing them is crucial for a better understanding of social inequalities in achievement and participation in STEM.

2.3. *Applying a life course perspective*

So far, most of the research on the intergenerational transmission of occupation-specific capital focused on adolescents or young adults. Prior research suggests that the influence of parental characteristics such as their education level on children's educational and occupational outcomes may differ across the life course (e.g., Breen & Jonsson, 2005; Erola, Jalonen, & Lehti, 2016). While parents play a crucial role in the educational career of children (Grolnick, Friendly, & Bellas, 2009), parental influences are reduced later on. Instead, friends likely become more relevant than parents during adolescence as children spend more time outside of the family (Ganotice & King, 2014). Indeed, some studies suggest that gender norms of friends or classmates can have a large influence on adolescents' STEM outcomes, particularly for girls (e.g., Salikutluk & Heyne, 2017; van der Vleuten & Steinmetz, 2018). However, at different stages within the education system, the role of family versus peer group might vary depending on minorities' country of origin due to cultural differences in family dynamics (e.g., Giordano, Cernkovich, & Demaris, 1993; Steinberg, Dornbusch, & Brown, 1992; see also Section 2.2). Without disregarding prior research, which focused primarily on STEM-related occupational aspirations and choices (e.g., Anaya et al., 2022; Sikora & Pokropek, 2012b), we know little about the strength of the association between parents' occupational field and students' STEM achievements at different stages of the education system and whether such an association varies depending on students' gender, migration background, and ethnic origin. Thus, another objective of the current study is to establish whether the patterns of association between parental STEM affiliation and children's STEM achievement also differ across educational stages.

3. Method

3.1. *Data and measurements*

We draw from two sources of data on students' STEM competencies at the primary and secondary school level. The data were made available by the Research Data Centre at the Institute for Educational Quality Improvement (FDZ at IQB). At the primary school level, we used data from the NAS, a repeated cross-sectional study conducted by the IQB that aims to assess to what extent students' competencies correspond to national educational standards (Stanat et al., 2014, 2019). A nationally representative sample of fourth grade students completed standardized achievement tests in mathematics and German (reading and listening) in 2011 and 2016 (Stanat, Pant, Böhme, & Richter, 2012; Stanat, Schipolowski, Rjosk, Weirich, & Haag, 2017). Each survey year, a random sample of schools was drawn, and one fourth grade class in each school was randomly selected for testing. In special needs schools, all fourth grade students were tested and treated as one large class. Information on students' familial background and socio-demographic characteristics was also collected through surveys of participating students and their parents (Richter, Böhme, Bastian-Wurzel, Pant, & Stanat, 2014; Schipolowski et al., 2019). Our analytic sample of the pooled data from both time points comprises data from N = 33,338 students, of which N =

6881 have a migrant background.

At the secondary level, we rely on the scientific use files from the German extension study of PISA (Klieme et al., 2013; Prenzel et al., 2007, 2010, 2015; Reiss et al., 2019, 2021). PISA is a repeated cross-sectional study that assesses the reading, mathematics, and science competencies of fifteen-year-old students across a large number of countries in a three-year cycle since 2000 (e.g., OECD, 2019). In contrast to IQB NAS, PISA defines competencies independent of school curricula and examines students' basic skills in each domain to be able to participate fully in society (OECD, 2019). In national extensions, the German PISA study additionally sampled one to two complete ninth grades of each selected school in each cycle from 2003 to 2018 (e.g., Sälzer & Reiss, 2016). The data also provide information on the socio-demographic and socio-economic characteristics of students and their parents. We pooled over all German PISA extension studies from 2003 to 2018 (six waves) to achieve a higher sample size of students with a migration background. Our sample includes N = 28,781 ninth grade students, of which N = 5333 have a migration background.

3.1.1. Dependent variables

Our dependent variables are students' results from standardized tests in STEM subjects. At the primary level, we focus solely on achievements in mathematics. Science subjects are not taught until secondary school in Germany. Since IQB NAS' definition of competency follows national educational standards, competency tests in science are not available in the data. In IQB NAS, all students were tested in five mathematical areas (numbers and operations, space and shape, patterns and structures, sizes and measurements, and data, frequency, and probability). Each student was assigned a booklet which only contained a subset of test items from the complete item pool. The booklets were constructed in a way that the test results can be transformed into a common scale using a generalized Rasch model (for technical details, see e.g., Weirich, Haag, & Sachse, 2017). Instead of presenting students' test results as point estimates, a probability distribution of likely competencies in the respective domain was estimated for each student. Fifteen test scores were randomly drawn from this distribution, referred to as plausible values (PVs), and are provided in the data. The results for the five mathematical areas were summarized into a global scale for mathematical competency, which we used for our analysis. Test scores are scaled to have a mean of 500 in the reference population of fourth graders in Germany and a standard deviation of 100.

At the secondary school level, achievements in mathematics and science are examined. Performance in both areas is important in decisions about later educational track choices such as advanced courses, vocational training, and higher education. The number of test items administered in each competency domain differs across PISA cycles to include additional skills such as specific subtypes of the three main domains (reading, mathematics, and science). We focus on global test scores for mathematical and science achievements provided for each PISA study. The test design is similar to the one of IQB NAS, and test scores are scaled using a generalized Rasch model (e.g., Heine & Reiss, 2019; OECD, 2017b). For PISA 2003–2012, five PVs for students' competencies are provided in the scientific use files, whereas for PISA 2015 and 2018, 10 PVs are available. For the pooled data set, we only used the first five PVs from 2015 and 2018. The test scores are standardized to have a mean of 500 and a standard deviation of 100 in the reference population of ninth graders in Germany. There is a high correlation between the test scores of mathematical and science competencies in our sample (r = 0.86).

3.1.2. Independent variables

Our main independent variables are students' gender, migration background, and ethnic origin as well as parental STEM occupation. Migration background was defined based on the parents' and students' country of birth. Students with parents born in Germany are considered natives (i.e., having no migration background), independent of where the child was born.[1] We further differentiated between three immigrant groups: one parent born abroad (independent of where the child was born), second generation (both parents born abroad, child in Germany), and first generation (both parents and child born abroad). Based on the children's migration background and parents' country of birth, we assigned each student a country of origin. Native students were assigned to Germany. Students with one foreign-born parent were assigned this particular parent's country of birth. Students from the second generation were assigned their parents' country of birth if both parents were born in the same country. If the parents were born in different countries, the mother's country of birth was selected. The robustness of the results has been checked in sensitivity analyses by assigning the father's country of birth to the offspring's country of origin (see Tables B.3–B.5 in Appendix B). The first generation was assigned the respective student's country of birth. We differentiated between the following aggregated origin groups which were identifiable in all data sets: Germany, Poland, Turkey, FSU, Former Jugoslav Republic (FYR), Southern Europe, and the rest of the world. Gender is measured with a dummy variable (1 = female).

To test the influence of parental occupation on students' scholastic achievements in STEM subjects, we generated a dummy variable indicating whether at least one parent has an occupational background in STEM. Information on parents' occupation was collected through open-ended answers about the parents' past or current occupations in the respective student and parent questionnaires of both IQB NAS and PISA. Whereas in IQB NAS and recent PISA studies occupations were classified in up to 4-digit codes of the International Standard Classification of Occupations 2008 (ISCO-08), the PISA studies 2003–2009 used codes of the ISCO-88 classification. We converted the latter to ISCO-08 codes before classifying parents' professions as STEM or non-STEM. This was done using Stata's ISCOGEN package (Jann, 2019). There is no clear definition of STEM professions and what is considered STEM varies between studies (Sikora & Pokropek, 2012b). We used the definition of STEM professions from Germany's Federal Employment Agency as orientation for our own classification and included both high-skill and middle-skill STEM jobs in mathematics, natural sciences, engineering, and medicine (Statistik der Bundesagentur für Arbeit, 2019). A detailed list of which professions are categorized as STEM can be found in Appendix B.

3.1.3. Control variables

Table 1 shows our control variables and how they were operationalized in both data sets. At both educational stages, we control for student's age, use of the German language at home, school type, parental education and occupational status, and study year. At the primary school level, we also control for whether students have special educational needs. Special needs schools were not sampled in the German PISA study and information on whether students have special educational needs is not provided for all PISA waves. Family occupational status is measured by the highest International Socio-economic Index of Occupational Status (ISEI; Ganzeboom, De Graaf, & Treiman, 1992) in the family. For PISA 2003–2009, the ISEI score was computed in Stata using ISCOGEN after parents' occupational information was converted from ISCO-88 to ISCO-08 to make the measure of ISEI comparable across PISA studies.

3.2. Analytical strategy

We estimated linear regression models at each educational stage separately for girls and boys. A first set of models was estimated in the full sample consisting of native and immigrant children to test the association between having at least one parent with an occupational STEM

[1] The IQB NAS also recognizes the third generation (both parents and child born in Germany, at least one grandparent born abroad). We categorized these students as having no migration background.

background and whether this relationship varies by generation status of immigrant children. We first tested the main effects of our variables of interest on students' competencies and then included interaction effects between parental STEM occupation and generation status. All models included the control variables as described above (see also Table 1). A second set of models was estimated only for immigrants and immigrant descendants to test variation in the relationship between having at least one parent work in STEM and ethnic origin, while controlling for generation status in addition to the other control variables.

Sampling and replication weights that account for the complex survey design of PISA and IQB NAS were provided in the data sets and applied in all models. As recommended, we relied on existing tools in Stata and R that allowed us to obtain the correct estimates and standard errors when dealing with plausible values, which can be considered a special form of multiple imputations (OECD, 2009). Regarding IQB NAS, we used the R package *eatRep* (Weirich & Becker, 2020). For the analyses of the PISA data, we used *repest* in Stata (Avvisati & Keslair, 2020). Since the results for mathematics and science achievement in ninth grade were rather similar, we do not discuss the results regarding science test scores in detail and instead present them in Tables B.1 and B.2 in Appendix B (online supplement). The scripts used for our analyses are available as supplementary material.

4. Results

Fig. 1 presents the unadjusted test scores for mathematical competencies of fourth (Fig. 1a) and ninth (Fig. 1b) graders by gender and ethnic origin. It is noteworthy that the results in the standardized mathematics tests at both stages of the education system are rather comparable. The largest differences between educational levels are observed among FYR students, who tend to perform better in ninth grade, and students from Southern European countries, who achieved better test scores in fourth grade. At both educational stages, immigrant girls and boys achieve lower test scores than native girls and boys. The largest differences are observed for Turkish-origin students. Moreover, girls underperform compared to boys in all ethnic groups considered. These gaps seem slightly smaller in ninth than fourth grade, particularly for Turkish-origin and FYR students. The unadjusted test scores for science competencies of ninth graders are reported in Fig. B1 in Appendix B, showing a pattern similar to the results regarding mathematical competencies.

Results for the first set of multivariate regression models carried out for the full sample of both natives and immigrants can be found in Table 2. The table presents the main effects of parental STEM occupation and migrant generation status on boys' and girls' mathematical competencies in fourth and ninth grade, as well as coefficients of the interactions between generation status and parents' occupational STEM background. Full models (including standard errors) are shown in Tables A1 and A3 in Appendix A separately for fourth and ninth graders.

Starting with the models without interaction effects, we observe a relatively small but positive effect of having at least one parent with occupational STEM background on mathematical competencies for girls in the fourth grade ($p < 0.05$; Table 2). For boys, the effect is close to zero and not statistically significant. In contrast, in the ninth grade, we find only a positive effect of parental STEM background on boys' math competencies ($p < 0.05$), but not on girls'. A comparison of the intercepts suggests that native girls underperform in math compared to native boys at both educational stages, which holds true even for girls with parental STEM background. An interesting finding is that the gender performance gap among the majority students in mathematics seems to be smaller in the ninth than fourth grade. Furthermore, all immigrant groups achieve on average lower test scores in mathematics than native boys and girls. The results are not significant for second-generation boys and first-generation girls in fourth grade. Overall, the disadvantages of first- and second-generation immigrants seem to be somewhat stronger in the ninth than fourth grade.

Turning to the last four columns of Table 2, all interaction effects are negative except for the second generation in grade four and nine and the first generation in grade nine. However, at both educational stages, the coefficients are rather small and not statistically significant for all immigrant groups. Thus, the results suggest no variation in the association of parents' occupational STEM background and students' mathematical competencies by generation status of immigrants. Overall, our models explain 27 % and respectively 21 % of the variance in boys' and girls' mathematical competencies in fourth grade. In ninth grade, our models explain about 40 % of the variance in student's mathematical competencies.

Lastly, Table 3 provides the results for the second set of models conducted in the migrant subsample (see Tables A2 and A4 for the full models). These models include interaction effects between parental STEM background and ethnic origin while controlling for generation status and all other student characteristics. Turkish students served as the reference category to estimate ethnic differences in students' STEM competencies. The main effects refer to ethnic differences in math achievement for students without parents in STEM occupations. Among both fourth and ninth grade students, Polish and FSU students perform significantly better on standardized mathematics tests than Turkish boys and girls. The difference is particularly large among female fourth graders, where it comprises over half of a standard deviation. No significant differences are observed between Turkish students and students from FYR and Southern Europe, except for FYR girls in ninth grade.

Results in Table 3 further indicate that parental STEM affiliation among students with Turkish background is not significantly associated with students' performance in mathematics, which was not the case among the native-born Germans (compare Table 2). From the interaction effects, we learn that having at least one parent with occupational STEM background seems to be more beneficial for all other immigrant boys than for Turkish boys at both educational stages. Despite the pronounced differences, none of the interaction effects are statistically significant. Among girls, the interaction effects are relatively small and also not statistically significant. The models explain about 20 % and 40 % of the variance in students' mathematical competencies in fourth and ninth grade, respectively. Our results do not substantially change when–in cases where the parents were born in different countries–we assign the father's, rather than the mother's, country of birth to students' origin country (see Tables B.3–B.5 in Appendix B).

Among ninth grade students, we also explored gender and ethnic gaps in science competencies. The results can be found in Tables B.1 and B.2 in Appendix B (online supplement). The overall results are similar to those regarding mathematics tests in ninth grade. Girls underperform compared to boys, although the gender gap is slightly smaller compared to math competencies. All immigrant groups perform worse in standardized science tests than native girls and boys. The differences seem to be somewhat larger than the gaps between natives and immigrants regarding math competencies. Parents' occupational STEM background is positively associated only with boys' science competencies in ninth grade. As regarding mathematics tests, we find no significant variation in this association by migration background and ethnic origin.

5. Discussion and conclusion

In this study, we explored whether having at least one parent with an occupational background in STEM is associated with higher achievement in STEM subjects (mathematics and science) at the end of primary school (fourth grade) and at the end of lower secondary school (ninth grade) in Germany. Specifically, we focused on intersectional patterns in the transmission of STEM-related capital by gender, migration background, and ethnic origin. For our empirical analyses, we used nationally representative data from large-scale assessment studies on students' performance in standardized tests.

Our results confirm the established findings that girls underperform in mathematics tests compared to boys at both educational stages.

Having at least one parent with occupational STEM background is positively associated with achievement in mathematics only for girls in fourth grade and boys in ninth grade. Thus, at least at the primary school level, our results support the theoretical considerations that girls might be more dependent on parents' STEM capital than boys. Boys' STEM competencies might not vary by parental STEM capital at the early stage due to existing stereotypes about boys' overall better performance in mathematics (irrespective of parental STEM affiliation). One possible explanation for the divergent findings at the secondary level might be related to the accentuated societal gender norms during adolescence — a time where occupational aspirations are formed (e.g., Law & Schober, 2021), which diminish the influence of parents' occupational background on STEM achievement for girls but strengthen it for boys. On the hand, this may be due to lower parental investment in daughters' STEM achievement during adolescence as a result of the underestimation of the relevance of STEM skills for girls' professional development (see also Bowden et al., 2017). On the other hand, it could be the case that, in contrast to boys, adolescent girls become more susceptive to peer influences (e.g., Salikutluk & Heyne, 2017). Unfortunately, separating these mechanisms was beyond the scope of this study.

All immigrant groups underperform in STEM fields irrespective of whether the parents have an occupational STEM background. In other words, we found no significant differences in the association between parents' STEM occupation and students' STEM achievement between natives and immigrants among both boys and girls at both educational stages. Hence, an explanation about the lower rate of transmission of parental STEM capital in (first-generation) immigrant families, discussed in the theoretical section of this study, could not been confirmed with our data. Apparently, STEM-affiliated immigrant parents are similarly effective in transferring their skills to their children's achievements in mathematics (and science) once structural inequalities between native and immigrant families are taken into account. This might be explained by the universal nature of STEM skills and the fact that the transmission of STEM skills is less dependent on proficiency in German language. However, this is not enough to close the achievement gap to native students in STEM subjects.

Against our theoretical expectations, we did not find statistically significant ethnic differences in the association between parental STEM affiliation and girls' and boys' STEM competencies. Still, there might be some variation in the success of such transmission across ethnic origins due to cultural differences in affinity towards STEM and gender ideology, even though sample sizes might have been too small to definitively establish the significance of such findings. Overall, the achievement gaps between natives and immigrants in mathematics seemed to be wider in ninth than fourth grade. Students from Eastern Europe (FSU and Poland) performed significantly better than Turkish immigrants at both educational stages. Compared to Turkish-origin students, no statistically significant differences in STEM achievement were found for FYR and Southern European students. Among ninth graders, the results regarding science competencies followed a similar pattern.

Our study has some limitations. First, it should be noted that our analyses do not allow for causal conclusions as they are based on cross-sectional data. Second, we were not able to compare the science competencies across the two educational stages. This is due to the fact that, in contrast to math, science subjects are not taught until secondary school in Germany and therefore competency tests in science were not available at the primary school level in IQB NAS. Nonetheless, we add to literature by showing that, at least for ninth graders, there are similar patterns in the intergenerational transmission of STEM-related capital in mathematics and science. Third, the comparability of our results across educational stages may be limited due to conceptual differences in the definition of math (and science) competencies between IQB NAS and PISA (see Section 3.1). Nevertheless, there is considerable overlap in the math and science tests between the two studies and the test scores are highly correlated with each other — about 0.80 and 0.90 for science and mathematics, respectively (van den Ham, Ehmke, Hahn, Wagner, & Schöps, 2016).

Given the increasing demand for a STEM workforce in Germany and other industrialized countries, focusing on the role of parental STEM background for children's STEM outcomes is important to better understand the reasons for the underrepresentation of women and ethnic minorities in STEM. By providing a first account of intersectional patterns in the transmission of STEM-related capital regarding students' achievement in STEM in Germany, our study contributes to this emerging literature. To better grasp the role of parental occupation for students' achievement in STEM, future research could differentiate between further STEM subfields regarding parental occupation. Prior research suggests that the (gender-specific) intergenerational transmission of STEM outcomes might vary between subfields (Sikora & Pokropek, 2012b). For example, scholars could consider the mathematical intensity of parents' STEM occupation and/or differentiate between science subfields to test whether intersectional patterns emerge in some STEM fields. Another promising strategy could be to differentiate between the mother's and father's occupations, which has been considered regarding gender-atypical career choices of immigrants and natives, yet not with a focus on STEM (e.g., van der Vleuten, Jaspers et al., 2018). This was, however, difficult in the present study due to low numbers of observations for immigrant mothers with occupational STEM background. Finally, the present study could be complemented by tackling the mechanisms potentially explaining gender-ethnic differences in the intergenerational transmission of parental STEM capital.

Funding information

The study was supported by a research grant awarded by the Fritz Thyssen Foundation, Germany to Irena Kogan for the project "Upwardly Mobile Through STEM? STEM Competences, Participation and Returns Among Ethnic Minority Women and Men in Germany (STEMobile)" [Award number: 10.20.2.001SO].

Role of the funding source

The funding source had no involvement in the study design; the collection, analysis or interpretation of data; the writing of the manuscript; or the decision to publish the results.

Declaration of Competing Interest

None.

Acknowledgements

We are grateful to Johannes Donix for excellent research assistance and Grace Caroline Olzinski for proofreading. For helpful feedback, we also thank the participants of the RC 28 Spring meeting in London 2022 and the MZES Mittelbau Colloquium. Replication files for our analyses can be found at: https://osf.io/wd4sp/.

Appendix A

See Appendix Tables A1–A4 here.

Table A1
Predicting fourth graders' test scores of mathematical competencies; full sample (full model).

	Model without interaction effects				Model with interaction effects			
	Boys		Girls		Boys		Girls	
	b	se	b	se	b	se	b	se
At least one parent with STEM background (ref.: both parents non-STEM)	0.84	(2.35)	4.37*	(2.11)	0.51	(2.46)	4.60*	(2.30)
Migration background (ref.: no migration background)								
One foreign-born parent	−15.26***	(3.70)	−19.77***	(3.87)	−14.73**	(4.57)	−18.93***	(4.85)
Second generation	−8.50	(5.13)	−13.59***	(3.90)	−10.62	(6.83)	−14.89**	(5.50)
First generation	−19.65*	(8.94)	−8.88	(7.84)	−18.71	(10.78)	0.18	(11.03)
Interaction effect								
Parent(s) in STEM × One foreign-born parent					−1.19	(6.92)	−1.76	(6.88)
Parent(s) in STEM × Second generation					4.41	(7.65)	2.57	(7.01)
Parent(s) in STEM × First generation					−2.47	(16.00)	−20.49	(16.41)
Highest ISCED in family (ref.: max. ISCED 2)								
ISCED 3—4	16.66***	(3.21)	17.30***	(3.17)	16.56***	(3.25)	17.18***	(3.17)
ISCED 5—6	42.87***	(3.65)	36.01***	(3.85)	42.83***	(3.65)	35.84***	(3.82)
Highest ISEI in family	0.97***	(0.08)	1.08***	(0.08)	0.97***	(0.08)	1.08***	(0.08)
Age (mean centered)	−24.81***	(2.01)	−16.57***	(2.30)	−24.80***	(2.02)	−16.63***	(2.29)
German spoken at home (ref.: always)								
Sometimes German, sometimes other language	−14.66***	(3.53)	−17.13***	(3.15)	−14.62***	(3.54)	−17.04***	(3.17)
Never German	−12.58	(15.34)	−8.83	(15.43)	−12.24	(15.44)	−9.92	(15.19)
General school (ref.: special needs school)	−91.75***	(15.27)	−73.75***	(19.13)	−91.68***	(15.25)	−73.19***	(19.06)
Special educational needs (ref.: no)	−75.95***	(7.88)	−90.28***	(10.21)	−75.93***	(7.87)	−90.52***	(10.11)
Study year 2016 (ref.: 2011)	−21.45***	(2.60)	−21.28***	(2.82)	−21.44***	(2.59)	−21.28***	(2.81)
Constant	461.66***	(4.53)	438.11***	(4.65)	461.85***	(4.67)	437.95***	(4.71)
R2	0.27		0.21		0.27		0.21	

IQB NAS waves 2011, 2016, N = 16,737 boys, N = 16,601 girls.
Notes: Results of linear regression analysis, data are weighted. Italics used for headings of categorical variables.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Table A2
Predicting fourth graders' test scores of mathematical competencies; migrant subsample (full model).

	Boys		Girls	
	b	se	b	se
At least one parent with STEM background (ref.: both parents non-STEM)	−5.97	(11.06)	5.44	(11.74)
Origin group (ref.: Turkish)				
Poland	28.80*	(12.57)	45.75***	(12.23)
FSU	28.90**	(8.93)	56.38***	(8.76)
FYR (+ Albania)	14.37	(11.72)	24.08	(12.61)
Southern European	23.03	(14.63)	18.40	(13.19)
Rest of the world	38.03***	(9.02)	50.22***	(8.08)
Interaction effect				
Parent(s) in STEM × Poland	24.67	(17.23)	−3.02	(18.43)
Parent(s) in STEM × FSU	18.46	(13.16)	2.24	(12.45)
Parent(s) in STEM × FYR (+ Albania)	12.09	(16.96)	−5.88	(23.42)
Parent(s) in STEM × Southern Europe	14.99	(19.80)	30.47	(19.58)
Parent(s) in STEM × Rest of the world	3.39	(13.83)	−3.99	(12.68)
Highest ISCED in family (ref.: max. ISCED 2)				
ISCED 3—4	12.83*	(5.98)	9.60	(6.46)
ISCED 5—6	36.88***	(7.62)	26.16**	(7.45)
Highest ISEI in family	0.54***	(0.15)	0.92***	(0.15)
Migration background (ref.: one foreign-born parent)				
Second generation	−0.37	(6.52)	−3.06	(4.97)
First generation	−16.65	(9.31)	−4.92	(8.58)
Age (mean centered)	−24.38***	(4.38)	−16.34**	(5.26)
German spoken at home (ref.: always)				
Sometimes German, sometimes other language	−3.34	(5.08)	−9.03	(4.77)
Never German	−2.96	(16.44)	0.58	(13.05)
General school (ref.: special needs school)	−55.90*	(25.06)	−99.57**	(33.07)
Special educational needs (ref.: no)	−73.10***	(12.82)	−56.10**	(18.21)
Study year 2016 (ref.: 2011)	−17.63**	(4.89)	−16.29**	(5.56)
Constant	439.79***	(9.4)	390.15***	(9.54)
R2	0.20		0.22	

IQB NAS waves 2011, 2016, N = 3,435 boys, N = 3,446 girls.
Notes: Results of linear regression analysis, data are weighted. Italics used for headings of categorical variables. FSU=Former Soviet Union, FYR=Former Yugoslav Republic.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Table A3
Predicting ninth graders' test scores of mathematical competencies; full sample (full model).

	Model without interaction effects				Model with interaction effects			
	Boys		Girls		Boys		Girls	
	b	se	b	se	b	se	b	se
At least one parent with STEM background (ref.: both parents non-STEM)	3.65*	(1.45)	2.19	(1.56)	3.56*	(1.71)	2.32	(1.75)
Migration background (ref.: no migration background)								
One foreign-born parent	−9.81***	(2.95)	−14.08***	(2.71)	−9.86*	(3.85)	−10.65**	(3.94)
Second generation	−9.55**	(3.67)	−23.01***	(3.67)	−9.65	(5.26)	−23.91***	(5.09)
First generation	−21.39***	(5.05)	−21.04***	(4.91)	−22.80***	(6.50)	−24.08***	(5.80)
Interaction effect								
Parent(s) in STEM ×One foreign-born parent					−0.30	(6.13)	−7.02	(5.52)
Parent(s) in STEM ×Second generation					0.09	(6.88)	1.62	(5.22)
Parent(s) in STEM ×First generation					2.61	(8.27)	5.91	(7.39)
Highest ISCED in family (ref.: max. ISCED 2)								
ISCED 3—4	15.66***	(2.31)	10.13***	(2.66)	15.64***	(2.30)	10.08***	(2.64)
ISCED 5—6	15.52***	(2.70)	12.31***	(2.81)	15.51***	(2.70)	12.28***	(2.78)
Highest ISEI in family	0.45***	(0.05)	0.47***	(0.05)	0.45***	(0.05)	0.48***	(0.05)
Age (mean centered)	−15.80***	(1.50)	−19.27***	(1.44)	−15.80***	(1.50)	−19.29***	(1.42)
German spoken at home (ref.: no)	22.49***	(3.71)	15.07***	(4.28)	22.39***	(3.77)	14.99***	(4.27)
"Gymnasium" (ref.: other school)	87.90***	(2.19)	79.56***	(1.98)	87.91***	(2.19)	79.54***	(1.97)
Study (ref.: 2003)								
2006	13.29**	(4.17)	11.34***	(3.04)	13.30**	(4.18)	11.39***	(3.05)
2009	13.59***	(3.63)	14.75***	(3.10)	13.60***	(3.63)	14.82***	(3.11)
2012	9.50**	(3.21)	8.91**	(2.78)	9.52**	(3.23)	8.97**	(2.78)
2015	−3.15	(5.62)	−0.20	(3.54)	−3.13	(5.62)	−0.15	(3.55)
2018	−6.61	(4.32)	1.85	(3.90)	−6.60	(4.32)	1.90	(3.90)
Constant	431.97***	(5.06)	421.53***	(5.41)	432.13***	(5.01)	421.49***	(5.46)
R2	0.39		0.40		0.39		0.40	

PISA (German extension) 2003—2018: N = 13,762 boys, N = 15,019 girls.
Notes: Results of linear regression analysis, data are weighted. Italics used for headings of categorical variables.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Table A4
Predicting ninth graders' test scores of mathematical competencies; migrant subsample (full model).

	Boys		Girls	
	b	se	b	se
At least one parent with STEM background (ref.: both parents non-STEM)	−3.11	(9.43)	1.89	(6.57)
Origin group (ref.: Turkish)				
Poland	23.24	(12.65)	25.08 **	(8.71)
FSU	27.04 **	(10.08)	39.71 ***	(6.70)
FYR (+ Albania)	10.85	(10.84)	34.71 **	(10.85)
Southern European	4.85	(9.43)	11.08	(10.48)
Rest of the world	15.86	(10.32)	28.37 ***	(6.25)
Interaction effect				
Parent(s) in STEM ×Poland	11.66	(15.25)	16.32	(11.39)
Parent(s) in STEM ×FSU	12.68	(12.60)	1.23	(8.42)
Parent(s) in STEM × FYR (+ Albania)	20.34	(14.62)	−10.24	(12.79)
Parent(s) in STEM ×Southern Europe	−3.11	(14.50)	1.54	(13.58)
Parent(s) in STEM ×Rest of the world	9.03	(11.94)	−1.28	(8.21)
Highest ISCED in family (ref.: max. ISCED 2)				
ISCED 3—4	13.03 *	(5.43)	3.74	(4.32)
ISCED 5—6	8.15	(5.55)	0.56	(5.26)
Highest ISEI in family	0.17	(0.13)	0.29 **	(0.10)
Migration background (ref.: one foreign-born parent)				
Second generation	−7.68	(4.79)	−12.50 **	(4.22)
First generation	−25.50 ***	(6.05)	−17.86 *	(7.09)
Age (mean centered)	13.966 ***	(3.38)	−19.43 ***	(2.63)
German spoken at home (ref.: no)	16.35 ***	(3.93)	12.13 **	(4.40)
"Gymnasium" (ref.: other school)	93.61 ***	(4.66)	85.85 ***	(3.97)
Study (ref.: 2003)				
2006	20.60 **	(7.57)	17.83 **	(5.94)
2009	19.77 **	(6.27)	24.93 ***	(5.43)
2012	17.65 **	(6.22)	18.35 ***	(5.38)
2015	6.08	(8.45)	4.00	(6.95)
2018	2.34	(6.68)	2.62	(7.17)
Constant	422.01 ***	(10.27)	394.49 ***	(8.65)
R2	0.38		0.42	

PISA (German extension) 2003—2018, N = 2,501 boys, N = 2,832 girls.
Notes: Results of linear regression analysis, data are weighted. Italics used for headings of categorical variables. FSU=Former Soviet Union, FYR=Former Yugoslav Republic.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Appendix B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.rssm.2022.100735.

References

Abada, T., & Tenkorang, E. Y. (2009). Gender differences in educational attainment among the children of Canadian immigrants. *International Sociology, 24*(4), 580–608.

Anaya, L., Stafford, F., & Zamarro, G. (2022). Gender gaps in math performance, perceived mathematical ability and college STEM education: the role of parental occupation. *Education Economics, 30*(2), 113–128.

Andersson, L., & Hammarstedt, M. (2011). Transmission of self-employment across immigrant generations: The importance of ethnic background and gender. *Review of Economics of the Household, 9*(4), 555–577.

Anger, C., Kohlisch, E., Koppel, O., & Plünnecke, A. (2021). *MINT-Frühjahrsreport 2021. MINT-Engpässe und Corona-Pandemie: von den konjunkturellen zu den strukturellen Herausforderungen*. Institut der deutschen Wirtschaft.

Avvisati, F., & Keslair, F. (2020). REPEST: Stata module to run estimations with weighted replicate samples and plausible values. Statistical Software Components. Boston College Department of Economics.

Aydemir, A., Chen, W. H., & Corak, M. (2013). Intergenerational education mobility among the children of Canadian immigrants. *Canadian Public Policy, 39*(Supplement 1), 108–122.

Bauer, P., & Riphahn, R. T. (2006). Education and its intergenerational transmission: country of origin-specific evidence for natives and immigrants from Switzerland. *Portuguese Economic Journal, 5*(2), 89–110.

Bayrakdar, S., & Guveli, A. (2021). Understanding the benefits of migration: multigenerational transmission, gender and educational outcomes of Turks in Europe. *Journal of Ethnic and Migration Studies, 47*(13), 3037–3058.

Becker, B., & Schmidt, F. (2013). Ungleiche Startvoraussetzungen zu Beginn der Schullaufbahn? Unterschiede in den mathematischen und sprachlichen Fähigkeiten von sechsjährigen Kindern nach Geschlecht und Migrationshintergrund. In A. Hadjar, & S. Hupka-Brunner (Eds.), *Geschlecht, Migrationshintergrund und Bildungserfolg* (pp. 52–76). Beltz Juventa.

Bourdieu, P. (1984). *Distinction: a social critique of the judgment of taste*. Routledge.

Bowden, M., Bartkowski, J. P., Xu, X., & Lewis, R. (2017). Parental occupation and the gender math gap: examining the social reproduction of academic advantage among elementary and middle school students. Article 6 *Social Sciences, 7*(1). https://doi.org/10.3390/socsci7010006.

Breen, R., & Goldthorpe, J. H. (1997). Explaining educational differentials. Towards a formal rational action theory. *Rationality and Society, 9*(3), 275–305.

Breen, R., & Jonsson, J. O. (2005). Inequality of opportunity in comparative perspective: recent research on educational attainment and social mobility. *Annual Review of Sociology, 31*, 223–243.

Buchmann, M., & Kriesi, I. (2012). Geschlechtstypische Berufswahl: Begabungszuschreibungen. *Aspirationen Und Institutionen Kölner Zeitschrift Für Soziologie Und Sozialpsychologie, 52*, 256–280.

Chachashvili-Bolotin, S., Lissitsa, S., & Milner-Bolotin, M. (2019). STEM outcomes of second-generation immigrant students with high-skilled parental backgrounds. *International Journal of Science Education, 41*(17), 2465–2483.

Chachashvili-Bolotin, S., Milner-Bolotin, M., & Lissitsa, S. (2016). Examination of factors predicting secondary students' interest in tertiary STEM education. *International Journal of Science Education, 38*(3), 366–390.

Chakraverty, D., & Tai, R. H. (2013). Parental occupation inspiring science interest. *Bulletin of Science, Technology & Society, 33*(1–2), 44–52.

Cheng, A., Kopotic, K., & Zamarro, G. (2019). Parental occupational choice and children's entry into a STEM Field. *EDRE Working Paper*. https://doi.org/10.2139/ssrn.3457307

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin, 143*(1), 1–35.

Chise, D., Fort, M., & Monfardini, C. (2021). On the intergenerational transmission of STEM education among graduate students. *B E Journal of Economic Analysis and Policy, 21*(1), 115–145.

Chiswick, B. R., Cohen, Y., & Zach, T. (1997). The labor market status of immigrants: Effects of the unemployment rate at arrival and duration of residence. *Industrial and Labor Relations Review, 50*(2), 289–303.

Chiswick, B. R., & Miller, P. W. (2007). The economics of language. *International analyses*. Routledge,.

Dabney, K. P., Chakraverty, D., & Tai, R. H. (2013). The association of family influence and initial interest in science. *Science Education, 97*(3), 395–409.

Diehl, C., Koenig, M., & Ruckdeschel, K. (2009). Religiosity and gender equality: comparing natives and Muslim migrants in Germany. *Ethnic and Racial Studies, 32*(2), 278–301.

Eccles, J. S., Freedman-Doan, C., Frome, P. M., Jacobs, J., & Yoon, K. S. (2000). Gender-role socialization in the family: A longitudinal approach. *In The Developmental Social Psychology of Gender* (pp. 333–360). Laurence Erlbaum Associates.

Erikson, R., & Goldthorpe, J. H. (2002). Intergenerational inequality: a sociological perspective. *Journal of Economic Perspectives, 16*(3), 31–44.

Erikson, R., Goldthorpe, J. H., & Hällsten, M. (2012). No way back up from ratcheting down? A critique of the "microclass" approach to the analysis of social mobility. *Acta Sociologica, 55*(3), 211–229.

Erola, J., Jalonen, S., & Lehti, H. (2016). Parental education, class and income over early life course and children's achievement. *Research in Social Stratification and Mobility, 44*, 33–43.

Ertl, B., & Hartmann, F.G. (2019). Interest Congruency of Female STEM Students Regarding Their Vocational Aspirations and Their Parents' Occupations. *Paper Presented at the 2019 Annual Meeting on AERA, Toronto, CA.*

Friedberg, R. M. (2000). You can't take it with you? Immigrant assimilation and the portability of human capital. *Journal of Labor Economics, 18*(2), 221–251.

Frome, P. M., & Eccles, J. S. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology, 74*(2), 435–462.

Ganotice, F. A., & King, R. B. (2014). Social influences on students' academic engagement and science achievement. *Psychological Studies, 59*(1), 30–35.

Ganzeboom, H. B. G., De Graaf, P. M., & Treiman, D. J. (1992). A standard international socio-economic index of occupational status. *Social Science Research, 21*(1), 1–56.

Gentrup, S., Lorenz, G., Kristen, C., & Kogan, I. (2020). Self-fulfilling prophecies in the classroom: Teacher expectations, teacher feedback and student achievement. *Learning and Instruction, 66*, Article 101296. https://doi.org/10.1016/j.learninstruc.2019.101296

Giordano, P. C., Cernkovich, S. A., & Demaris, A. (1993). The family and peer relations of black adolescents. *Journal of Marriage and Family, 55*(2), 277–287.

Gottburgsen, A., & Gross, C. (2012). Welchen Beitrag leistet „Intersektionalität" zur Klärung von Kompetenzunterschieden bei Jugendlichen? In R. Becker, & H. Solga (Eds.), *Soziologische Bildungsforschung* (pp. 86–110). Springer VS.

Grolnick, W. S., Friendly, R. W., & Bellas, V. M. (2009). Parenting and children's motivation at school. In K. R. Wentzel, & A. Wigfield (Eds.), *Handdbook of motivation at school* (pp. 279–300). Routledge.

van den Ham, A.-K., Ehmke, T., Hahn, I., Wagner, H., & Schöps, K. (2016). Mathematische und naturwissenschaftliche Kompetenz in PISA, im IQB-Ländervergleich und in der National Educational Panel Study (NEPS) – Vergleich der Rahmenkonzepte und der dimensionalen Struktur der Testinstrumente. In Bundesministerium für Bildung und Forschung (Ed.), *Forschungsvorhaben in Ankopplung an Large-Scale-Assessments* (pp. 140–160). W. Bertelsmann Verlag.

Han, S. (2016). Staying in STEM or changing course: do natives and immigrants pursue the path of least resistance? *Social Science Research, 58*, 165–183.

Hazari, Z., Sadler, P. M., & Sonnert, G. (2013). The science identity of college students: exploring the intersection of gender, race, and ethnicity. *Journal of College Science Teaching, 42*(5), 82–91.

Heath, A. F., Rothon, C., & Kilpi, E. (2008). The second generation in Western Europe: education, unemployment, and occupational attainment. *Annual Review of Sociology, 34*(1), 211–235.

Heine, J.-H., & Reiss, K. (2019). PISA 2018 – die Methodologie. In K. Reiss, M. Weis, E. Klieme, & O. Köller (Eds.), *PISA 2018. Grundbildung im internationalen Vergleich*. Waxmann.

Holmes, K., Gore, J., Smith, M., & Lloyd, A. (2018). An integrated analysis of school students' aspirations for STEM careers: which student and school factors are most predictive? *International Journal of Science and Mathematics Education, 16*(4), 655–675.

Hübner, N., Wille, E., Cambria, J., Oschatz, K., Nagengast, B., & Trautwein, U. (2017). Maximizing gender equality by minimizing course choice options? Effects of obligatory coursework in math on gender differences in STEM. *Journal of Educational Psychology, 109*(7), 993–1009.

Idema, H., & Phalet, K. (2007). Transmission of gender-role values in Turkish-German migrant families: The role of gender, intergenerational and intercultural relations. *Zeitschrift Für Familienforschung, 19*(1), 71–105.

Inglehart, R., & Norris, P. (2003). *Rising tide: gender equality and cultural change around the world*. Cambridge University Press.

Inglehart, R., Norris, P., & Welzel, C. (2002). Gender equality and democracy. *Comparative Sociology, 1*(3), 321–345.

Jacobs, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: do parents matter? *New Directions for Child and Adolescent Development, 106*, 5–21.

Jann, B. (2019). *ISCOGEN: Stata module to translate ISCO codes. Statistical software components*. Boston College Department of Economics.

Jonsson, J. O., Grusky, D. B., Di Carlo, M., Pollak, R., & Brinton, M. C. (2009). Microclass mobility: social reproduction in four countries. *American Journal of Sociology, 114*(4), 977–1036.

Kaiser, N., & Schels, B. (2016). Vorbild Mutter - Vorbild Vater? Wann können wir eine soziale Vererbung in der Berufswahl von Jungen und Mädchen beobachten? *Zeitschrift Für Soziologie Der Erziehung Und Sozialisation, 36*(1), 39–59.

Kao, G., & Thompson, J. S. (2003). Racial and ethnic stratification in educational achievement and attainment. *Annual Review of Sociology, 29*, 417–442.

Klieme, E., Artelt, C., Hartig, J., Jude, N., Köller, O., Prenzel, M., … Stanat, P. (2013). *Programme for International Student Assessment 2009 (PISA 2009)(Version 1) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_PISA_2009_v1

Knoll, B., Riedel, N., & Schlenker, E. (2017). He's a chip off the old block. The persistence of occupational choices across generations. *Labour, 31*(2), 174–203.

Kogan, I., Kalter, F., Liebau, E., & Cohen, Y. (2011). Individual resources and structural constraints in immigrants' labour market integration. In M. Wingens, M. Windzio, H. de Valk, & C. Aybek (Eds.), *A life-course perspective on migration and integration* (pp. 75–100). Springer.

Kretschmer, D. (2018). Explaining differences in gender role attitudes among migrant and native adolescents in Germany: intergenerational transmission, religiosity, and integration. *Journal of Ethnic and Migration Studies, 44*(13), 2197–2218.

Law, H., & Schober, P. (2021). Gendered occupational aspirations among German youth: role of parental occupations, gender division of labour, and family structure. *Journal of Family Research*. https://doi.org/10.20377/jfr-603
Leahey, E., & Guo, G. (2001). Gender differences in mathematical trajectories. *Social Forces, 80*(2), 713–732.
Leslie, L. L., McClure, G. T., & Oaxaca, R. L. (1998). Women and minorities in science and engineering: a life sequence analysis. *Journal of Higher Education, 69*(3), 239–276.
Lissitsa, S., & Chachashvili-Bolotin, S. (2019). Enrolment in mathematics and physics at the advanced level in secondary school among two generations of highly skilled immigrants. *International Migration, 57*(5), 216–234. https://doi.org/10.1111/imig.12550
Lissitsa, S., & Chachashvili-Bolotin, S. (2021). Occupational reproduction and mobility in STEM–parental narratives of their child's occupational choice. *Educational Studies*. https://doi.org/10.1080/03055698.2021.1884047
Lühe, J., Becker, M., & Maaz, K. (2018). Elterliche Geschlechterrollenvorstellungen, familiärer Hintergrund und Schulleistungen. *Zeitschrift Für Pädagogische Psychologie, 32*, 155–169.
Moakler, M. W., & Kim, M. M. (2014). College major choice in STEM: revisiting confidence and demographic factors. *Career Development Quarterly, 62*(2), 128–142.
Mues, A., Birtwistle, E., Wirth, A., & Niklas, F. (2021). Parental (STEM) occupations, the home numeracy environment, and kindergarten children's numerical competencies. Article 819 *Education Sciences, 11*(12). https://doi.org/10.3390/educsci11120819.
Muller, C. (1998). Gender differences in parental involvement and adolescents' mathematics achievement. *Sociology of Education, 71*(4), 336–356.
OECD. (2009). *PISA Data Analysis Manual SPSS®* (Second ed.). OECD Publishing.
OECD. (2014). Do parents' occupations have an impact on student performance?. *PISA in Focus*. OECD Publishing. https://doi.org/10.1787/5jz8mr7kp026-en
OECD. (2017a). *OECD science, technology and industry scoreboard 2017: the digital transformation*. OECD Publishing.
OECD. (2017b). *PISA 2015 technical report*. OECD Publishing.
OECD. (2019). *PISA 2018 assessment and analytical framework*. OECD Publishing.
Oguzoglu, U., & Ozbeklik, S. (2016). Like father, like daughter (unless there is a son): Parental occupational investment and STEM field choice in college. *IZA Discussion Paper, No. 10052*.
Phalet, K., & Schönpflug, U. (2001). Intergenerational transmission in Turkish immigrant families: parental collectivism, achievement values and gender differences. *Journal of Comparative Family Studies, 32*(4), 489–504.
Plasman, J. S., Gottfried, M., & Williams, D. (2021). Following in their footsteps: the relationship between parent STEM occupation and student STEM coursetaking in high school. *Journal for STEM Education Research, 4*(1), 27–46.
Plasman, J. S., Gottfried, M., Williams, D., Ippolito, M., & Owens, A. (2021). Parents' occupations and students' success in STEM Fields: a systematic review and narrative synthesis. *Adolescent Research Review, 6*(1), 33–44.
Polavieja, J. G., & Platt, L. (2014). Nurse or mechanic? The role of parental socialization and children's personality in the formation of sex-typed occupational aspirations. *Social Forces, 93*(1), 31–61.
Portes, A., & Rumbaut, R. G. (2001). *Legacies: the story of the immigrant second generation*. University of California Press.
Prenzel, M., Artelt, C., Baumert, J., Blum, W., Hammann, M., Klieme, E., & Pekrun, R. (2010). *Programme for International Student Assessment 2006 (PISA 2006) (Version 1) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_PISA_2006_v1
Prenzel, M., Baumert, J., Blum, W., Lehmann, R., Leutner, D., Neubrand, M., … Schiefele, U. (2007). *Programme for International Student Assessment 2003 (PISA 2003) (Version 1) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_PISA_2003_v1
Prenzel, M., Sälzer, C., Klieme, E., Köller, O., Mang, J., Heine, J.-H., … Müller, K. (2015). *Programme for International Student Assessment 2012 (PISA 2012) (Version 5) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_PISA_2012_v5
Qin, D. B. (2006). The role of gender in immigrant children's educational adaptation. *Current Issues in Comparative Education, 9*(1), 8–19.
Reiss, K., Mang, J., Heine, J.-H., Weis, M., Schiepe-Tiska, A., Diedrich, J., … O., K. (2021). *Programme for International Student Assessment 2018 (PISA 2018) (Version 1) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_PISA_2018_v1
Reiss, K., Sälzer, C., Schiepe-Tiska, A., Mang, J., Heine, J.-H., Weis, M., … O., K. (2019). *Programme for International Student Assessment 2015 (PISA 2015) (Version 3) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_PISA_2015_v3
Richter, D., Böhme, K., Bastian-Wurzel, J., Pant, H. A., & Stanat, P. (2014). *IQB-Ländervergleich 2011. Skalenhandbuch zur Dokumentation der Erhebungsinstrumente*. Humboldt-Universität zu Berlin, Institut zur Qualitätsentwicklung im Bildungswesen.
Ridgeway, C. L. (2011). *Framed by gender: how gender inequality persists in the modern world*. Oxford University Press.
Röder, A., & Mühlau, P. (2014). Are they acculturating? Europe's immigrants and gender egalitarianism. *Social Forces, 92*(3), 899–928. https://doi.org/10.1093/sf/sot126
Salikutluk, Z., & Heyne, S. (2017). Do gender roles and norms affect performance in maths? Ihe impact of adolescents' and their peers' gender conceptions on maths grades. *European Sociological Review, 33*(3), 368–381.
Sälzer, C., & Reiss, K. (2016). PISA 2015 – die aktuelle Studie. In K. Reiss, C. Sälzer, A. Schiepe-Tiska, E. Klieme, & O. Köller (Eds.), *PISA 2015. Eine Studie zwischen Kontinuität und Innovation* (pp. 13–44). Waxmann.
Schipolowski, S., Busse, J., Rjosk, C., Mahler, N., Becker, B., & Stanat, P. (2019). IQB-Bildungstrend 2016. Skalenhandbuch zur Dokumentation der Erhebungsinstrumente in den Fächern Deutsch und Mathematik. Humboldt-Universität zu Berlin, Institut zur Qualitätsentwicklung im Bildungswesen.
Schneebaum, A., Rumplmaier, B., & Altzinger, W. (2016). Gender and migration background in intergenerational educational mobility. *Education Economics, 24*(3), 239–260.
Shoraka, M., Arnold, R., Kim, E. S., Salinitri, G., & Kromrey, J. (2015). Parental characteristics and the achievement gap in mathematics: Hierarchical Linear Modeling analysis of Longitudinal Study of American Youth (LSAY). *Alberta Journal of Educational Research, 61*(3), 280–293.
Sikora, J., & Pokropek, A. (2012aaa). Gender segregation of adolescent science career plans in 50 countries. *Science Education, 96*(2), 234–264.
Sikora, J., & Pokropek, A. (2012bbb). Intergenerational transfers of preferences for science careers in comparative perspective. *International Journal of Science Education, 34*(16), 2501–2527.
Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: a longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*(1), 70–83. https://doi.org/10.1037/0012-1649.42.1.70
Sjaastad, J. (2012). Sources of inspiration: The role of significant persons in young people's choice of science in higher education. *International Journal of Science Education, 34*(10), 1615–1636.
Stanat, P., Pant, H. A., Böhme, K., & Richter, D. (2012). *Kompetenzen von Schülerinnen und Schülern am Ende der vierten Jahrgangsstufe in den Fächern Deutsch und Mathematik. Ergebnisse des IQB-Ländervergleichs 2011*. Waxmann.
Stanat, P., Pant, H. A., Böhme, K., Richter, D., Weirich, S., Haag, N., … Reimers, H. (2014). *IQB-Ländervergleich Primarstufe 2011 (IQB-LV 2011) [IQB National Assessment Study 2011 (IQB-LV 2011)] (Version 3) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_LV_2011_v3
Stanat, P., Schipolowski, S., Rjosk, C., Weirich, S., & Haag, N. (2017). IQB-Bildungstrend 2016. Kompetenzen in den Fächern Deutsch und Mathematik *am Ende der 4. Jahrgangsstufe im zweiten Ländervergleich*. Waxmann.
Stanat, P., Schipolowski, S., Rjosk, C., Weirich, S., Mahler, N., Kohrt, P., & Wittig, J. (2019). *IQB-Bildungstrend Primarstufe 2016 (IQB-BT 2016) [IQB Trends in Student Achievement 2016 (IQB-BT 2016)] (Version 1) [Data set]*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_BT_2016_v1
Statistik der Bundesagentur für Arbeit. (2019). *Berichte: Blickpunkt Arbeitsmarkt – MINT-Berufe*. Nürnberg.
Steinberg, L., Dornbusch, S. M., & Brown, B. B. (1992). Ethnic differences in adolescent achievement an ecological perspective. *American Psychologist, 47*(6), 723–729.
Tilbrook, N., & Shifrer, D. (2022). Field-specific cultural capital and persistence in college majors. Article 102654 *Social Science Research, 103*. https://doi.org/10.1016/j.ssresearch.2021.102654.
van der Vleuten, M., Jaspers, E., Maas, I., & van der Lippe, T. (2018). Intergenerational transmission of gender segregation: How parents' occupational field affects gender differences in field of study choices. *British Educational Research Journal, 44*(2), 294–318.
van der Vleuten, M., Steinmetz, S., & van de Werfhorst, H. (2018). Gender norms and STEM: the importance of friends for stopping leakage from the STEM pipeline. *Educational Research and Evaluation, 24*(6–7), 417–436.
Weeden, K. A., & Grusky, D. B. (2004). Are there any big classes at all? *Research in Social Stratification and Mobility, 22*(4), 3–56.
Wei, T., Liu, X., & Barnard-Brak, L. (2015). Gender differences in mathematics and reading trajectories among children from kindergarten to eighth grade. *Research in Education, 93*(1), 77–89.
Weirich, S., & Becker, B. (2020). *Replikationsanalysen mit eatRep*. IQB – Institut zur Qualitätsentwicklung im Bildungswesen. https://doi.org/10.5159/IQB_Tutorial_Replikationsanalyse_v2
Weirich, S., Haag, N., & Sachse, K. A. (2017). Grundlagen der Kompetenzmessung im IQB-Bildungstrend 2016. In P. Stanat, S. Schipolowski, C. Rjosk, S. Weirich, & N. Haag (Eds.), *IQB-Bildungstrend 2016. Kompetenzen in den Fächern Deutsch und Mathematik am Ende der 4. Jahrgangsstufe im zweiten Ländervergleich* (pp. 355–385). Waxmann.
Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual Review of Sociology, 41*, 331–357.
Yazilitas, D., Svensson, J., de Vries, G., & Saharso, S. (2013). Gendered study choice: a literature review. A review of theory and research into the unequal representation of male and female students in mathematics, science, and technology. *Educational Research and Evaluation, 19*(6), 525–545.