



Career Transitions in Teacher Education: A Multigroup Analysis of STEM and Non-STEM Graduates

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Received: 4 March 2025 / Accepted: 7 May 2026
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Abstract

In Germany, there is a shortage of teachers in the STEM (Science, Technology, Engineering, and Mathematics) area which poses a serious problem to society and economy. This shortage is, among other factors, caused by the insufficient number of new students, the high number of university dropouts as well as unfavorable working conditions which lead to early career exits. While motives for study choice and study dropout have already been widely researched, we do not know much about teacher graduates who choose not to enter the profession upon completion of their studies. We believe that this decision and its underlying motives largely depend on the availability of attractive alternatives outside school, which are subject-related. In particular, we believe that the chances for finding an attractive, alternative occupation is much higher for STEM teacher graduates than for any other teacher graduates. Thus, in this study, we use multigroup structural equation modeling to identify predictors for turning away from the teaching profession, differentiating between STEM and non-STEM graduates. Our analysis includes motivation to choose teacher education studies, personality traits, interest, study-related factors, and various sociodemographic variables. While we find that initial motives for choosing teacher education studies were the strongest predictors of professional retention for non-STEM students, we were not able to identify specific patterns for STEM students. The results suggest that more research is required in order to be able to design appropriate interventions.

Keywords Multigroup analysis · STEM · Structural equation modeling · Teacher education

Introduction

Unlike in most countries, teacher education in Germany follows the pattern of vocational training rather than traditional studies and consists of a theoretical university phase (B.Ed. and M.Ed.)¹ and a subsequent practical phase completed directly at the

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schools, i.e., the preparatory service. Although teacher education courses are intended to prepare students specifically for becoming teachers, about one fifth of the students do not enter the preparatory service upon graduation and will not be available to the schools (Franz et al., 2023).

Given that these circumstances contribute to the shortage of teaching staff, which is particularly prevalent in the STEM area (science, technology, engineering and mathematics, e.g., Anger et al., 2021), it seems worth investigating why some teacher graduates decide to turn away from the teaching profession.

Existing research on determinants of alternative professional pathways suggests several levels of influence, e.g., individual, training related or economic. Considering these jointly might produce a more realistic picture. In particular, we believe that the likelihood of choosing a career other than teaching, and the determinants of that choice, are driven by the alternatives available. Many studies on post-university retention of student teachers do not consider that the opportunities for taking up an alternative career, particularly regarding job availability or compensation, may vary greatly across subjects and type of teaching degree (see, e.g., Klemm, 2020). Especially in the STEM-subjects (Science, Technology, Engineering, and Mathematics), it may be straightforward to find an attractive occupation outside school given the skills shortage, which we discuss below.

To address these circumstances in a comprehensible yet accurate way and to gain profound knowledge on the professional retention of teacher graduates, we apply multigroup structural equation models (Jöreskog, 1971; Sörbom, 1974) to data from the National Educational Panel Study (NEPS)² which contain individual and teacher-training specific information on students from Germany. We group respondents into STEM and non-STEM teacher graduates which allows for differences in the determinants of post-university retention.

Only graduates from secondary school teacher training were considered since they study their chosen subjects in depth. Thus, it seems easier for them to find a job in an alternative field compared with primary school or special education teachers. In summary, we expect to gain insights into the motives for turning away from the teaching profession upon the completion of university teacher education which will provide indications for the development of interventions.

In what follows, we give a description of the theoretical framework and discuss previous findings. We proceed with an overview of the data used for our analyses and the methodological approach. Finally, we will discuss the results and conclusions to be drawn from them.

Background, Theoretical Foundation and Previous Findings

Teacher Education in Germany

In Germany, the decision to pursue a teaching career is already taken at the very beginning of university studies when students enroll into special teacher training (B.Ed.) programs. In principle, it is possible to switch to a regular bachelor's program, however, those who choose teacher education programs usually have very spe-

cific ideas about their future careers (Bauer et al., 2011). The traditional division of the German secondary-school system into *Hauptschule*, *Realschule* and *Gymnasium*, with the latter preparing for university studies (Dustmann et al., 2017), also applies to teacher education. Study programs which prepare for teaching at the *Gymnasium* are the focus of this study. They have a strong emphasis on content knowledge, but they also include courses on pedagogical content knowledge and general pedagogical knowledge (see Shulman, 1986). Teacher education students must choose at least two main subjects. After completing their studies, they are obliged to pass an 18 to 24 months *preparatory service* to teach at public schools (Kultusministerkonferenz [KMK], 2012, 2019a, 2019b), which are state-funded and attended by more than 90% of all students (Statistisches Bundesamt, 2020). The state financing ensures comparable quality and endowment at educational institutions all over the country.

During preparatory service, teacher candidates receive practical training at schools and attend teaching seminars (Doil & Pietzner, 2023). Out of those who successfully completed their preparatory service, 98% work in the teaching profession afterwards, usually at public schools (Gülen et al., 2022; Lenz et al., 2019).

Labor Market for Teacher Education Graduates

Entry options for teachers in Germany are linked to subjects and school type. While there is a shortage of teaching staff at most types of schools an excess supply of teachers for upper secondary schools has been recorded in recent years. This trend is broadly similar across federal states (e.g., Klemm, 2020). In what follows, we focus on the situation in the labor market for upper-secondary school teachers.

In spite of the overall excess supply, there are subjects with teacher shortages. Even though it was not possible for us to get access to concrete numbers on the recruitment of teaching staff in individual subjects, it is well known that especially shortages in the STEM area have steadily worsened during the last few years and the situation is expected to deteriorate. Therefore, natural scientists and mathematicians without a teaching background are being recruited into the schools, so-called lateral hires (e.g., Doil & Pietzner, 2023). In a parallel development, given their focus on content knowledge, graduates of upper-secondary school teaching courses can opt for careers outside the school. Even though the teaching profession is often chosen due to intrinsic motivation and because it offers high job security as well as making it possible to combine family and work, higher earnings in certain non-teaching fields might attract teacher graduates since teachers' salaries are bound by collective agreements. Previous research suggests that the wage differential between teaching and non-teaching professions has an effect on the attrition of beginning teachers (Gilpin, 2011). Furthermore, Rots et al. (2014) find a negative relationship between newly graduated student teachers' perception of the availability of attractive employment alternatives and their entry into the teaching profession. Due to the shortages of skilled workers in STEM (e.g., Anger et al., 2021), the expectations or chances of finding an attractive alternative to teaching, particularly in terms of wages, can be assumed to be substantially higher compared to, for instance, foreign languages.

In light of these circumstances, differentiating between STEM and non-STEM teachers' post-study pathways seems particularly insightful.

Theoretical Foundation and Previous Findings

Having set out the reasons for studying STEM and non-STEM teacher graduates separately, we now turn to additional variables which may have an impact on their professional retention.

Since the German teacher education system has some special features, we cannot draw on international studies to inform the debate (Gülen et al., 2022; Klusmann et al., 2012). In what follows, we focus on recent findings on career paths of teacher trainees in Germany. Franz et al. (2023) suggest that expectancy-value theory (EVT; Wigfield & Eccles, 1992, 2000) provides a framework for understanding the career choices of teacher graduates. Accordingly, choices are made based on the subjective value and expectations of success for both the teaching profession and existing alternatives (Franz et al., 2023). Following the authors, a variety of determinants for the transition to the teaching profession can be derived from the EVT. The aspect of personal relevance, i.e., attainment value, can be measured in terms of personal characteristics, whereas interest and motivation cover the dimensions of intrinsic value and utility value. Costs can be understood as negative aspects of the engagement in a certain task, these can include monetary as well as psychological costs (Wigfield & Eccles, 1992, 2000). We include study satisfaction as one factor representing costs since low study satisfaction may cause psychological costs which may cause students to turn away from the teaching profession (Drüge et al., 2014; Franz et al., 2023). Final grades reflect achievement and can be considered determinants of expectancies for success as a teacher (Franz et al., 2023). Using data from the NEPS, the authors study the career paths of teacher education graduates within the first 12 months after graduation. The results suggest that women had a higher chance to transition to the preparatory service, and a lower chance to take up an occupation which is not related to teaching. Furthermore, students who had obtained an M.Ed. had a higher chance to transition directly to the teaching profession while the likelihood for transitioning to a job outside teaching decreases compared to those who obtained the first state examination. In addition, better final grades increased the chance to work in a non-teaching job, whereas having studied at least one subject from the STEM area led to a higher chance of starting a preparatory service. Effects have also been found for certain intrinsic and extrinsic motives for study choice as well as dimensions from the Big Five. Furthermore, higher study satisfaction increased the chance to start the preparatory service. However, the authors' model has a low pseudo-R², which suggests that there are factors not considered up to now, which affect the professional pathway.

Gülen et al. (2022) also used NEPS data to study the relationship of career paths and socio-demographic (e.g., age) factors with achievement-related (e.g., high school GPA) and education-related (e.g., study motivation) factors. More precisely, the authors test for group differences between students pursuing three different career paths: “profession-specific”, “academic”, and “not profession-specific”. Profession-specific retention refers to students who are either completing their preparatory service or already working as teachers. Academic retention refers to those who have started or completed a PhD program. Students with a not profession-specific retention are those who work in a profession outside school without ever having worked in the teaching profession. The authors found that students who pursue an academic career

were more often male, more often had an academic parental background, and were younger at the beginning of studies compared to the other two groups. Furthermore, those in the group of academic retention differed from the other students with respect to achievement-related factors, i.e., better high school GPA and better grades in the degree program. However, there were no performance differences between students with profession-specific versus not profession-specific retention. In addition, students pursuing an academic career more often have had linear school careers compared to the other two groups. A low presumed level of difficulty was less important for choosing teacher education for those with academic retention compared to those with no profession-specific retention. Furthermore, intrinsic motivation of study choice is lower for students with not profession-specific career paths compared to the other two groups. Extrinsic motivation is lower for graduates with an academic path compared to those with profession-specific careers. Intellectual interests of students with an academic pathway were higher than for the other two groups. Finally, students who opted for an academic or not profession-specific career had more often changed their type of degree compared to those with profession-specific retention and the share of students who changed their subject was the highest among the group with academic retention.

Collectively, these studies suggest that there are multiple levels of influence on the professional retention of teacher graduates, i.e., motivation, personal characteristics, and study-related factors.

The Present Study

Even though previous research identified a variety of variables which influence the career paths of teacher graduates, the decision-making process as a whole does not seem to be well understood. One reason might be that the existing literature does not appropriately account for differences in the availability of alternatives between different types of degrees and subjects. However, it seems plausible that the decision to choose a career other than teaching strongly depends on these. Hence, we focus on students who completed a university program which prepares them for becoming teachers at a Gymnasium. These types of programs have a strong focus on subject-related content and potentially pave the way for perspectives outside the teaching profession. In view of the differences already mentioned, it seems fruitful to take a detailed look at students who have chosen at least one STEM subject and students who have opted for a combination of subjects outside the STEM field. Given that the initial decision to become a teacher is already taken with the choice of a teacher education program and given the largely state-funded education system with comparable conditions across schools and universities, Germany provides an ideal setting for gaining greater insights into the topic.

We use data from the NEPS on students who completed the university part of teacher education and were then able to choose whether they wanted to move on into the preparatory service or look for an alternative occupation. We focus on these students instead of those who finished their preparatory service, since it can be assumed that the decision to become a teacher or not is already taken before going into preparatory service as 98% of those students who complete the preparatory service work as

teachers afterwards (Gülen et al., 2022). Based on the following research questions, we aim to shed more light on this issue: Which parameters make it more or less likely to remain in a teacher education program after the completion of university-based teacher education studies? How do these relationships differ between STEM- and non-STEM graduates?

Given previous findings as well as the suggested group differences in the availability of jobs both in the teaching profession and alternatives in the industry, we assume the impact of certain variables on the retention in the teaching profession to differ between the groups. However, we rely on an exploratory approach here, i.e., we do not have any specific hypotheses given the lack of studies that discuss this issue.

Overall, we expect to gain a better understanding of the factors which impact teacher graduates' decision to find work either inside or outside school.

Data and Methodology

Sample

In this study, we use data from the starting cohort “First-Year Students” (SC5) of the NEPS (NEPS Network, 2024). SC5 contains data on students from Germany who were enrolled for the first time in a public or state-approved institution of higher education in the winter semester of 2010/11 and who were followed up in a longitudinal study design until after their entry to the workforce. To be able to study teacher-specific questions, trainee teachers were oversampled on purpose (FDZ-LIFBi, 2023) and received additional questions relating to teacher education (Ortenburger et al., 2023).

Our analysis sample consists of $N=1,119$ students who studied for teaching at the Gymnasium and who obtained either their first state examination or M.Ed. To create our research data set, we combined information from several longitudinal and cross-sectional datasets as well as episode data.³

Variables and Constructs

SC5 from the NEPS contains a variety of manifest and latent variables which relate to students' competencies, educational choices and study success as well as labor market entry and professional success (Ortenburger et al., 2023). In this section, we review variables and constructs relevant for the study at hand. In line with Franz et al. (2023), our choice of variables is based on the EVT and further important previous findings.

Outcome Variable

Our outcome variable *teacher* is dichotomous. It takes on the value 1 for any individual who entered the preparatory service or who became a teacher at any time after their studies during the period under observation.⁴ For individuals who never entered preparatory service or took up a teaching career, *teacher* equals 0. As a teaching career, we exclusively define teaching at secondary schools. Furthermore, we only

included professional careers. This means that periods of unemployment or parental leave, for instance, were excluded from the analysis.

Grouping Variable

The binary variable *STEM*, which is equal to 1 for individuals who studied at least one STEM subject and 0 otherwise, divides our dataset into two groups to run a multigroup analysis. Physics, chemistry, biology, mathematics, and computer science were classified as STEM subjects.

Explanatory Variables

Motivation to Choose Teacher Education Studies was measured by adapting a short version of the FEMOLA instrument (Fragebogen zur Erfassung der Motivation für die Wahl des Lehramtsstudiums; English: Questionnaire for Assessing Motivation for Choosing Teacher Education; Pohlmann & Möller, 2010), a standardized questionnaire assessing various factors influencing the decision to pursue a teaching career. Three items ranging from 1 (“did not apply at all at the time”) to 4 (“was completely true at the time”) were used per subscale and data collection took place retrospectively in 2014. We included two intrinsic motives: professional interest (Cronbach’s $\alpha=0.65$) and pedagogical interests ($\alpha=0.76$) as well as three extrinsic motives: financial benefit ($\alpha=0.86$), good work-life balance of the teaching profession ($\alpha=0.77$), social impact ($\alpha=0.67$; Ortenburger et al., 2023). We did not consider self-concept as a teacher due to the low α (0.53). Furthermore, we excluded the motive of low presumed level of study difficulty given that there were categories for which we did not have any observations in our data.

Personality was measured with a short version of the “Big Five Inventory” (BFI-10) by Rammstedt and John (2007), which contains only two items per dimension, except for agreeableness (Wohlkinger et al., 2011). We only included the dimensions extraversion (outgoing, sociable, $\rho=0.72$) and openness (artistic and imaginative, $\rho=0.56$)⁵ since we assume that these have the largest impact on the decision of becoming a teacher or to opt for an alternative career. Extraversion is particularly relevant for the choice of and retention in the teaching profession since this profession is associated with a high level of social interaction which goes along with communication skills (Keiner & Hany, 2017). Openness, on the other hand, reflects receptivity to new experiences and a preference for variety (Costa & McCrae, 1992). It therefore seems plausible that higher Openness is associated with a greater willingness to change career direction. The items were measured in 2012 and 2016. If available, the measurements from 2016 were considered, if not, measurements from 2012 were used. This should not introduce substantial bias given that personality traits are assumed to be relatively stable in adulthood over short time spans. For both constructs, we used the average scores of the two items. Despite the rather low reliability of the subscales, the instrument shows a high convergent validity with approved, longer Big Five Scales (see, e.g., Franz et al., 2023; Rammstedt & John 2007).

Interest was measured on the “Interest Inventory Life-Span” (IILS) which was developed by the NEPS and which is based on two inventories. First, the revised Allgemeiner Interessen-Struktur-Test (AIST-R; Bergmann & Eder, 2005), which is based on Holland’s (1997) theory of vocational personalities and work environments, often referred to as the RIASEC model. This model categorizes people and work environments into six broad types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional, helping to match individuals’ interests with compatible career paths. Second, a German version (von Maurice, 2006) of the Inventory of Children’s Activities-Revised (ICA-R) by Tracey and Ward (1998). For the students in SC5, one item from the ICA-R as well as two items from the AIST-R were used for each scale (Wohlkinger et al., 2011). We used the mean value across the three items for each of the dimensions and only included social ($\alpha=0.62$) and intellectual ($\alpha=0.66$) interests since we believe that these have the largest impact on the decision whether or not to enter the teaching profession, particularly in STEM subjects. Social interest maps onto instructing, helping, and guiding others which are central features of teaching. Investigative interest, by contrast, reflects both analytic and scientific engagement which is salient for mathematics and science subjects. The internal consistency of the subscales is rather low but considered sufficient given the heterogeneity of the scales (Franz et al., 2023). The interests were measured in 2015 and 2011. We used the latest available information.

We also included **study-related variables**. First, we included study satisfaction which was measured with a single item ranging from 0 to 10 (0=not at all satisfied; 10=completely satisfied) in the years 2011 to 2014. For each individual, we used the latest available information. Additionally, the final study grades were included. We use the German 1–5 scale, where 1=very good, 2=good, 3=satisfactory, 4=sufficient (lowest passing grade) and 5=fail. Contrary to common practice, we decided not to use the grades of the university entrance qualifications given that they lack comparability due to the different types of entrance qualifications and requirements in the different federal states.

We further included several **socio-demographic variables**. These were age at the end of studies, gender (dichotomous; 0=female, 1=male), a dichotomous predictor migrant that indicated whether a person had a migration background and the HISEI. ISEI 08 is an indicator of socioeconomic status (Ganzeboom, 2010), and HISEI indicates the highest parental status based on ISEI08. Furthermore, we controlled for whether children lived in the same household as the interviewee at the time that the studies ended.

In addition, we included a time trend to control for time-specific impacts on the job choice, e.g., the development of the strength of the labor market over the years. To allow for more flexibility, we also added a squared time trend.

Lastly, we included dummy variables for different regions based on the location of the university where the students completed their studies (North, South, West, East; reference category: Berlin). In this way, we were able to control for regional differences in the availability of teacher occupations or alternatives that might have an impact on the career choice. An overview of the entire descriptive statistics can be found in Table A1 in the Online Supplementary Material (ESM).

Methodology

To identify motives for choosing not to enter the teaching profession as well as to detect potential differences between STEM and non-STEM teacher graduates with respect to these motives, we used multigroup structural equation modeling. This analysis strategy is frequently used in educational research to investigate subgroup-specific structural relations (e.g., Lv et al., 2022; Wang et al., 2023). Data preparation was executed in Stata (Version 17; StataCorp, 2021) and subsequent statistical analyses were conducted using the packages *lavaan* (Rosseel, 2012) and *sem Tools* (Jorgensen et al., 2018) in R. For comparison of scale scores between groups, it is required that each latent variable is measured equally across groups, i.e., strong measurement invariance must hold (Meredith, 1993; Svetina et al., 2019). For latent variables with categorical indicators, this implies that both factor loadings and thresholds are equal across groups (e.g., Putnick & Bornstein, 2016). In our data, we did not find any evidence against strong invariance. Specifically, we modeled five latent constructs (pedagogical, subject-related, social, financial, and work-life balance related motives), each measured by three categorical indicators. These constructs correspond to the motives for choosing teacher education as operationalized in the FEMOLA instrument. In the structural part of the model, the dichotomous outcome variable (*teacher*) was regressed simultaneously on all five latent constructs as well as on the observed covariates described in Sect. 4.2. Thus, both latent and observed predictors were included to explain teacher graduates' decision to enter the teaching profession or to pursue an alternative career.

We estimated all structural paths without imposing equality constraints between the groups. For missing values, we applied pairwise deletion which means that each covariance is computed based on all cases with non-missing values for the respective pair of variables (e.g., Marsh, 1998). An advantage of this method is that we can use as many observations as possible.⁶ Pairwise deletion works well under the assumption of MCAR (Missing Completely at Random; see, e.g., Rubin, 1976 for more information on mechanisms through which data can be missing).

Binary covariates were recoded to have the values 0 and 1. All variables with $2 < K < 5$ levels were treated as categorical, whereas variables with more than 5 categories were treated as continuous. Exogenous ordinal variables were coded numerically to preserve the original order.

Nominal categorical variables with $K > 2$ levels were replaced by a set of $K-1$ dummy variables. Endogenous categorical variables were declared as 'ordered' in the fitting function to be treated as such in the model. To assess potential multicollinearity among the observed covariates, we computed group-specific variance inflation factors (VIFs) and pairwise correlation matrices. Following common rules of thumb, $VIF < 5$ is considered unproblematic, values between 5 and 10 indicate moderate collinearity, and values above 10 are regarded as problematic. Latent constructs were not included in these diagnostics but evaluated in the measurement model.

Since our outcome variable is dichotomous, a probit link function is used (see Rosseel, 2017).⁷ In this case, *lavaan* applies the WLSMV estimator (Muthén, 1984) by default. It uses diagonally weighted least squares (DWLS) for parameter estimation, while employing the full weight matrix for computing robust standard errors as well

as a mean- and variance-adjusted test statistic (Rosseel, 2017). Given that it does not rely on the assumption of normally distributed variables, it is commonly regarded as the best option for modeling categorical data (e.g., Brown, 2006).

Due to the small sample size, there are some sparse cells present. However, the WLSMV estimator in lavaan is robust against these and empty cells are excluded from the analysis by default. For continuous covariates we screened for univariate outliers using standardized scores ($|z| > 3$ within groups). Only very few cases ($< 1.5\%$ per variable) were flagged, and these were retained for analysis since their exclusion did not meaningfully affect parameter estimates or standard errors.

To evaluate overall model fit, we compute a range of established SEM criteria indices in addition to the model χ^2 -statistic, which is in line with reporting practices in comparable studies (Lv et al., 2022; Wang et al., 2023). Robust indices were used due to WLSMV estimation whenever available. We considered values of RMSEA < 0.06 , CFI/TLI ≥ 0.95 and SRMR < 0.08 as indicators of good model fit (e.g., Hu & Bentler, 1999).

Within this framework, we estimate a multi-group structural equation model with a probit link for the binary outcome (staying in teaching). Since the outcome distribution is skewed toward staying in teaching (see Table 2), class imbalance primarily affects precision rather than the consistency of probit estimates; accordingly, we do not apply over-/under-sampling and instead emphasize effect sizes with uncertainty. Additionally, both the overall and subgroup samples are representative of the respective populations (teacher graduates in Germany and within the STEM vs. non-STEM domains), so over- or under-sampling would not improve inference but might distort population-level comparability.

Results

Group Comparison

Before proceeding with our actual statistical analysis, we check for differences between the groups regarding our explanatory variables. We conducted mean comparisons between STEM and non-STEM students, results are displayed in Table 1. Given the high number of tests we used a Bonferroni-adjusted significance threshold of $\alpha = 0.003$, which corresponds to the conventional level of 0.05 divided by the number of tests ($m = 16$). We report unadjusted p -values, but interpret them relative to this adjusted threshold. For the FEMOLA constructs, we find nominally significant differences for financial interest and social impact. More specifically non-STEM graduates were more likely to choose teacher education due to financial benefits ($\Delta_M = M_0 - M_1 = 0.10$, $p = .0382$) or social influences ($\Delta_M = 0.14$, $p = .004$). In spite of the nominal significance, the former does not remain significant after adjusting for multiple comparisons.

Furthermore, we find significant differences regarding the Big Five personality traits considered. Non-STEM students showed higher levels of both extraversion ($\Delta_M = 0.14$, $p = .003$) and openness ($\Delta_M = 0.28$, $p < .001$) which also survive Bonferroni correction.

Table 1 Comparison of variables between STEM and non-STEM students

	STEM=0		STEM=1		Group Comparison			
	M	SD	M	SD	M_0-M_1	SE	<i>p</i>	<i>t</i>
FEMOLA:								
Professional interest	3.26	0.59	3.21	0.55	0.05	0.04	0.180	1.34
Pedagogical interest	3.30	0.60	3.30	0.58	-0.01	0.04	0.885	-0.14
Financial benefit	2.89	0.73	2.79	0.71	0.10	0.05	0.038	2.08
Work-life balance	2.83	0.73	2.79	0.72	0.04	0.05	0.485	0.70
Social impact	1.96	0.71	1.82	0.62	0.14	0.05	0.004	2.92
Big Five:								
Extraversion	3.96	0.76	3.82	0.75	0.14	0.05	0.003	2.97
Openness	3.74	0.84	3.46	0.85	0.28	0.05	<0.001	5.42
Interest:								
Intellectual	2.50	0.66	3.49	0.91	-1.00	0.05	<0.001	-20.24
Social	3.81	0.68	3.64	0.67	0.19	0.04	<0.001	4.59
Study-related variables:								
Study satisfaction	6.95	2.02	6.99	1.91	-0.05	0.12	0.706	-0.37
Final study grade	1.78	0.45	1.90	0.47	-0.12	0.03	<0.001	-4.11
Socio-demographic variables:								
Age	25.93	1.96	25.73	2.56	0.20	0.14	0.157	1.42
HISEI	61.07	19.49	62.31	18.95	-1.24	1.20	0.300	-1.03
	%	<i>n</i>	%	<i>n</i>	$prop_0-prop_1$	<i>SE</i>	<i>p</i>	<i>z</i>
Male	26.60	172	35.11	165	-0.09	0.03	0.002	-3.10
Migrant	13.25	86	8.72	41	0.05	0.02	0.018	2.36
Children	7.10	46	8.51	40	-0.01	0.02	0.382	-0.87
<i>N</i>	649		470					

Relatively large group differences existed between intellectual interest ($\Delta_M = -1.00, p <.001$) and there were also differences with respect to social interest ($\Delta_M=0.19, p <.001$). Both remained significant after adjusting for the high number of tests. Intellectual interests of STEM students greatly exceeded those of non-STEM students, while social interests were slightly higher among non-STEM students. Study grades were found to be better among non-STEM graduates ($\Delta_M = -0.12, p <.001$). Finally, the share of males was higher among STEM teacher graduates ($\Delta_p=prop_0 - prop_1=-0.09, p =.002$) and the share of individuals with a migration background ($\Delta_p=0.05, p =.018$) was higher among non-STEM graduates. The latter does, however, not remain significant taking into account the Bonferroni-adjusted threshold.

Even though some of the group differences found are small, these findings show that the groups differ right from the beginning of their studies. We take account of these differences by including them in our model.

The differences found make it likely that the reasons for remaining in the teacher profession or not could also differ between the groups. A multigroup SEM is appropriate to explore differences in these operating mechanisms in addition to studying absolute group differences.

Professional Retention of Teacher Graduates

In the analyses that follow, the dependent variable *teacher* refers to staying in teaching (1=enters preparatory service or a teaching position; 0=pursues an alternative, non-teaching career). Table 2 provides descriptive context on non-teaching occupations and should not be read as the definition of the model outcome.

First, when we look at the shares of students in alternative occupations it becomes clear that this figure is more than twice as high for non-STEM students compared to STEM students (13.4% vs. 6.4%, $p < .001$).

The share of all teacher graduates who chose an alternative occupation amounts to 117 (10.5%). Of these, 30 were enrolled into at least one STEM subject whereas 87 did not study a STEM subject. This shows that non-STEM students are more likely to pursue alternatives and that there is a considerable share of students who do not enter the teaching profession upon completion of their studies, which calls for a closer examination of their motivations. The first point does not change the rationale of this paper which is to investigate STEM graduates who do not enter the teaching profession despite having taken a teacher training degree. Our emphasis on STEM is policy- and supply-driven: in shortage subjects, even small outflows create disproportionate coverage gaps and recruitment risks.

Multigroup Analysis

Given that we used a probit regression model, the interpretation of the coefficients is not straightforward. It is the relationship between the probit of the outcome and the independent variables which is modeled linearly rather than the relationship between the coefficient and the outcome. In other words, we predict the z-score change of our outcome following a one-unit change of the explanatory variable. Unlike ordinary regression analyses, where the coefficients represent the average effect of the independent variable on the outcome, $P(Y = 1 | \mathbf{X})$ must be computed based on the z-scores and specific values of \mathbf{X} . To ease interpretation, we also report two different types of standardized coefficients in Table 3, depending on the type of predictor. For observed predictors (both continuous and dummy variables), we provide semi-standardized coefficients (*std.nox*). These scale the outcome to standard-deviation units but keep predictors in their natural metric (0→1 change for dummies, one-unit change for

Table 2 Professional retention of teacher graduates, differentiating between STEM and non-STEM students

	STEM=0	STEM=1	Total	prop ₀ -prop ₁	<i>p</i>
Preparatory service/ Teaching	562 (86,6%)	440 (93,6%)	1,002 (89,5%)	-0,07	<0,001
Alternative occupa- tion	87 (13,4%)	30 (6,4%)	117 (10,5%)		
<i>N</i>	649	470	1,119		

Shares within group (STEM=0 and STEM=1) in parentheses

Table 3 Results of the multigroup analysis

↑STEM=0
↓STEM=1

Outcome: Preparatory Service/Teaching	<i>b</i>	<i>SE</i>	<i>z</i> -value ⁹	<i>p</i>	95%-CI	Std. coeff.
FEMOLA:	-0.260	0.101	-2.574	0.010	[-0.458, -0.062]	-0.195
Professional interest	-2.414	14.056	-0.172	0.864	[-29.964, 25.135]	-0.223
Pedagogical interest	0.173	0.090	1.917	0.055	[-0.004, 0.349]	0.128
Financial benefit	-0.846	5.024	-0.168	0.866	[-10.693, 9.000]	-0.127
Work-Life balance	0.254	0.108	2.356	0.018	[0.043, 0.466]	0.189
Social impact	0.521	3.100	0.168	0.876	[-5.555, 6.598]	0.070
	-0.099	0.142	-0.702	0.483	[-0.377, 0.178]	-0.068
	-0.331	2.000	-0.166	0.868	[-4.251, 3.589]	-0.072
	-0.066	0.122	-0.541	0.588	[-0.306, 0.174]	-0.045
	-1.424	8.674	-0.164	0.870	[-18.425, 15.588]	-0.152
Big Five:	-0.148	0.106	-1.399	0.162	[-0.356, 0.060]	-0.140
Extraversion	0.152	1.897	0.080	0.936	[-3.566, 3.869]	0.027
Openness	-0.085	0.087	-0.981	0.327	[-0.256, 0.085]	-0.080
	0.125	1.448	0.086	0.931	[-2.713, 2.963]	0.022
Interest:	-0.011	0.036	-0.300	0.764	[-0.080, 0.059]	-0.010
Intellectual	0.245	1.503	0.163	0.871	[-2.701, 3.190]	0.044
Social	-0.001	0.043	-0.016	0.987	[-0.084, 0.083]	-0.001
	-0.348	2.034	-0.171	0.864	[-4.335, 3.639]	-0.063
Study-related variables:	0.065	0.033	1.950	0.051	[-0.000, 0.129]	0.061
Study satisfaction	-0.111	0.682	-0.163	0.870	[-1.448, 1.226]	-0.020
Final study grades	0.213	0.174	1.219	0.223	[-0.129, 0.554]	0.200
	1.163	6.719	0.173	0.863	[-12.007, 14.332]	0.209
Socio-demographic variables:	-0.069	0.045	-1.555	0.120	[-0.157, 0.018]	-0.065
Age	-0.128	0.524	-0.245	0.807	[-1.155, 0.898]	-0.023
Male	-0.180	0.166	-1.084	0.278	[-0.505, 0.145]	-0.169
	-1.680	10.429	-0.161	0.872	[-22.120, 18.761]	-0.302
Migrant	0.140	0.224	0.626	0.532	[-0.299, 0.580]	0.132
	2.355	16.695	0.141	0.888	[-30.366, 35.076]	0.424
HISEI	0.004	0.004	1.206	0.228	[-0.003, 0.011]	0.004
	0.056	0.339	0.166	0.868	[-0.608, 0.721]	0.010
Children	-0.225	0.292	-0.771	0.441	[-0.796, 0.347]	-0.212
	1.533	8.107	0.189	0.850	[-14.356, 17.422]	0.276
Regions (reference category: Berlin)	0.504	0.488	1.032	0.302	[-0.453, 1.461]	0.474
North	3.560	21.159	0.168	0.866	[-37.911, 45.032]	0.641
South	0.093	0.419	0.222	0.824	[-0.728, 0.914]	0.088
West	3.228	20.202	0.160	0.873	[-36.367, 42.822]	0.581
East	0.283	0.398	0.711	0.477	[-0.497, 1.062]	0.266
	4.436	27.289	0.163	0.871	[-48.960, 57.824]	0.798
Time trend ^a :	0.450	0.430	1.046	0.295	[-0.393, 1.294]	0.424
<i>t</i>	3.689	22.331	0.165	0.869	[-40.079, 47.457]	0.664
<i>t</i> ²	0.105	0.093	-1.133	0.257	[-0.287, 0.077]	-0.099
	-0.743	4.608	-0.161	0.872	[-9.775, 8.289]	-0.134
	-0.014	0.047	-0.306	0.759	[-0.106, 0.077]	-0.013
	0.116	0.843	0.137	0.891	[-1.537, 1.769]	0.021

Unstandardized estimates

^a centered

continuous variables). This facilitates interpretation and comparability of effect sizes while avoiding distortions caused by group-specific distributions of binary predictors, which would affect fully standardized coefficients (*std.all*). For latent predictors, by contrast, we report fully standardized coefficients (*std.all*), as these set the factor variance to one and thereby allow for comparability of effect magnitudes across groups, provided that at least metric invariance holds. Inference is always based on unstandardized coefficients, while the standardized values are reported to improve interpretability.

The measurement models for both groups are provided in Figure A1 in the appendix (ESM) and structural paths are displayed in Table 3.⁸ We fit group-wise probit models. Group-wise correlation tables of observed covariates are provided in Appendix A2 and A3 (ESM). Collinearity diagnostics (see Table A4) showed no problematic cases since group-specific VIFs were all < 10.

Since the STEM subsample is much smaller, standard errors are inflated and statistical precision is limited. Accordingly, we interpret non-significant coefficients as inconclusive rather than as clear evidence of no effect.

Generally, motives for choosing to enter the preparatory service or directly starting work as a teacher, differed between both groups. In the group of non-STEM graduates, we find that the FEMOLA constructs are related to the likelihood of choosing the teaching profession on completion of university studies. Pedagogical ($b=0.173$, $SE=0.090$, $p=.055$) and financial ($b=0.254$, $SE=0.108$, $p=.018$) motives for choosing teacher education were positively associated with the likelihood of remaining in the teaching profession while higher content-related interests ($b=-0.260$, $SE=0.101$, $p=.010$) were associated with a higher predicted likelihood to abandon teaching.

In addition, we find positive associations between study satisfaction ($b=0.065$, $SE=0.033$, $p=.051$) and the likelihood of becoming a teacher. Social or intellectual interest as well as personal characteristics or socio-demographic variables did, however, not show significant associations with the professional retention of non-STEM graduates. Furthermore, we do not find significant relationships for the region in which the degree was obtained or the year of graduation.

For the group of STEM-students, we did not find any significant links between our independent variables and the likelihood of choosing to remain in the teaching profession. Potential explanations will be discussed in the next section.

The multi-group SEM was found to fit the data well: CFI = 0.963 and TLI = 0.988; RMSEA = 0.036 and SRMR = 0.057). Even though the χ^2 -statistic was statistically significant ($\chi^2(725)=1015.58$, $p < .001$) we rely on the incremental and residual-based indices all of which meet common cut-off criteria (see Hu & Bentler, 1999).

Discussion and Conclusion

In Germany, especially for STEM subjects, there are worsening teacher shortages. In addition to dropouts from university teacher training courses and attrition of qualified teachers already working in the profession, an often-neglected group in this context are newly graduated students who decide not to complete their preparatory service, taking up a job outside school instead.

With the present study, we aim to contribute to a better understanding of this phenomenon. Given that the availability of alternative occupations as well as that of teacher positions varies between different subject areas, any analysis of this topic must take account of these differences.

We analyzed the motives of teacher graduates for entering the teaching profession based on data from the NEPS and considered motivation to choose teacher education studies, personality, interest, study-related as well as socio-demographic variables. We studied potential differences regarding these relationships between STEM- and non-STEM graduates using multigroup SEM and exclusively focused on students with a degree for secondary school teaching.

First, we find that among the students in our sample, around 10% did not start a preparatory service or teaching under the period of study. This proportion is a little lower than the one found in previous studies (e.g., Franz et al., 2023; Gülen et al., 2022). However, we have to take into account that these previous studies do not focus on secondary teachers only. We further find that the share of graduates who decided to enter the teaching profession was much higher among STEM (94%) than among non-STEM students (87%, $p < .01$).

Moreover, we show that in the group of non-STEM graduates, the initial motivation for choosing teacher education in the first place showed the strongest relationship with the likelihood of remaining in the teaching profession.

In particular, financial motives as well as pedagogical interest were linked to a higher likelihood of becoming a teacher while motives related to content-related interest was related to a higher likelihood of searching for an alternative occupation. One rationale behind these findings might be that for students who had a high content-related interest in, for instance, German studies, teacher education constituted a safe fallback plan given the precarious possibilities at the labor market for students of German language with respect to both availability and wages. In this case, the teaching profession and the associated civil servant status offer a financially attractive and secure alternative option. The fact that at the same time financial motives for choosing teacher education did not matter for STEM-students underlines these findings given that in STEM subjects attractive occupations apart from teaching can be found. Thus, it is plausible that for these non-STEM students it was clear from the beginning that they would only become teachers if they did not find another job. On the other hand, those who really studied teacher education due to pedagogical interest decided on remaining in this profession, at least for now, as reflected in the positive relationship between pedagogical interest and the retention in the teaching profession. This finding is also consistent with the finding that the rate of students who turn away from the teaching profession is much higher among non-STEM students since we can assume that STEM students who are not interested in becoming teachers directly choose purely scientific studies rather than teacher education studies. This interpretation is supported by the stronger role of social influences in shaping the decision to study teacher education among non-STEM graduates.

Thus, we have a selection effect in that the STEM graduates are already largely only those who want to teach. The non-STEM group is more heterogeneous in this respect.

For the group of non-STEM students, study satisfaction was significantly related to professional retention, similarly to the results by Franz et al. (2023). Higher study satisfaction is associated with a greater likelihood of entering a preparatory service

or directly starting work as a teacher. Given that the university-based studies already have an apprenticeship-like character, this finding is not surprising.

In contrast to findings of other studies (e.g., Franz et al., 2023; Gülen et al., 2022) which suggest that particularly gender is related to the career decisions of teacher graduates, we observe no such association in our data. Furthermore, in contrast to Franz et al. (2023), we do not find evidence that final study grades are associated with career decisions. However, the results by Gülen et al. (2022), who explicitly consider academic retention, suggest that final study grades are only related to academic retention, but not to non-academic retention. The authors also find a relationship between parental educational background and academic retention while we do not detect any significant relationship between socio-demographic variables and the likelihood of remaining in the teaching profession.

Interestingly, professional retention was independent from the region in which the students obtained their study degree. If we assume that the regional mobility of the graduates is limited, one might have expected to find at least some relationship here since the job availability varies across regions in Germany. Similarly, we do not find any relationship to the year in which the students graduated even though such an association might be expected.

Overall, our findings suggest that initial motives for studying teacher education as well as the study satisfaction throughout the studies are associated with the retention of non-STEM teacher graduates in the profession.

When we now look at STEM students, none of the predictors considered was found to be related to the likelihood of entering the preparatory service after graduation or directly starting a teaching career.

Thus, it is hard to identify specific patterns. Existing theories such as the EVT do not seem to offer explanations here. Therefore, the decision for not going into preparatory service remains poorly explained for STEM students. It is unclear which interventions could really make a change, and more research is required in this area.

Given that Franz et al. (2023), controlling for the subject area as well as the school type, identified several factors that predict retention in the teaching profession, we expected to find at least some of these relationships in this group.

One reason for the absence of (strong) associations might be the small sample size among STEM students who opt for alternative careers. However, there was no data set available that is superior to the NEPS regarding the question at hand. Still, the small sample size might lead to low statistical power, making it hard to identify statistically significant relationships even if they existed in the population. Another limitation arises with regard to the relatively low reliability estimates for some of the constructs used in our analyses. Low reliability is, again, associated with the reduction of statistical power as well as the attenuation of structural coefficients (see Bollen, 1989; Cohen et al., 2003). Thus, these results should be treated with caution. However, we believe that this is only one part of the story. For instance, we should consider that the previous study does not allow for different structural paths between STEM and non-STEM teacher graduates and that the outcome variable was not defined in the same way as we did. Moreover, there are important differences even within STEM students that may lead to heterogeneous patterns which result in the lack of significant findings. Unfortunately, we cannot study these in more detail given the low number of cases. Furthermore, given that STEM graduates often can

find attractive alternatives apart from teaching, it might be that the factors we studied here are simply not that meaningful for this group, given that this may already be a fairly homogeneous group due to selection effects. Only those who intend to become teachers remain in the group at this stage.

Even though we were able to identify motives for turning away from the teaching profession among non-STEM graduates, a prediction of the risk of leaving the teacher career currently seems difficult as also implied by the low R-squared in other studies (e.g., Franz et al., 2023).

In general, it might be interesting to take a closer look at those who switch during or after their bachelor's degree course, since we assume that this is more common. Furthermore, the period of observation is limited, and we only consider developments in the professional sphere. It is possible that some graduates take up their preparatory service after completing a PhD or parental leave. Moreover, we must consider the possibility of bias given that the data were collected retrospectively. Another problem related to the longitudinal structure of the NEPS data is panel attrition. In addition, constructs have been measured at different points which might produce further distortions (see also Franz et al., 2023).

Maybe the key to understanding the phenomenon is to employ a process perspective that considers the accumulation of a variety of motives using intensive longitudinal data (e.g., Heusel, 2023; Kelava & Brandt, 2019). By capturing the evolving nature of these factors over time, such studies could offer deeper insights into underlying mechanisms and potentially inform more targeted interventions.

¹In Germany, following the Bologna Process, teacher training was changed from the traditional "Staatsexamen" (state examination) to a bachelor's and master's system, accompanied by various other innovations. Before that, the first state examination was awarded upon the successful completion of the theoretical study phase. At the time of the data collection for this study, the changeover was just taking place such that some students received a M.Ed., and others passed their first state examination.

²This paper uses data from the National Educational Panel Study (NEPS; see Blossfeld & Roßbach, 2019). The NEPS is carried out by the Leibniz Institute for Educational Trajectories (LifBI, Germany) in cooperation with a nationwide network.

³For further information on episode data, see, e.g., FDZ-LIFBi (2023).

⁴At private schools it is sometimes possible to teach without completing a preparatory service. However, this only was the case for a very small number of individuals.

⁵To compute average scores, some items were inverted.

⁶A variety of studies (e.g., Enders, 2001) suggest that full-information maximum likelihood (FIML) is a superior approach for handling missing data, however, it is not supported for categorical data estimation in lavaan.

⁷Lavaan by default uses a probit link function for dichotomous outcomes, the use of logistic functions is not possible in this case.

⁸Group-wise estimates use unbalanced subsamples (STEM < non-STEM). Holding variance constant, SE scales $\approx 1/\sqrt{n}$. Thus, the smaller STEM subsample naturally shows larger SEs even though Table 1 reports similar within-group means and standard deviations. Cross-group SE magnitudes are not directly comparable and depend on the group sizes.

⁹SEs are relatively large due to small sample sizes.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10763-026-10682-y>.

Funding Open Access funding enabled and organized by Projekt DEAL.

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