Teaching and Teacher Education 181 (2026) 105730

Contents lists available at ScienceDirect

Teaching and Teacher Education

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

Research paper

Long-term trajectories of teacher self-efficacy across phases of teacher education

Sebastian Franz [a,*], Jennifer Paetsch [b]

[a] Catholic University of Eichstätt-Ingolstadt, Germany
[b] University of Bamberg, Germany

ARTICLE INFO

Keywords:
Teacher self-efficacy
Motivation
Personality
Career stage
Teacher education

ABSTRACT

This study investigated the development of teacher self-efficacy (TSE) among 2719 German teachers over 8 years using panel data. Piecewise multilevel growth models captured within-person change across career stages; university-based teacher education, the induction phase, and early in-service teaching. The average TSE trajectory showed a small linear decline. Entry into the induction phase was not associated with a significant change in average TSE, whereas entry into in-service teaching was linked to a small increase. Despite modest average changes, there was substantial variability in individuals' TSE trajectories. While primary teachers and those with strong intrinsic motivation to teach reported higher baseline TSE, primary teachers exhibited a sharper decline upon entering the induction phase than teachers of other levels. Sociodemographic and personality characteristics did not predict the within-stage rates of change. By separating TSE trajectories from changes associated with career-stage entry, this study extends existing research on the longitudinal development of TSE.

1. Introduction

The growing demands placed on teachers make understanding how to best support them in managing these challenges increasingly important (Grossman et al., 2009; Schleicher, 2018). A key factor in this context is teacher self-efficacy (TSE), defined as a teacher's beliefs about their professional capabilities. TSE is widely acknowledged to be essential for understanding how teachers navigate the complexities of their profession (Klassen & Tze, 2014; Zee & Koomen, 2016). High TSE is associated with higher-quality instruction, greater job satisfaction, fewer burnout symptoms, and better student outcomes (Duan et al., 2024; Holzberger et al., 2014; Jerrim et al., 2025; Zee & Koomen, 2016). For example, a systematic review by Zee and Koomen (2016) concluded that higher teacher self-efficacy is most consistently associated with classroom organization and management and, to a somewhat lesser extent, with instructional and emotional support. Furthermore, Lazarides et al. (2018) found that higher teacher classroom-management self-efficacy was associated with students' perceptions of a more mastery-oriented classroom climate. Given the relevance of TSE to classroom practice, exploring its development is essential for informing and enhancing teacher education (Chao et al., 2017; Hayes et al., 2020; Täschner et al., 2024).

TSE beliefs are considered malleable and responsive to contextual and individual factors during the formative periods of teacher education and early professional experience (Klassen & Durksen, 2014; Pfitzner-Eden, 2016). These career stages are thought to be crucial in forming the professional identity and resilience of teachers, which have possible long-term implications for their instructional practices and career persistence (Tschannen-Moran & Hoy, 2007).

Scholars generally agree that TSE changes during teacher training (Pfitzner-Eden, 2016; Täschner et al., 2024). Yet little is known about the long-term trajectories of changes in TSE or how it evolves when teachers transition from training to teaching practice. A growing body of literature has examined how TSE changes across university-based and practice-based teacher training (Ma et al., 2021; Zee et al., 2016), but studies primarily focus on mean differences between time points and intervention effects, rather than within-person patterns of change over longer periods (Klassen & Durksen, 2014; Rushby et al., 2025; Täschner et al., 2024). Another methodological limitation of this research is whether the individual items used to measure TSE consistently capture

This 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.

* Corresponding author. Ostenstraße 26, Eichstätt, 85072, Germany.
E-mail address: sebastian.franz@ku.de (S. Franz).

https://doi.org/10.1016/j.tate.2026.105730
Received 23 January 2026; Received in revised form 29 June 2026; Accepted 1 July 2026
Available online 2 July 2026

the same underlying constructs across different time points. While this issue is typically addressed using the concept of measurement invariance (Mackinnon et al., 2022), studies examining changes in TSE often fail to rigorously test measurement invariance, despite its importance (Swan et al., 2011; Woolfolk Hoy & Spero, 2005).

Research suggests that TSE is affected by the challenges of early career teaching (Garvis et al., 2012; Zee et al., 2025), as the induction period is characterized by a demanding transition marked by adaptation to school environments and the formation of a professional teacher identity (Feiman-Nemser, 2001; Voss & Kunter, 2020). Cross-sectional studies have found associations between TSE and individual characteristics such as gender (Calkins et al., 2024; Fackler et al., 2021; Klassen & Chiu, 2010), motivational orientation (Bilim, 2014; Calkins et al., 2024; Thornberg et al., 2025), and personality factors (Franz et al., 2022; Senler & Sungur-Vural, 2013; Wang & Shen, 2022). However, the extent to which these factors predict changes in TSE over time remains unclear, as they have received limited attention in longitudinal studies. This is particularly relevant because self-efficacy is not merely a direct result of experiences but is rather shaped by an individual's interpretation and integration of efficacy-relevant information from diverse sources (Morris et al., 2017).

This study aimed to address these gaps by investigating the long-term development of TSE across teacher education phases in Germany over an eight-year period. Specifically, we examined the differences in TSE trajectories across early career stages and the effects of time-invariant predictors of TSE variability on both the starting point of TSE and its growth. By comparing TSE trajectories across teacher career stages, this study explored changes in the context for developing self-efficacy as teachers progress from initial training to full-time practice (Morris et al., 2017). This provides a dynamic perspective of TSE development during critical transitions, offering insights that may have implications for teacher education.

2. Theoretical framework

2.1. Socialization into the teaching profession

Socialization into the teaching profession can be conceptualized within the framework of Organizational Socialization Theory (OST; Bauer & Erdogan, 2011; Richter et al., 2022), which emphasizes how individuals are gradually integrated into the profession's norms, roles, and practices. In the teacher education context, this process occurs through university-based training, practicum experiences, and the early years of teaching, often referred to as the induction phase (Feiman-Nemser, 2001). This transition varies by country and depends on national training systems. In Germany, a university-based teacher education program (TEP) is followed by a structured induction phase, during which novice teachers participate in complementary seminars and gradually assume teaching responsibilities under supervision (Voss & Kunter, 2020). In contrast, systems such as that in the United States involve entry into full professional responsibility directly after university training (OECD, 2005). Regardless of the specific pathway, beginner teachers must simultaneously expand their pedagogical skills, adapt to institutional norms, and develop a professional identity (Tynjälä & Heikkinen, 2011). The early years in a teacher's career are commonly characterized as a highly demanding phase of professional socialization (Fantilli & McDougall, 2009; Richter et al., 2013), which may vary by school type, given that various organizational environments differ in terms of student characteristics, curricular complexity, and instructional goals (Klassen & Chiu, 2010; Kraft & Papay, 2014).

OST posits that socialization processes are critical for the development of adaptive professional beliefs, such as TSE. In this context, self-efficacy is a key mechanism linking socialization experiences to outcomes such as job satisfaction, instructional effectiveness, and retention (Bauer & Erdogan, 2011; Klassen & Chiu, 2010). Klassen and Chiu (2010) argue that TSE is dynamic rather than fixed, reflecting a lifelong developmental process that fluctuates according to personal characteristics and individuals' interpretations of their environments and circumstances.

2.2. Theoretical foundations and sources of teacher self-efficacy

TSE is defined as teachers' beliefs in their ability to effectively execute teaching tasks and manage professional challenges in specific contexts (Skaalvik & Skaalvik, 2007; Tschannen-Moran & Hoy, 2001). Bandura (1977, 1997) proposed that self-efficacy beliefs have four sources: mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states. The influence of these sources on self-efficacy beliefs is considered indirect and dependent on cognitive processes that shape the perception, interpretation, and integration of efficacy-related information (Morris et al., 2017).

While TSE sources are accessible across all career stages, their relative importance varies (Pfitzner-Eden, 2016; Täschner et al., 2024). Mastery experiences—individuals' interpretations of their own accomplishments—are considered the most important source of self-efficacy (Bandura, 1997). In teacher education, these experiences arise from various scenarios, including practicum settings as part of pre-service training, mentor-supported teaching in the induction phase, and routine classroom practice during the in-service phase, all of which have exhibited consistent effects on TSE at every career stage (Palmer, 2011; Pfitzner-Eden, 2016; Tschannen-Moran & McMaster, 2009). Vicarious experiences are obtained by analyzing videotaped teaching and observing experienced teachers operating in real-life situations, and are important for forming TSE beliefs during the initial training and induction phases. These experiences help trainee teachers develop confidence and competence in facing unfamiliar tasks (Grammatikopoulos et al., 2013; Thiel et al., 2023; Van der Scheer & Visscher, 2016). In-service teachers may also benefit from vicarious experiences through team teaching and professional development (Mather & Visone, 2024; Mintzes et al., 2013). All career stages feature social persuasion, which manifests as feedback and encouragement provided by mentors and teacher educators (Pfitzner-Eden, 2016; Prilop et al., 2021; Richter et al., 2013; Weber et al., 2019) and during discussions and collaborations with colleagues (Hoogendijk et al., 2018; Palmer, 2011; Smith et al., 2020). Additionally, physiological and emotional states, such as practicum anxiety or teaching stress, provide internal cues about one's capabilities throughout all career stages (Bach & Hagenauer, 2022; Burić et al., 2020; Klassen & Durksen, 2014).

Research suggests that pre-service teachers benefit from vicarious experiences and social persuasion because they lack extensive mastery experiences, whereas in-service teachers tend to rely on their accumulated mastery experiences and the emotional regulation strategies they have developed through their ongoing practice (Pfitzner-Eden, 2016). Consequently, TSE trajectories may vary across career stages due to differential access to sources of self-efficacy (Klassen & Chiu, 2010; Pfitzner-Eden, 2016).

2.3. Changes in TSE at different career stages

2.3.1. Teacher education program at the university

Initial teacher education at university represents a formative phase during which pre-service teachers begin to construct their TSE beliefs. They typically have limited experience with the practical demands of classroom teaching during this period, and therefore an incomplete understanding of the profession's complexities (Tschannen-Moran & Hoy, 2001; Voss & Kunter, 2020; Woolfolk Hoy & Spero, 2005). At this early stage, pre-service teachers' TSE is primarily sourced from vicarious experiences (e.g., observing experienced teachers) and social persuasion (e.g., coaching and supervisor feedback), with limited opportunities to gain mastery experiences through teaching (Knoblauch & Chase, 2015; Martins et al., 2015; Pfitzner-Eden, 2016).

Research consistently demonstrates that, during university teacher education, TSE increases through engaging in teaching experience during practical (Berg & Smith, 2018; Klassen & Durksen, 2014; Pfitzner-Eden, 2016), microteaching (Huβner et al., 2022, 2023), coaching (Weber et al., 2019), and observing and analyzing video lessons (Gold et al., 2017; Schlosser & Paetsch, 2023; Thiel et al., 2023). Practicum experiences, as part of the university teacher education curriculum, strengthen TSE, with effect sizes ranging from $d = 0.20$ to $d = 0.66$ for areas such as classroom management, instructional strategies, and student engagement (Berg & Smith, 2018; Pfitzner-Eden, 2016). Klassen and Durksen (2014), using a longitudinal design with weekly assessments, observed a significant upward linear trajectory in TSE over a nine-week practicum, with a mean slope coefficient of 0.24 (i.e., rate of change). Practica were particularly effective when students had already experienced microteaching during a seminar (Huβner et al., 2022, 2023) or had received coaching through a mixture of face-to-face and video-based reflection and feedback (Weber et al., 2019). Other studies have also reported changes in TSE following teacher education students' observation of video lessons and subsequent reflection, showing medium effect sizes (Gold et al., 2017; Schlosser & Paetsch, 2023; Thiel et al., 2023).

2.3.2. *The induction phase and early career teaching*

The teacher induction phase encompasses the transition from teacher education to professional practice as well as the initial years of teaching, during which novice teachers encounter a range of significant challenges (Fantilli & McDougall, 2009). The development of TSE is particularly change-sensitive during this phase (Klassen & Chiu, 2010; Woolfolk Hoy & Spero, 2005), as beginner teachers encounter the full spectrum of professional demands for the first time while receiving reduced mentoring support relative to that provided during their previous practicum experiences (Dicke et al., 2015; Ingersoll & Strong, 2011). This period also coincides with a critical phase of professional socialization, as teacher candidates enter the practical context of schools to be confronted by organizational norms and values that often differ from those emphasized during their university training (Hoy & Woolfolk, 1990). The ideals promoted during teacher education may, in fact, conflict with experienced teachers' established practices and expectations, creating tensions that shape novices' self-efficacy (Hoy & Woolfolk, 1990).

The transition from a TEP to the induction phase is often described as a "reality shock" (Dicke et al., 2015; Voss & Kunter, 2020). Tynjälä and Heikkinen (2011) highlight that the gradual development of professional competence means that early career teachers initially become increasingly aware of their limitations, which may undermine self-efficacy. A study by Dicke et al. (2015) reported that pre-service teachers' classroom management TSE declines ($M_{t1} = 4.26$; $M_{t2} = 3.81$; $M_{t3} = 3.95$) when they first encounter the full range of professional demands alongside reduced mentoring support and have not attended any additional classroom management courses. Conversely, other studies found that pre-service teachers exhibit significantly higher average TSE after completing preparatory service than before the preparatory phase, with medium to large effect sizes ($d = 0.6$ to $d = 1.9$) that vary among TSE domains (Bacon, 2020; Woolfolk Hoy & Spero, 2005). Furthermore, Richter et al. (2013) found that beginner teachers' TSE developed differently depending on mentoring style, with significant gains when mentors adopted a constructivist-oriented approach.

2.3.3. *The in-service phase*

The transition from supervised induction to autonomous in-service practice involves the full assumption of professional roles and responsibilities. Theoretically, this transition is less likely to produce a sharp downward shift in TSE than entry into induction, as novice teachers have already navigated the initial phase of becoming more aware of their limitations and, in parallel, have accumulated mastery experiences and established classroom routines during induction. The loss of structured supervisory support and the assumption of full instructional and assessment responsibility may nevertheless lead to a temporary decline in TSE during the first months of in-service teaching (Hartl & Holzberger, 2022; Voss & Kunter, 2020), potentially followed by recovery as teachers consolidate their routines (Swan et al., 2011; Woolfolk Hoy & Spero, 2005).

Empirical research has produced mixed findings regarding the development of TSE during the in-service phase. Cross-sectional research investigating the relationship between teaching experience and TSE suggests a curvilinear pattern, finding that TSE increases up to 23 years of experience, then declines steadily (Klassen & Chiu, 2010). Longitudinal studies have also provided inconsistent evidence regarding changes in TSE during this phase. While some research demonstrates that the average TSE of early career teachers increases over a five-year period (George et al., 2018), some studies report a significant decline during the first years of teaching (Hartl & Holzberger, 2022), followed by recovery in subsequent years (Swan et al., 2011; Woolfolk Hoy & Spero, 2005). Other research suggests that TSE tends to stabilize during later career stages. Künsting et al. (2016) investigated changes in TSE by initially surveying teachers 4–6 years after obtaining their first teaching degree and once again 7 years later, and observed no significant latent or manifest changes in TSE during this period. This stability is further supported by a high bivariate latent factor correlation ($r = 0.66$) and a strong path coefficient ($\beta = 0.73$) between the measurement points. Another study of experienced teachers in inclusive education revealed stable average TSE over three years across five measurement points, with strong correlations between the measurement points that ranged from 0.44 to 0.81 (Savolainen et al., 2022).

2.4. *Teacher characteristics associated with TSE*

Self-efficacy reflects an individual's processing and interpretation of efficacy-relevant information (Morris et al., 2017). Klassen and Chiu (2010) suggest that teacher characteristics are associated with TSE directly and indirectly through teachers' professional experience. Time-varying characteristics (e.g., occupational stress, workload, and perceived collegial and administrative support) can alter the cognitive appraisal of TSE sources, thereby shaping TSE formation and maintenance (Klassen & Chiu, 2010; Klusmann et al., 2008;Skaalvik & Skaalvik, 2007). Beyond these dynamic influences, time-invariant teacher characteristics (e.g., gender, personality) represent stable individual differences that systematically shape how teachers process and weigh efficacy-relevant information across all their professional experiences (Bandura, 1997; Klassen & Chiu, 2010). The present study focuses on these time-invariant characteristics, as they may affect teachers' interpretation of subsequent experiences and their integration into efficacy beliefs (Watt & Richardson, 2007) and are robustly linked not only to TSE but also to other consequential teaching outcomes, including instructional quality and classroom management ((Burić & Kim, 2020; Klusmann et al., 2008). Furthermore, analyzing the association between stable individual characteristics and TSE development helps to clarify the possibility of anticipating, early in a teacher's career, whether they may benefit from targeted support during later career transitions.

The existing evidence on gender differences in TSE is mixed, with some studies indicating higher self-efficacy among male teachers (Calkins et al., 2024; Fackler & Malmberg, 2016; Skaalvik & Skaalvik, 2016) and others observing no effect of gender on TSE (Tschannen-Moran & Hoy, 2007; Zizhan & Rafols, 2024).

Prior research has demonstrated that career motivation is a predictor of TSE: intrinsic motivation (e.g., personal fulfillment, helping students) is positively associated with TSE, whereas extrinsic motivation (e.g., job security, salary) is not (Bilim, 2014; Calkins et al., 2024; Thornberg et al., 2025). Only the extrinsic motive of choosing teaching as a fallback career has been found to be negatively related to TSE (Bilim, 2014). Although motivation to pursue a teaching career may evolve throughout teacher education and the early career in response to changing contextual experiences (Ryan & Deci, 2020), the present study focuses specifically on motivation at the time of career choice, examining whether these initial career motives are associated with subsequent TSE development across early career stages.

Research has consistently reported correlations between TSE and the Big Five personality traits (Djigić et al., 2014; Senler & Sungur-Vural, 2013). Extraversion, conscientiousness, and agreeableness are positively associated with TSE, while openness is negatively associated (Djigić et al., 2014; Senler & Sungur-Vural, 2013; Wang & Shen, 2022). Studies have produced inconsistent results on the relationship between TSE and neuroticism, with some identifying a negative correlation (Djigić et al., 2014; Franz et al., 2022) and others finding no significant association (Senler & Sungur-Vural, 2013).

In studies examining the educational context, primary teachers report higher TSE than secondary teachers (Klassen & Chiu, 2010; Wolters & Daugherty, 2007). However, domain-specific analyses indicate that secondary teachers may have higher content-specific TSE, whereas primary teachers exhibit stronger TSE for student engagement (Ryan et al., 2015). Beyond these group-level differences, a cross-national TALIS analysis of 23 countries revealed that teachers accounted for 87 % of the variance in TSE, schools for 4 %, and countries for 8 %((Vieluf et al., 2013), indicating a small but meaningful contribution of organizational and cultural contexts.

3. The present study

While existing evidence on the developmental trajectory of TSE across teaching career stages is limited by methodological constraints and study design variability, previous research has identified certain trends that inform the present investigation. Prior studies suggest that TSE increases during teacher education (Pfitzner-Eden, 2016), then temporarily declines during the induction phase before rising toward the end of it for an overall increase, followed by a subsequent decrease after the first year of teaching (Bacon, 2020; Voss & Kunter, 2020; Woolfolk Hoy & Spero, 2005). Studies have reported that TSE tends to increase again during the early in-service years, before potentially stabilizing or declining in the later career stages (Klassen & Chiu, 2010; Savolainen et al., 2022).

A key limitation of most longitudinal studies in this field is their reliance on only two or three measurement points, typically involving comparisons of TSE mean values rather than modeling trajectories of within-person change (Bach & Hagenauer, 2022; Swan et al., 2011; Woolfolk Hoy & Spero, 2005). Understanding of the intra-individual patterns of change and inter-individual variability of TSE trajectories therefore remains limited. Furthermore, existing research has predominantly examined TSE changes within isolated career stages (George et al., 2018; Pfitzner-Eden, 2016), leaving a research gap regarding the developmental differences between career phases (Rushby et al., 2025; Zee et al., 2016).

This study addressed these gaps by using longitudinal data from the German National Education Panel Study (NEPS) to assess TSE development over 8 years, spanning multiple career stages. This approach enabled the examination of long-term developmental patterns while ensuring sufficient statistical power to detect small changes, given the large sample size. The repeated measurement structure also enabled the analysis of phase-specific trajectories and transition-related shifts in levels, providing a more nuanced understanding of TSE development across different stages of teacher education and professional practice. To overcome the analytical limitations of prior studies, we tested for measurement invariance across measurement points and employed multilevel modeling to estimate developmental trajectories based on within-person changes.

Drawing on the reviewed literature, this study addresses the following two research questions: First, how does TSE change within and across different career stages of teacher education in Germany? Consistent with previous research (e.g., Dicke et al., 2015; Klassen & Chiu, 2010; Pfitzner-Eden, 2016; Swan et al., 2011; Woolfolk Hoy & Spero, 2005), we expected TSE to increase during university teacher education (H1a), but anticipated a curvilinear pattern during the in-service phase, with an initial decline followed by an increase (H1b). Furthermore, we expected a negative level shift in TSE during the transition from the TEP to the induction phase (H2a) and from the induction phase to the in-service phase (H2b).

Given that the induction phase varies from 12 to 24 months and NEPS participants are primarily surveyed once annually, only a limited number of participants have multiple observations during the induction phase. This meant that the within-stage changes during the induction phase could not be investigated.

Second, to what extent are individual teacher characteristics, such as gender, school type, personality, and initial teaching motivation, associated with within-stage and between-stage changes in TSE? Consistent with prior research, which found that female teachers and those working in primary education report higher TSE than their male and secondary school counterparts (Calkins et al., 2024; Fackler & Malmberg, 2016), we expected a positive effect of female (H3) and primary school (H4) on within-stage slopes and transition-related level shifts. Furthermore, consistent with previous findings (Bilim, 2014; Calkins et al., 2024; Thornberg et al., 2025), we hypothesized (H5) that there would be a positive association between student teachers' intrinsic motivation for choosing teaching as a career and within- and between-stage changes in TSE. Finally, drawing on research linking personality traits to TSE (Djigić et al., 2014; Senler & Sungur-Vural, 2013), we presumed that extraversion, conscientiousness, and agreeableness would be positively associated with within-stage and between-stage changes in TSE (H6), and neuroticism and openness to new experiences (H7) would be negatively related.

4. Data and methods

4.1. Data and sample

We utilized data from the NEPS student cohort in Germany, which represents a nationwide sample of first-year students who began their study program in the winter term of 2010/11 (Blossfeld & Roβbach, 2019; NEPS Network, 2024). This dataset contained an oversample of teacher education students (Schaeper et al., 2023), and TSE was measured annually from 2015 to 2022, resulting in eight measurement points. Information about participants' career stages was collected concurrently with TSE measurements during annual telephone interviews. Missing data on educational and occupational pathways were collected retrospectively from the participants.

The analytical sample was derived using a stepwise filtering process that refined the data from the initial 5821 teacher education students. We included only individuals with career stage information and TSE measurements during the observation period, excluding those still enrolled in university training at the final measurement point and those already teaching at baseline. We also excluded cases with implausible transitions, such as moving from the induction phase back into the TEP. The final analytical sample comprised 2719 pre-service teachers and 12123 observations.

Participants' average age at the start of their studies in October 2010 was 20 years old (SD = 2.7), ranging from 17 to 57 years old. Of the participants, approximately 75 % were female, and 5 % were not born in Germany. All teacher types were represented in the sample; 12.5 % were primary teachers, 15.5 % lower secondary teachers, 59.8 % upper secondary teachers, 4.3 % vocational school teachers, 7.8 % special school teachers, and 0.5 % without differentiation or missing values.

4.2. Analytical strategy

To ensure the comparability of the latent construct of TSE across time, we tested for longitudinal measurement invariance using established procedures (Chen, 2007). We estimated a series of increasingly restrictive confirmatory factor analysis (CFA) models, and model fit was assessed using standard criteria, including changes in comparative fit index (CFI; ΔCFI ≤0.010) and root mean square error of approximation (RMSEA; ΔRMSEA ≤0.015; Chen, 2007). If full scalar invariance was not supported, partial invariance was established by releasing the constraints on the parameters that contributed most to the misfit, as indicated by the modification indices.

We employed multilevel modeling (MLM) to estimate TSE trajectories across career stages, accounting for the longitudinal panel data structure with multiple repeated measures nested within each individual (Snijders & Bosker, 2012). MLM is particularly suitable for analyzing our data because it accommodates unbalanced designs in which participants contribute different numbers of observations across measurement points (Hox, 2010). Time was coded as a wave index ranging from 0 (baseline) to 7 (final wave), with each unit corresponding to approximately one calendar year, allowing time-related coefficients to be interpreted per wave.

We followed a fully nested five-step model build-up, with each step adding a single component, enabling comparisons to be evaluated using likelihood ratio tests (LRTs). The unconditional means model (M0), which included only a random intercept, was used to partition the variance of TSE into between- and within-person components and to compute the intraclass correlation coefficient (ICC; Singer & Willett, 2003). We subsequently added a fixed linear effect of time while retaining the random-intercept structure (M1), testing whether average TSE changes linearly across the 8-year period. We then introduced a random slope on time that allows trajectories to vary across teachers (M2), testing whether teachers differ systematically in their rate of TSE change. In M3, a piecewise structure was introduced by adding two level-shift indicators that capture discontinuities at career stage transitions from TEP into the induction phase and from the induction phase into the in-service phase (Singer & Willett, 2003). Then, a post-transition slope was included at each individual's actual transition point into the in-service phase (M4) by adding a person-specific variable that tracks the time since entry into in-service teaching (Flora, 2008; Sterba, 2014), allowing the in-service slope to differ from the TEP slope. It was not possible to model a post-transition slope for the induction phase because participants contributed an average of only 1.5 observations during this stage (47.6 % contributed a single observation). To assess curvilinear development during the in-service phase, we also estimated M4b, which added a quadratic term for time since in-service entry. The random-effects structure from M2 was carried forward throughout. The fixed effect for the post-transition slope captures the average within-stage trajectory after entry into in-service teaching and was estimated from the subsample of teachers observed in this phase. A random slope for this parameter was not included because approximately 42 % of participants did not participate in in-service teaching during the observation period, leaving no post-transition observations for deriving person-specific deviations from the average trajectory.

Model comparison was performed using pairwise LRTs between consecutive nested models, supplemented by Akaike (AIC) and Bayesian (BIC) information criteria (Hox, 2010). Maximum likelihood estimation (ML) was used for model comparison, and restricted maximum likelihood was used to obtain less biased variance component estimates (Hox, 2010). Significance tests for fixed effects used Satterthwaite-corrected degrees of freedom.

We then extended the preferred piecewise model to include time-invariant individual-difference predictors of the TSE intercept and the trajectory components. Separate models were estimated on the multiply imputed data: a gender model (M5), a teacher-type model (M6), a motivation model (M7), and a personality model (M8). Each predictor or set of predictors was incorporated with main effects on the intercept, the TEP slope, and the level shifts at induction and in-service entry. No interactions with a within-induction slope were estimated, as the induction phase was parameterized as a level shift rather than as a slope. All continuous predictors were standardized using grand means computed from the observed data, ensuring that the same scaling parameters were applied across all imputed datasets to maintain the comparability of pooled estimates.

4.3. Missing data

Table 1 shows the distribution of completed waves per participant, indicating that more than half of the participants had at least four valid TSE measurements. Diagnostic analyses supported the assumption that the data were missing at random (MAR). We evaluated the missingness mechanism in several ways. First, logistic regression models predicting the probability of being missing at the next wave from variables observed at the current wave (TSE score, age, gender, career stage, personality, and motivation) identified several significant predictors of attrition, indicating that missingness was systematically related to observed information and was therefore inconsistent with a missing-completely-at-random (MCAR) mechanism. Consistent with this finding, Little's MCAR test of the TSE factor scores across waves rejected the null hypothesis of MCAR. These results justify the use of full information maximum likelihood (FIML) and multiple imputation, both of which yield unbiased estimates under MAR (Enders, 2010).

A complementary attrition analysis showed that stayers (observed at the final wave; $n = 991$) and earlier leavers ($n = 1728$) did not differ in baseline TSE ($t(2263) = -0.05$, $p = .964$, $d < 0.01$) or in their overall rate of change (person-specificslopes, $p = .685$; leaver × time interaction, $p = .332$). Leavers were somewhat more likely to be primary or lower-secondary teachers and to have a migration background, although these associations were weak (Cramér's $V \leq 0.09$). The only trajectory component related to attrition was a somewhat more negative induction-entry shift among leavers (see Section 5.3), plausibly reflecting their overrepresentation among primary teachers. Attrition was therefore unrelated to baseline TSE or overall rates of change. The remaining associations, although statistically detectable given the large sample, were small and involved covariates already included in our analysis and imputation models. This pattern is consistent with a missing-at-random mechanism and supports the use of FIML and multiple imputation, although the estimated change associated with entry into the induction phase should be interpreted with some caution.

We used FIML for all CFA and measurement invariance models. We generated 20 imputed datasets for the multilevel growth models that included the time-invariant predictors using multiple imputation by chained equations with multilevel predictive mean matching (van Buuren & Groothuis-Oudshoorn, 2011; White et al., 2011). The imputation model included all substantive analysis variables (including career stage, the TSE outcome, demographics, personality, and motivation scales) as predictors, clustered by individuals and conforming to the recommended practice of including all analysis-model variables in the imputation model (Enders, 2010). Imputation convergence was assessed using trace plots and density comparisons of the observed versus imputed distributions. The results from the 20 imputed datasets were pooled using Rubin's rules (Rubin, 1987).

Table 1
Number of completed waves per participant.

Number of valid measurement points	N (persons)	Proportion
1	423	15.6 %
2	430	15.8 %
3	314	11.5 %
4	246	9 %
5	202	7.4 %
6	277	10.2 %
7	374	13.8 %
8	453	16.7 %

4.4. Software

All analyses were conducted in R (R Core Team, 2025) using the following packages: lavaan (Rosseel, 2012) for measurement-invariance analyses, lme4 (Bates et al., 2015) and *lmerTest* (Kuznetsova et al., 2017) for multilevel growth models, mice (van Buuren & Groothuis-Oudshoorn, 2011) for multiple imputation, and ggplot2 (Wickham et al., 2016) for visualization.

4.5. Measurement

4.5.1. Teacher self-efficacy

General TSE was assessed using the German instrument developed by Schwarzer and Schmitz (1999). This scale comprises 10 items rated on a four-point Likert scale (see Ortenburger et al., 2023, for item formulation). A CFA was performed to evaluate the one-factor model. The first measurement model included all items, and no further restrictions showed an acceptable fit to the data (χ^2(df) = 1754.606 (35); CFI = 0.905; RMSEA = 0.06; SRMR = 0.035). However, the CFI value falls under the established threshold of 0.95; we therefore excluded one item (tg68007, "Even if I am very committed to the development of my students, I know that I cannot achieve very much") from the measurement model based on modification indices. Furthermore, to improve the model fit, error covariances were permitted between items tg68008 and tg68009, as well as between tg68005 and tg68006. Both item pairs show conceptual similarities, as tg68008 and tg68009 both refer to implementing innovations, and tg68005 and tg68006 both refer to adapting lessons to challenging circumstances. The final model showed a good model fit (χ^2(df) = 612.61 (33); CFI = 0.964; RMSEA = 0.038; SRMR = 0.022). TSE demonstrated acceptable internal consistency across all measurement points (Cronbach's α = .74; McDonald's Ω = 0.78).

We tested the measurement invariance of TSE to ensure that we had captured the same underlying constructs across different time points. The fit indices are presented in Table 2.

Metric invariance was confirmed, as differences in CFI and RMSEA appeared to be small within the proposed thresholds (ΔCFI = −0.002; ΔRMSEA = −0.003). However, the changes in RMSEA (ΔRMSEA = 0.011) and CFI (ΔCFI = −0.047) suggested that scalar measurement invariance was not achieved. Based on the modification indices, we relaxed the equal-intercepts constraint for some items (tg68001, tg68002, and tg68004) and estimated a partial scalar measurement model. Consequently, the alterations in RMSEA (ΔRMSEA = 0.004) and CFI (ΔCFI = −0.013) were substantially diminished, although ΔCFI remained above the 0.01 threshold. Factor scores for the longitudinal analyses were extracted from the partial scalar model using regression, ensuring that the TSE composite reflected a measurement-invariant latent construct. Because full scalar invariance was not achieved, observed mean-level changes in TSE may partly reflect item-specific measurement non-equivalence (Robitzsch & Lüdtke, 2023); longitudinal trajectories should therefore be interpreted with appropriate caution.

4.5.2. Time-invariant variables

We assessed personality traits using a condensed version of the BFI-10 (Rammstedt & John, 2007). We measured four of the Big Five dimensions—openness to experience, neuroticism, conscientiousness, and extraversion—using two items for each, and assessed agreeableness using three items (Wohlkinger et al., 2011). Data collection using the BFI-10 began in the third wave, approximately 18 months after participants had commenced their university studies.

Reliability assessment using the Spearman–Brown coefficient revealed low to moderate values across the dimensions (openness: r = 0.37; neuroticism: r = 0.39; conscientiousness: r = 0.42; extraversion: r = 0.61). The agreeableness construct demonstrated questionable internal consistency (Cronbach's α = .31; McDonald's Ω = 0.35) and was consequently excluded from the analysis. Previous studies have shown that, while this shortened scale for personality dimensions exhibits poor to modest internal consistency, it demonstrates strong convergent validity (Rammstedt & John, 2007).

To assess participants' initial motivation for pursuing teacher education, we used a shortened version of the Factors Influencing the Choice of Teaching as a Career (FEMOLA) scale, which was administered in the eighth wave, more than 4 years after the study had started (Pohlmann & Möller, 2010). This instrument comprises several subdimensions. Intrinsic motivation is captured by the subdimensions pedagogical interest (Cronbach's α = .76; McDonald's Ω = 0.77), subject interest (Cronbach's α = .71; McDonald's Ω = 0.73), and ability-related beliefs (Cronbach's α = .49; McDonald's Ω = 0.50). Extrinsic motivation is represented by financial utility (Cronbach's α = .86; McDonald's Ω = 0.86), time utility (Cronbach's α = .78; McDonald's Ω = 0.80), social influences (Cronbach's α = .69; McDonald's Ω = 0.72), and perceived study demands (Cronbach's α = .72; McDonald's Ω = 0.74). Each dimension was assessed using three items rated on a 4-point Likert scale. Ability-related beliefs were excluded from subsequent analyses due to a low reliability coefficient.

5. Results

5.1. Descriptive statistics

The means and number of observations of TSE scores across the different measurement points and career stages are displayed in Fig. 1. Sample sizes varied considerably across years and career stages because participants either failed to answer the questions about TSE (item non-response), did not participate in the respective survey wave (unit non-response), or dropped out of the panel study (panel dropout/attrition).

During the TEP stage, the largest sample was observed in 2015 (n = 2584), and the smallest in 2020 (n = 55). The induction phase had the largest sample in 2017 (n = 1006), whereas no participants were included in 2015 due to sample restrictions. The in-service phase demonstrated sample sizes ranging from 215 participants in 2016 to 1369 participants in 2020.

The TSE was scaled to a mean of zero across all measurement points and participants. During the teachers' education, the mean TSE values ranged from −0.3 (2016) to 0.17 (2015). In the induction phase, the mean values ranged from −0.28 (2016) to 0.14 (2017). For in-service teachers, means ranged from −0.13 (2022) to 0.18 (2017).

Table 3 presents the descriptive statistics and reliability coefficients for the time-invariant covariates measured in this study. Conscientiousness had the highest mean value (M = 3.30, SD = 0.50) and neuroticism the lowest (M = 2.81, SD = 0.52), with approximately 10.5 % missing values due to unit non-response. For intrinsic motivation, pedagogical interest exceeded (M = 3.36, SD = 0.57) subject

Table 2
Test for measurement invariance.

Model	X^2 (df)	CFI	RMSEA	SRMR	vs	$\Delta\chi^2$ (df)	p-value	ΔCFI	ΔRMSEA	ΔSRMR
M1: Configural	968 (264)	0.956	0.042	0.028	—	—	—	—	—	—
M2: Metric	1067 (327)	0.954	0.039	0.033	M1	99 (63)	0.003	−0.002	−0.003	0.005
M3: Scalar	1878 (390)	0.907	0.05	0.044	M2	811 (63)	<0.001	−0.047	0.011	0.011
M3a: Partial Scalar	1379 (369)	0.937	0.043	0.038	M2	313 (42)	<0.001	−0.017	0.004	0.005

Fig. 1. Observed TSE means and observed observations by career stage and year.

Table 3
Descriptives and reliability coefficients of time-invariant variables.

	Items	*M*	*SD*	Min	Max	Proportion of missing values (persons)	α	Ω	*r*
Personality Traits (Big Five)									
Extraversion	2	3.20	0.39	2	5	10.5 %	—	—	0.61
Openness	2	3.16	0.6	1	5	10.5 %	—	—	0.36
Conscientiousness	2	3.30	0.5	1.5	5	10.5 %	—	—	0.42
Neuroticism	2	2.81	0.52	1	5	10.5 %	—	—	0.39
Intrinsic Motivation									
Pedagogical interest	3	3.36	0.57	1	4	31.6 %	0.76	0.77	—
Subject interest	3	3.07	0.64	1	4	31.6 %	0.71	0.73	—
Extrinsic Motivation									
Financial utility	3	2.83	0.73	1	4	31.6 %	0.86	0.86	—
Time utility	3	2.83	0.72	1	4	31.6 %	0.78	0.80	—
Social influences	3	1.86	0.70	1	4	31.6 %	0.69	0.72	—
Study demands	3	1.41	0.52	1	4	31.6 %	0.72	0.74	—

Note. α = Cronbach's Alpha; Ω = McDonald's Omega; *r* = Spearman-Brown coefficient.

interest ($M = 3.07$, $SD = 0.64$). Among the extrinsic motivation factors, financial ($M = 2.83$, $SD = 0.73$) and time utility ($M = 2.83$, $SD = 0.70$) were around the theoretical mean, whereas social influences ($M = 1.86$, $SD = 0.70$) and study demands ($M = 1.41$, $SD = 0.52$) had the lowest means. Approximately 31.6 % of the sample had missing values for all motivation measurements.

5.2. *TSE trajectories*

To systematically evaluate the changes in TSE over time, we compared six nested growth models of increasing complexity: an unconditional model (M0), a linear growth model with random intercept (M1), a linear growth model with random intercept and random slope

Table 4
Model comparison for piecewise growth models.

Model	Npar	AIC	BIC	logLik	$\Delta\chi^2$	*df*	*p*	vs
M0: Null	4	30,214	30,236	−15,104	—	—	—	
M1: Linear time + random intercept	5	30,213	30,243	−15,103	2.34	1	0.126	M0
M2: + random slope	7	30,057	30,102	−15,023	159.84	2	<0.001	M1
M3: + level shifts	9	30,047	30,107	−15,016	13.91	2	<0.001	M2
M4a: + linear in-service slope	10	30,048	30,115	−15,015	1.41	1	0.235	M3
M4b: + quadratic in-service slope	11	30,049	30,123	−15,015	2.27	2	0.321	M3

Note. Npar = number of estimated parameters. All models estimated with ML (REML = FALSE). $\Delta\chi^2$ and *p* values from pairwise comparisons between nested models (reference model in 'vs' column). M4a/M4b represent two alternative piecewise parameterizations branching from M3.

(M2), a linear growth model with random intercept and random slope and level shift for entry into the induction and in-service phases (M3), a piecewise growth model adding a linear in-service slope (M4a) and, a piecewise growth adding a quadratic in-service slope (M4b). Table 4 presents the model fit statistics for each functional form, and Table 5 lists the coefficients and *ICC*.

The unconditional model (M0) served as the baseline. The random effects showed that approximately 52.5 % of the variance in TSE scores could be attributed to between-person differences (*ICC* = 0.525), with the remaining 47.5 % attributable to within-person variation over time. This relatively high *ICC* indicates substantial individual differences in TSE trajectories and suggests considerable within-person changes over time, supporting the application of MLM.

A simple linear time trend with a random intercept (M1) did not improve model fit compared to the null model ($\Delta\chi^2(1) = 2.34, p = .126$), indicating that TSE did not follow a uniform monotonic trajectory over the 8-year period. However, allowing slopes to vary randomly across teachers (M2) substantially improved model fit ($\Delta\chi^2(2) = 159.84$, $p < .001$), suggesting that a flat average trajectory masks considerable between-person variation rather than reflecting true stability. We therefore retained the random-slope specification for all subsequent models. The variance of individual slopes (τ_{11}) translated into a standard deviation of approximately 0.09 per wave, indicating that roughly 95 % of teachers' slopes fell within ±0.18 *SD* per wave around the (near-zero) population average.

Introducing level shifts and the transition into the induction and in-service phases (M3) improved model fit compared to M2 ($\Delta\chi^2(2) = 13.91$, $p < .001$). Yet, neither piecewise models with linear slope (M4a; $\Delta\chi^2(1) = 1.41$, $p = .235$) nor the quadratic slope (M4b; $\Delta\chi^2(2) = 2.27$, $p = .321$) during the in-service phase showed an improvement in model fit compared to the model with only level shifts (M3). This indicates that career-stage transitions produce level shifts in TSE but do not introduce phase-specific slopes; the linear time trend describes within-stage change equally well across all three career phases. We therefore retained M3.

Parameter estimates for M3 are reported in Table 5 and translated into cumulative changes across each career phase. Fig. 2 provides a graphical representation of the results. Because TSE was standardized ($M = 0$, $SD = 1$), coefficients are directly interpretable as SD units. The intercept at baseline did not differ from the grand mean ($B = 0.019$, $SE = 0.018$, $p = .282$). The TEP slope was small but significant ($B = -0.020$, $SE = 0.018$, $p < .001$), corresponding to a cumulative change of only approximately −0.06 *SD* across the three waves most participants spent in TEP. Contrary to H1a, TSE declined significanly over time rathern than increasing whereas the model comparison also does not support H1b.

The induction-phase level shift was not statistically significant ($B = 0.006$, $SE = 0.021$, $p = .789$), indicating no transition-specific shift. TSE did not decline at entry into the induction phase; H2a was therefore not supported. A small but statistically significant positive level shift of +0.09 *SD* was observed at the transition into in-service teaching ($B = 0.091$, $SE = 0.029$, $p = .020$), the opposite direction from the temporary decline predicted by H2b.

Random effects were consistent across all models. The between-person ($\tau_{00} \approx 0.55$) and within-person ($\sigma^2 \approx 0.45$) variance remained virtually unchanged from M0 to M4b, indicating that the piecewise fixed effects explained only a small proportion of the within-person variation in TSE. The random slope variance ($\tau_{11} = 0.008$) was small in absolute terms—as expected for standardized outcomes—but its inclusion produced the largest single fit improvement in the model sequence ($\Delta\chi^2 = 159.84, p < .001$), confirming substantial individual variation in TSE trajectories not captured by the average growth model.

5.3. Time-invariant predictors of TSE

Tables 6–9 present the estimates from models that extend the preferred piecewise growth specification (M3) by sequentially adding sets of time-invariant predictors: gender (Table 6), teacher type (Table 7), motivational variables (Table 8), and personality traits (Table 9). Initial teaching motives and personality traits were standardized prior to analysis.

Gender was not significantly associated with any component of TSE development (Table 6). Female teachers did not differ from male teachers in baseline TSE ($B = 0.018$, $SE = 0.041$, $p = .656$), nor did the linear time slope ($B = 0.006$, $SE = 0.014$, $p = .637$). There was no difference between female and male teachers in level shift at the transition from the TEP to the induction phase ($B = -0.070$, $SE = 0.049$, $p = .155$), or at the entrance to the in-service phase ($B = -0.030$, $SE = 0.068$, $p = .662$). H3 was therefore not supported.

Teacher type exhibited significant effects on baseline TSE and the magnitude of transition-related level shifts (Table 7). Compared to primary teachers, upper secondary ($B = -0.230$, $SE = 0.058$, $p < .001$) and vocational ($B = -0.398$, $SE = 0.105$, p 0.001) teachers reported substantially lower baseline TSE, corresponding to differences of approximately 0.23 and 0.40 *SD*, respectively. Lower secondary ($B = -0.050$, $SE = 0.071$, $p = .482$) and special education ($B = -0.068$, $SE = 0.085$, $p = .422$) teachers did not differ significantly from primary teachers in baseline TSE. Several interactions with the linear time slope reached statistical significance: relative to primary teachers, upper secondary ($B = -0.038$, $SE = 0.019$, $p = .049$) and vocational ($B = -0.070$, $SE = 0.034$, $p = .038$) teachers exhibited greater negative linear change in TSE. The interactions with lower secondary ($p = .162$) and special education ($p = .094$) teachers were insignificant. A more complex pattern emerged for the level-shift interactions. The transition from TEP into the induction phase was less negative for upper secondary ($B = 0.161$, $SE = 0.066$, $p = .015$), vocational ($B = 0.399$, $SE = 0.123$,

Table 5
Piecewise multilevel growth model estimates for TSE development.

	M0	M1	M2	M3	M4a	M4b
Fixed effects						
Intercept	0.006 (0.016)	0.017 (0.018)	0.017 (0.017)	0.019 (0.018)	0.016 (0.018)	0.016 (0.018)
Time (TEP slope)		−0.005 (0.003)	−0.005 (0.004)	−0.020 (0.006)***	−0.012 (0.009)	−0.012 (0.009)
Induction level shift				0.006 (0.021)	−0.007 (0.024)	−0.007 (0.024)
In-service entry shift				0.091 (0.029)**	0.075 (0.032)*	0.069 (0.033)
Time since in-service					−0.013 (0.011)	0.003 (0.021)
Time since in-service^2						−0.004 (0.004)
Random effects						
σ^2 (within-person)	0.489	0.489	0.449	0.449	0.449	0.449
τ_{00} (between-person)	0.540	0.541	0.554	0.552	0.552	0.552
τ_{11} (random slope)			0.008	0.008	0.008	0.008
ICC	0.525	0.525	0.553	0.552	0.552	0.552

Note. Unstandardized coefficients with standard errors in parentheses. Time coefficients expressed per wave (≈1 year). Satterthwaite-corrected *p*-values. ICC = intraclass correlation coefficient.
**p* < .05. ***p* < .01. ***p < .001.

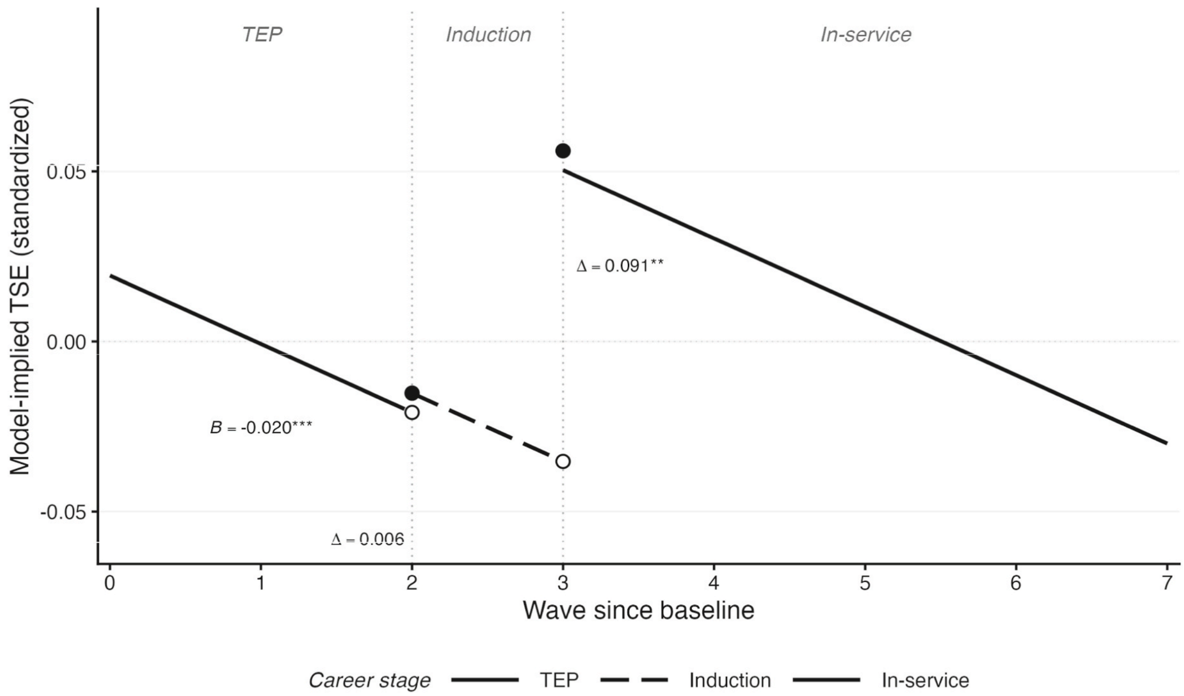

Fig. 2. Predicted TSE Trajectory (M3).
Note. Population-average trajectory implied by the preferred model (M3) for a representative teacher transitioning at modal waves. The four piecewise components are visible as: the linear time slope (consistent across all phases), the induction-phase level shift, and the in-service entry level shift.

Table 6
Multilevel piecewise growth model with gender as moderator.

	B (SE)	95 % CI	p
Fixed effects: Piecewise base			
Intercept	0.006 (0.036)	[-0.063, 0.076]	0.857
Time (linear slope, per wave)	−0.025 (0.012)*	[-0.048, −0.002]	0.032
Induction phase (ref. TEP)	0.059 (0.043)	[-0.025, 0.143]	0.171
In-service entry (ref. TEP)	0.113 (0.058)	[-0.001, 0.228]	0.053
Fixed effects: Predictor main effects			
Female	0.018 (0.041)	[-0.062, 0.099]	0.656
Linear slope × female	0.006 (0.014)	[-0.020, 0.033]	0.637
Induction shift × female	−0.070 (0.049)	[-0.167, 0.027]	0.155
In-service entry × female	−0.030 (0.068)	[-0.162, 0.103]	0.662
Random effects			
Within-person variance (σ^2)	0.449		
Between-person variance (τ_{00})	0.552		
Random slope variance (τ_{11})	0.008		
ICC	0.552		

Note. Unstandardized coefficients with standard errors in parentheses. Time coefficients expressed per wave (≈1 year). Estimation by REML on 20 multiple imputed datasets, pooled via Rubin's rules. Satterthwaite-corrected *p*-values. *ICC* = intraclass correlation coefficient. *N* = 2719 participants, 12,123 observations.
**p* < .05. ***p* < .01. ***p < .001.

p = .001), and special education (B = 0.228, SE = 0.095, p = .016) teachers compared to primary teachers. Similarly, the transition from the induction to the in-service phase was more positive for vocational (B = 0.455, SE = 0.162, p = .005) and special education (B = 0.271, SE = 0.135, p = .044) teachers than for primary teachers, with upper secondary teachers demonstrating a positive, yet nonsignificant, effect (B = 0.163, SE = 0.092, p = .078). These results provide partial support for H4: primary teachers reported higher baseline TSE than upper secondary and vocational colleagues, but their developmental trajectory included a more pronounced downward induction shift than was observed among teachers in other school types. A parallel pattern emerged for panel attrition: participants who later left the study showed a more negative induction-entry shift than those who remained (leaver × induction interaction; B = −0.12, p = .008; omnibus $\Delta\chi^2(4)$ = 12.0, p = .018), consistent with their higher representation among primary teachers.

Initial teaching motivation shows only main effects on baseline TSE (Table 8). Among intrinsic motives, pedagogical interest shows a strong positive association with TSE (B = 0.213, SE = 0.021, p < .001); subject interest was also positively related, although to a lesser extent (B = 0.050, SE = 0.021, p = .021). Among extrinsic motives, time utility was positively associated with TSE (B = 0.051, SE = 0.023, p = .029), whereas financial utility (B = −0.017, SE = 0.023, p = .457) and social influence (B = −0.010, SE = 0.023, p = .665) were not significant. Perceived study demands showed a negative main effect on TSE (B = −0.083, SE = 0.025, p = .001). None of the motivational variables interacted significantly with either the TEP or in-service slopes, indicating that motivation was associated with stable between-teacher differences in TSE rather than with variation in change over time. Overall, these findings partially support H7: intrinsic motivational factors for pursuing a teaching career were positively related to TSE levels, but motivational variables did not predict change in TSE across career stages.

Personality traits did not show any relation to TSE development (Table 9). None of the Big Five traits—extraversion (B = 0.009, SE = 0.019, p = .656), conscientiousness (B = −0.034, SE = 0.020, p = .081), neuroticism (B = −0.035, SE = 0.019, p = .071), and openness (B = 0.026, SE = 0.018, p = .165)—were significantly associated with baseline TSE. Similarly, no significant interactions emerged between personality traits and either the TEP or in-service slopes, indicating that personality did not moderate the developmental trajectory of TSE. These findings do not support either H8 or H9.

Across all four models, the fixed effects of the piecewise base components remained largely unchanged. Random effects were similarly stable: within-person variance ($\sigma^2 \approx 0.45$) and between-person variance ($\tau_{00} \approx$ 0.49–0.55) shifted only minimally, with the ICC remaining at 0.52–0.55 across all models. The added predictors thus accounted for only a small share of the substantial inter-individual variation,

Table 7
Multilevel piecewise growth model with teacher type as moderator.

Parameter	B (SE)	95 % CI	*p*
Fixed effects: Piecewise base			
Intercept	0.192 (0.053)***	[0.088, 0.296]	<0.001
Time (linear slope, per wave)	0.016 (0.018)	[-0.018, 0.051]	0.357
Induction phase (ref. TEP)	−0.137 (0.061)*	[-0.256, −0.018]	0.024
In-service entry (ref. TEP)	−0.058 (0.084)	[-0.222, 0.107]	0.491
Fixed effects: Predictor main effects (ref. primary)			
Lower secondary	−0.050 (0.071)	[-0.189, 0.089]	0.482
Upper secondary	−0.230 (0.058)***	[-0.343, −0.117]	<0.001
Vocational	−0.398 (0.105)***	[-0.604, −0.193]	<0.001
Special education	−0.068 (0.085)	[-0.234, 0.098]	0.422
Fixed effects: Predictor × Linear slope(ref. primary)			
Linear slope × Lower secondary	−0.033 (0.023)	[-0.079, 0.013]	0.162
Linear slope × Upper secondary	−0.038 (0.019)*	[-0.076, −0.000]	0.049
Linear slope × Vocational	−0.070 (0.034)*	[-0.136, −0.004]	0.038
Linear slope × Special education	−0.046 (0.028)	[-0.100, 0.008]	0.094
Fixed effects: Predictor × Level shifts (ref. primary)			
Induction shift × Lower secondary	0.017 (0.083)	[-0.146, 0.180]	0.841
Induction shift × Upper secondary	0.161 (0.066)*	[0.031, 0.291]	0.015
Induction shift × Vocational	0.399 (0.123)**	[0.157, 0.641]	0.001
Induction shift × Special education	0.228 (0.095)*	[0.042, 0.414]	0.016
In-service entry × Lower secondary	−0.018 (0.113)	[-0.239, 0.203]	0.872
In-service entry × Upper secondary	0.163 (0.092)	[-0.018, 0.344]	0.078
In-service entry × Vocational	0.455 (0.162)**	[0.137, 0.772]	0.005
In-service entry × Special education	0.271 (0.135)*	[0.007, 0.535]	0.044
Random effects			
Within-person variance (σ^2)	0.448		
Between-person variance (τ_{00})	0.545		
Random slope variance (τ_{11})	0.008		
ICC	0.549		

Note. Unstandardized coefficients with standard errors in parentheses. Time coefficients expressed per wave (≈1 year). Estimation by REML on 20 multiple imputed datasets, pooled via Rubin's rules. Satterthwaite-corrected *p*-values. *ICC* = intraclass correlation coefficient. *N* = 2719 participants, 12,123 observations.
*$p < .05$. **$p < .01$. ***$p < .001$.

suggesting that the time-invariant characteristics examined here do not capture the sources of trajectory heterogeneity. Where predictors were associated with TSE, this occurred primarily through differences in baseline levels and, in some cases, the magnitude of transition-related level shifts.

6. Discussion

This study examined the long-term development of TSE across career stages over an 8-year period in a nationwide German panel study of 2719 teachers. By using a piecewise multilevel growth specification, we were able to distinguish between within-stage change and transition-related level shifts and to test for moderation by teacher characteristics. This approach overcomes the key limitations of earlier two-to three-wave studies based on cross-time mean comparisons (Bach & Hagenauer, 2022; Swan et al., 2011; Woolfolk Hoy & Spero, 2005). Three findings stand out. First, TSE showed a small but reliable linear decline across all career phases, rather than the increase expected during teacher education. Second, entry into the induction phase was not associated with the anticipated negative level shift often posited in the context of early professional socialization processes (Dicke et al., 2015;

Table 8
Multilevel piecewise growth model with initial teaching motivation as moderator.

Parameter	B (SE)	95 % CI	*p*
Fixed effects: Piecewise base			
Intercept	0.025 (0.018)	[-0.010, 0.060]	0.161
Time (linear slope, per wave)	−0.020 (0.006)***	[-0.032, −0.009]	<0.001
Induction phase (ref. TEP)	0.003 (0.021)	[-0.038, 0.044]	0.891
In-service entry (ref. TEP)	0.090 (0.029)**	[0.033, 0.148]	0.002
Fixed effects: Predictor main effects			
pedagocial interest	0.210 (0.021)***	[0.169, 0.251]	<0.001
subject interest	0.048 (0.021)*	[0.005, 0.090]	0.027
financial utility	−0.014 (0.023)	[-0.060, 0.032]	0.556
time utility	0.049 (0.023)*	[0.003, 0.095]	0.035
social influence	−0.011 (0.024)	[-0.057, 0.036]	0.653
low demands	−0.087 (0.024)***	[-0.135, −0.039]	<0.001
Fixed effects: Predictor × Linear slope			
Linear slope × pedagocial interest	−0.006 (0.007)	[-0.020, 0.009]	0.455
Linear slope × subject interest	−0.007 (0.007)	[-0.021, 0.007]	0.328
Linear slope × financial utility	−0.007 (0.007)	[-0.022, 0.007]	0.331
Linear slope × time utility	0.003 (0.007)	[-0.012, 0.018]	0.703
Linear slope × social influence	0.002 (0.008)	[-0.014, 0.017]	0.833
Linear slope × low demands	−0.006 (0.007)	[-0.020, 0.009]	0.453
Fixed effects: Predictor × Level shifts			
Induction shift × pedagocial interest (std)	−0.000 (0.025)	[-0.050, 0.049]	0.985
Induction shift × subject interest	−0.009 (0.025)	[-0.059, 0.041]	0.723
Induction shift × financial utility	0.027 (0.028)	[-0.027, 0.082]	0.321
Induction shift × time utility	−0.004 (0.027)	[-0.057, 0.050]	0.892
Induction shift × social influence	−0.021 (0.028)	[-0.077, 0.035]	0.453
Induction shift × low demands	0.033 (0.026)	[-0.018, 0.084]	0.206
In-service entry × pedagocial interest	0.011 (0.037)	[-0.061, 0.084]	0.756
In-service entry × subject interest	−0.005 (0.035)	[-0.075, 0.064]	0.881
In-service entry × financial utility	0.047 (0.037)	[-0.026, 0.121]	0.206
In-service entry × time utility	−0.035 (0.038)	[-0.110, 0.039]	0.351
In-service entry × social influence	−0.012 (0.040)	[-0.090, 0.067]	0.77
In-service entry × low demands	0.021 (0.036)	[-0.049, 0.092]	0.549
Random effects			
Within-person variance (σ^2)	0.448		
Between-person variance (τ_{00})	0.489		
Random slope variance (τ_{11})	0.008		
ICC	0.522		

Note. Unstandardized coefficients with standard errors in parentheses. Time coefficients expressed per wave (≈1 year). Estimation by REML on 20 multiple imputed datasets, pooled via Rubin's rules. Satterthwaite-corrected *p*-values. *ICC* = intraclass correlation coefficient. *N* = 2719 participants, 12,123 observations.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 9
Multilevel piecewise growth model with personaliy as moderator.

Parameter	B (SE)	95 % CI	p
Fixed effects: Piecewise base			
Intercept	0.020 (0.018)	[-0.016, 0.055]	0.278
Time (linear slope, per wave)	−0.020 (0.006)**	[-0.031, −0.008]	0.001
Induction phase (ref. TEP)	0.005 (0.021)	[-0.037, 0.046]	0.823
In-service entry (ref. TEP)	0.088 (0.029)**	[0.030, 0.146]	0.003
Fixed effects: Predictor main effects			
Extraversion	0.006 (0.019)	[-0.031, 0.044]	0.744
Conscientiousness	−0.031 (0.020)	[-0.070, 0.008]	0.115
Neuroticism	−0.036 (0.019)	[-0.073, 0.002]	0.064
Openness to new experience	0.024 (0.018)	[-0.012, 0.060]	0.191
Fixed effects: Predictor × Linear slope			
Linear slope × Extraversion	0.001 (0.006)	[-0.011, 0.014]	0.822
Linear slope × Conscientiousness	−0.000 (0.006)	[-0.012, 0.012]	0.965
Linear slope × Neuroticism	−0.001 (0.006)	[-0.013, 0.012]	0.916
Linear slope × Openness to new experience	0.001 (0.006)	[-0.011, 0.014]	0.839
Fixed effects: Predictor × Level shifts			
Induction shift × Extraversion	−0.016 (0.022)	[-0.059, 0.027]	0.461
Induction shift × Conscientiousness	0.014 (0.022)	[-0.030, 0.058]	0.536
Induction shift × Neuroticism	0.003 (0.023)	[-0.042, 0.047]	0.912
Induction shift × Openness to new experience	0.003 (0.022)	[-0.041, 0.046]	0.908
In-service entry × Extraversion	−0.046 (0.030)	[-0.106, 0.014]	0.131
In-service entry × Conscientiousness	0.022 (0.030)	[-0.038, 0.081]	0.474
In-service entry × Neuroticism	0.000 (0.031)	[-0.061, 0.062]	0.99
In-service entry × Openness to new experience	−0.010 (0.031)	[-0.071, 0.050]	0.732
Random effects			
Within-person variance (σ^2)	0.449		
Between-person variance (τ_{00})	0.550		
Random slope variance (τ_{11})	0.008		
ICC	0.550		

Note. Unstandardized coefficients with standard errors in parentheses. Time coefficients expressed per wave (≈1 year). Estimation by REML on 20 multiple imputed datasets, pooled via Rubin's rules. Satterthwaite-corrected *p*-values. ICC = intraclass correlation coefficient. N = 2719 participants, 12,123 observations.
**p* < .05. ***p* < .01. ***p < .001.

Voss & Kunter, 2020). Instead, the average TSE level remained unchanged at this transition. Third, entry into in-service teaching was associated with a small but statistically significant upward shift, contrary to the negative shift anticipated, given the expectation that the assumption of full instructional and assessment responsibility would temporarily destabilize TSE (Hartl & Holzberger, 2022; Voss & Kunter, 2020). Across the full 8-year period, the cumulative average change in TSE remained small, and the inclusion of time-invariant predictors did not alter the trajectory components. At the same time, the random-slope variance revealed substantial heterogeneity in trajectories around this average pattern, indicating that average stability does not imply universal stability and that the time-invariant characteristics we examined did not capture the sources of this trajectory heterogeneity.

6.1. Development of TSE across career stages

Contrary to expectations derived from prior research, we found no evidence of average growth in TSE during university-based teacher education. Instead, our results show a small decline in TSE during TEP. This challenges the assumption that engagement in coursework and practical necessarily produces accumulating confidence. Rather, it aligns with arguments suggesting that early TSE may reflect optimistic prospective beliefs that become recalibrated as candidates encounter the demands of the profession (Baumert & Kunter, 2006; Tynjälä & Heikkinen, 2011; Weinstein, 1989). It is also consistent with Klassen and Chiu's (2010) characterization of TSE as a dynamic construct that fluctuates with personal characteristics and individuals' interpretations of their environment, rather than as a unidirectional growth process.

Similarly, the transition into the induction phase was not accompanied by a significant level shift in TSE. This result contradicts studies reporting an initial decline in TSE, particularly classroom-management self-efficacy, upon entering induction (Dicke et al., 2015), but is consistent with the broader observation that structured induction systems can buffer against early-career destabilization (Richter et al., 2013; Voss & Kunter, 2020). Within the OST framework (Bauer & Erdogan, 2011), beginner teachers in the induction phase gradually assume responsibility under supervision while continuing to have access to seminars and mentoring. This structural feature may sustain access to all four sources of efficacy (Bandura, 1997), particularly social persuasion via mentor feedback (Richter et al., 2013) and scaffolded mastery experiences, thereby attenuating the abrupt confrontation with classroom reality that is sometimes invoked to explain early-induction declines in TSE (Dicke et al., 2015; Voss & Kunter, 2020).

The most prominent change in TSE was observed at the transition into full in-service teaching, which was associated with a small, statistically significant positive level shift. This is contrary to the literature that found a temporary decline at this transition (e.g., Hartl & Holzberger, 2022). This observed positive shift could be attributed to several mechanisms. From a socialization perspective (Bauer & Erdogan, 2011), the formal acquisition of full professional status, including autonomous classroom decision-making and the removal of supervisory monitoring, may itself function as a source of efficacy through enhanced perceived agency. From a self-efficacy perspective (Bandura, 1997; Morris et al., 2017), the mastery experiences accumulated during the induction phase may translate into stable confidence once novice teachers operate without scaffolded supervision. The fact that neither a phase-specific linear slope nor a quadratic curvature improved fit beyond the level-shift specification indicates that the average post-transition trajectory does not deviate from the small linear decline observed across all phases; in particular, there was no detectable temporary dip-and-recovery pattern in the population-average trajectory as has been documented elsewhere (Hartl & Holzberger, 2022; Swan et al., 2011; Woolfolk Hoy & Spero, 2005).

Across all models, over half of the variance in TSE was attributable to stable between-person differences, with the remainder reflecting within-person fluctuations. This decomposition is broadly consistent with cross-national variance-component evidence from the TALIS study ((Vieluf et al., 2013)), where the bulk of TSE variance was contributed by the differences between teachers, with smaller contributions from school- and country-level factors. The random-slope component in our models revealed substantial heterogeneity in trajectories, indicating that the lack of pronounced change in the average trajectory masks substantial differences in how individuals develop over time. The inclusion of gender, teacher type, initial teaching motivation, and personality traits explained only a small share of this within-person variance; substantial between-person variability in trajectories persisted even though individual trajectories can vary meaningfully around that average.

6.2. Time-invariant predictors of TSE

Contrary to previous studies (Calkins et al., 2024; Fackler & Malmberg, 2016), gender was associated with neither baseline TSE nor with change over time. The absence of gender effects in longitudinal models suggests that previously reported differences may reflect contextual or task-specific factors rather than enduring disparities in global TSE (Calkins et al., 2024).

Consistent with prior research, school type was associated with differences in baseline TSE: primary teachers reported higher initial TSE than upper secondary and vocational teachers. Lower secondary and special-education teachers did not differ significantly from the primary reference group. These baseline differences are consistent with contextual disparities in instructional demands, student-group heterogeneity, and curricular expectations across school types (Klassen & Chiu, 2010; Wolters & Daugherty, 2007), as well as with broader differences in professional socialization environments (Kraft & Papay, 2014).

In contrast to baseline-only patterns reported by earlier studies, school type also moderated transition-related level shifts. The level shift from the TEP to the induction phase was less negative—that is, the transition was experienced as more positive—among upper secondary, vocational, and special education teachers than among primary teachers. Substantively, this means that primary teachers experienced a small downward shift at induction entry, while teachers in other school types did not. A similar pattern emerged at the transition from the induction to the in-service phase, with vocational and special-education teachers showing greater positive shifts than primary teachers. These transition-related differences are consistent with the view that primary education places particular demands on classroom management and student engagement skills (Klassen & Chiu, 2010; Ryan et al., 2015), making the induction phase a more efficacy-relevant transition point in this context. They also illustrate that the trajectories of TSE—not its baseline levels alone—vary by school context, even if the within-stage rate of change does not.

Intrinsic motivation for choosing the teaching profession emerged as the strongest individual-difference predictor of TSE. Pedagogical interest exhibited a particularly large positive association with baseline TSE, and including motivational variables in the model reduced between-person variance. This is consistent with theoretical accounts of motivation as a stable orientation that filters how teachers interpret efficacy-relevant experiences ((Watt & Richardson, 2007)) and with empirical work linking intrinsic motivation to professional engagement and persistence (Bilim, 2014; Calkins et al., 2024; Thornberg et al., 2025). Among extrinsic indicators, time utility was positively related to TSE, while perceived study demands were negatively related, but neither financial utility nor social influence reached statistical significance. Motivational variables did not interact with any trajectory component, indicating that motivation for choosing the teaching profession is associated with teachers' starting point but not their rate or direction of change. This pattern aligns with Klassen and Chiu's (2010) view of TSE, which holds that while initial motivational orientations provide the lens through which efficacy-relevant experiences are evaluated, they do not directly shape the developmental curve. However, these findings should be interpreted in light of the fact that only teachers' initial career motives were included in the analyses. From a Self-Determination Theory perspective, motivation is expected to evolve across teacher education and early career as a function of ongoing interactions between individuals and their environment (Ryan & Deci, 2020).

Contrary to expectations from prior research (Djigić et al., 2014; Senler & Sungur-Vural, 2013), no personality trait was significantly associated with either baseline TSE or any trajectory component, although neuroticism showed a negative but insignificant trend in the predicted direction. These null findings should be interpreted in light of the limited reliability of the abbreviated two-item personality scales used in this study (Rammstedt & John, 2007). It is also possible that personality is more strongly linked to domain-specific TSE (e.g., classroom-management self-efficacy under stress) or to situational variability than to the stable global construct we examined ((Kim et al., 2019)). The present results are therefore best interpreted as inconclusive regarding the personality–TSE link rather than as evidence that personality is unrelated to TSE development.

6.3. Limitations and future research

Several limitations of this study concerning the data structure, attrition, modeling constraints, measurement limitations, generalizability, and causal inference should be acknowledged when interpreting its results.

Data collection points were unevenly distributed across all career stages. While we accounted for variations in career-stage progression, we did not consider the underlying reasons for differences in training duration, which may influence TSE development. Furthermore, we did not observe the students for the first 3–4 years of their TEP, which limits our ability to draw conclusions about early TSE development. Panel attrition may have introduced bias despite appropriate handling of missing values using FIML and multiple imputation methods. Teachers who left the study may have differed systematically from those who remained, meaning that late-career patterns may partly reflect changes in sample composition rather than universal within-person development. Although a missing-at-random assumption is plausible given the covariates included in our models, interpretations of the apparent TSE trajectories in later career stages should remain cautious. Teachers who did not participate in the last wave showed a steeper decline at entry into the induction phase than those who remained in the study. Accordingly, the estimated change associated with entry into the induction phase should be interpreted with some caution.

The induction phase was modeled using a level-shift parameter rather than a within-stage slope because participants contributed an average of only 1.5 observations during this period. Within-induction developmental change could therefore not be tested, and prior inconsistent findings on within-stage induction trajectories (Bacon, 2020; Dicke et al., 2015; Richter et al., 2013) cannot be addressed with the present data.

Motivation to pursue a teaching career was assessed only once as a retrospective measure of teachers' initial career motives and modeled as a time-invariant predictor. However, there is evidence that motivation changes across career stages (Ponnock et al., 2018), consistent with Self-Determination Theory (Ryan & Deci, 2020). Consequently, the observed associations should be interpreted as reflecting the relation between initial career motives and TSE rather than the effects of motivation throughout the study period. Future longitudinal research should therefore examine how changes in teaching motivation and TSE reciprocally influence one another over time. Personality traits were measured using a short scale that, despite demonstrating adequate convergent validity in prior research (Rammstedt & John, 2007), may not reflect the Big Five personality traits.

Furthermore, the analyses were limited to time-invariant predictors. Time-varying contextual factors, such as perceived stress, mentoring quality, workload, and organizational support, are central to self-efficacy theory (Bandura, 1997) and should be included in future research. Finally, we assessed general rather than domain-specific TSE, which may provide a more nuanced understanding of how different self-efficacy dimensions fluctuate over time and across instructional contexts. Future research should incorporate these specific facets of TSE to obtain a more comprehensive understanding of its developmental trajectory.

The focus on normative developmental patterns and differences between career stages, limited exploration of individual predictors of TSE development. Future research should examine how individual factors (e.g., coping strategies and professional identity development) interact with contextual factors to shape TSE trajectories. While the sample was large and representative of the German teacher education system, the generalizability of our findings to other educational contexts remains ambiguous. Cross-cultural studies should be conducted to provide valuable insights into how contextual factors influence the development of professional beliefs.

Despite the longitudinal study design, we cannot make causal claims about the factors influencing TSE trajectories. Experimental studies examining the impacts of interventions would provide stronger evidence of effective approaches to fostering positive professional beliefs. Finally, the COVID-19 pandemic occurred during the observation period, leading to school closures that may also have affected TSE trajectories (Pressley & Ha, 2021).

6.4. Implications

Our findings may offer relevant considerations for TEPs and professional development initiatives. Given differences in TSE levels and trajectories across career stages, it is reasonable to adopt a differentiated perspective that considers the specific characteristics and demands of each stage. Because higher TSE has been associated with more effective instructional practices and mastery-oriented classroom environments (Jerrim et al., 2025; Lazarides et al., 2018; Zee & Koomen, 2016), fostering TSE throughout the early career may contribute not only to teachers' professional development but also to instructional quality.

Our findings suggest that prospective teachers begin their training with relatively high TSE and that this initial confidence exhibits a small but reliable downward trend across the teacher education phases. This is consistent with the interpretation that early TSE may reflect optimistic prospective beliefs that become recalibrated as candidates gain practical experience (Baumert & Kunter, 2006; Tynjälä & Heikkinen, 2011). The absence of a sharp downward shift at the entry into the induction phase challenges the characterization of this transition as a “reality shock” in the German context (Dicke et al., 2015; Voss & Kunter, 2020) and points to the structured support system characteristic of the German induction phase as a plausible buffering mechanism.

Our findings on inter-individual differences in TSE trajectories suggest that broad generalizations of a linear development of beginner teachers’ TSE across career stages should be treated with caution, as substantial variation was observed among teacher candidates. Thus, one-size-fits-all approaches to teacher professional development may not be optimally effective. Instead, more targeted strategies that acknowledge transitional phases and provide tailored support during these periods appear to be more promising.

Furthermore, the average stability of TSE at the transition into the German induction phase may be indicative of the potential value of structured mentoring and graded introductions to teaching responsibilities. However, alternative explanations cannot be ruled out, including selection processes by which less efficacious candidates leave the pathway before this transition. Although our design did not allow us to examine within-induction change directly, the stable average TSE level at this transition is at least consistent with theoretical accounts emphasizing how structured induction systems can provide continued access to the four sources of efficacy (Bandura, 1997), including scaffolded mastery experiences (Dicke et al., 2015), vicarious learning through expert observation (Cabaroglu, 2014; Grammatikopoulos et al., 2013), social persuasion via mentor feedback (Gratacós et al., 2023; Munshi, 2018; Richter et al., 2013), and support for managing emotional demands during challenging situations (Voss & Kunter, 2020). The pattern observed in our data—average stability at the TEP-to-induction transition followed by a small upward shift at induction-to-in-service entry—contributes longitudinal evidence to the literature, which has thus far relied largely on cross-time mean comparisons of two or three waves.

The school-type moderation findings carry an additional implication. Whereas primary teachers reported higher baseline TSE, they also experienced the more pronounced negative shift at the TEP-to-induction transition; teachers in other school types did not. This pattern suggests that the efficacy-relevant demands of the induction phase differ across instructional contexts. Targeted induction support may therefore benefit primary teachers in particular, especially in domains (e.g., classroom management of large mixed-age groups) where the early shift from training to autonomous practice represents a particularly steep efficacy demand (Klassen & Chiu, 2010; Ryan et al., 2015). Differentiated mentoring calibrated to the instructional demands of each school type could plausibly attenuate this transition-specific dip.

Finally, the small average linear decline of TSE across the 8-year period, accompanied by considerable inter-individual variation in trajectories and punctuated by a small but reliable upward shift at entry into in-service teaching, suggests that teachers may benefit from ongoing support throughout their careers, not solely during initial teacher education or early career stages. Professional development programs could be tailored to address the specific challenges of a teaching career, paying particular attention to periods when TSE typically declines. For example, studies have shown that the disruptions caused by the COVID-19 pandemic led to decreased self-efficacy. Research also suggests that the demands of teaching heterogeneous student populations can affect TSE (Fackler et al., 2021; Fackler & Malmberg, 2016). Teacher support could include the provision of continued access to high-quality mastery experiences through structured professional development with practical implementation (Palmer, 2011; Tschannen-Moran & McMaster, 2009), vicarious experiences through peer observation and team teaching (Mather & Visone, 2024; Mintzes et al., 2013), social persuasion through professional learning communities and instructional coaching (Hoogendijk et al., 2018; Smith et al., 2020), and addressing physiological and emotional states with support for managing stress and preventing burnout (Buonomo et al., 2019; Burić et al., 2020).

7. Conclusion

This study extends previous TSE research by modeling within-stage developmental trajectories and changes associated with career-stage entry over an 8-year period in a large nationally representative sample of German teachers. The findings reveal a complex picture: rather than the upward trajectory often reported by shorter-term studies of teacher education, the average TSE trajectory showed a small but reliable linear decline across all career phases. Structural career transitions were associated with average changes in TSE levels rather than gradual changes in developmental trajectories. Contrary to expectations, entry into the induction phase was not accompanied by a decline in TSE, whereas entry into in-service teaching was followed by a small positive increase. Initial intrinsic motivation to pursue a teaching career and primary-school teaching were associated with higher baseline TSE. Furthermore, TSE level shifts at career transitions varied across school types, most notably for primary teachers, who experienced a more pronounced negative shift at the entry into the induction phase than teachers in other school types. Substantial individual variation in trajectories highlights that one-size-fits-all approaches to professional development may be poorly matched to the heterogeneity of teacher development. By separating the within-phase developmental trajectories of TSE from changes associated with career-stage entry, and by examining development over an 8-year period while accounting for individual differences in trajectories, this study extends existing research on the longitudinal development of TSE across early career stages.

CRediT authorship contribution statement

Sebastian Franz: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft. **Jennifer Paetsch:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Sebastian Franz reports was provided by KU University Eichstätt-Ingolstadt. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

References

Bach, A., & Hagenauer, G. (2022). Joy, anger, and anxiety during the teaching practicum: How are these emotions related to dimensions of pre-service teachers' self-efficacy? *Zeitschrift Für Bildungsforschung, 12*(2), 295–311. https://doi.org/10.1007/s35834-022-00343-9

Bacon, W. J. (2020). New teacher induction: Improving teacher self-efficacy. *[Doctoral Dissertation, University of Kentucky Libraries]*. https://doi.org/10.13023/ETD.2020.109

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W.H.Freeman and Company.

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., Dai, B., Grothendieck, G., Green, P., & Bolker, M. B. (2015). Package ‘lme4’. *Convergence, 12*(1), 2.

Bauer, T. N., & Erdogan, B. (2011). Organizational socialization: The effective onboarding of new employees. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology, 3* pp. 51–64). American Psychological Association. https://doi.org/10.1037/12171-002. *Maintaining, expanding, and contracting the organization*.

Baumert, J., & Kunter, M. (2006). Stichwort: Professionelle Kompetenz von Lehrkräften [Keyword: Professional competence of teachers]. *Zeitschrift für Erziehungswissenschaft, 9*(4), 469–520. https://doi.org/10.1007/s11618-006-0165-2

Berg, D. A., & Smith, L. F. (2018). The effect of school-based experience on preservice teachers' self-efficacy beliefs. *Issues in Educational Research, 28*(3), 530–544.

Bilim, I. (2014). Pre-service elementary teachers' motivations to become a teacher and its relationship with teaching self-efficacy. *Procedia - Social and Behavioral Sciences, 152*, 653–661. https://doi.org/10.1016/j.sbspro.2014.09.258

Blossfeld, H.-P., & Roßbach, H.-G. (Eds.). (2019). *Education as a lifelong process: The German National Educational Panel Study (NEPS)* (2nd ed.). Fachmedien Wiesbaden: Springer. https://doi.org/10.1007/978-3-658-23162-0.

Buonomo, I., Fiorilli, C., & Benevene, P. (2019). The impact of emotions and hedonic balance on teachers' self-efficacy: Testing the bouncing back effect of positive emotions. *Frontiers in Psychology, 10*, 1670. https://doi.org/10.3389/fpsyg.2019.01670

Burić, I., Slišković, A., & Sorić, I. (2020). Teachers' emotions and self-efficacy: A test of reciprocal relations. *Frontiers in Psychology, 11*. https://doi.org/10.3389/fpsyg.2020.01650. Article 1650.

Burić, Irena, & Kim, Lisa E. (2020). Teacher self-efficacy, instructional quality, and student motivational beliefs: An analysis using multilevel structural equation modeling. *Learning and Instruction, 66*, 101302. https://doi.org/10.1016/j.learninstruc.2019.101302. https://linkinghub.elsevier.com/retrieve/pii/S0959475219300222, 101302.

Cabaroglu, N. (2014). Professional development through action research: Impact on self-efficacy. *System, 44*, 79–88. https://doi.org/10.1016/j.system.2014.03.003

Calkins, L., Wiens, P., Parker, J., & Tschinkel, R. (2024). Teacher motivation and self-efficacy: How do specific motivations for entering teaching relate to teacher self-efficacy? *Journal of Education, 204*(2), 427–438. https://doi.org/10.1177/00220574221142300

Chao, C. N. G., Chow, W. S., Emily, Forlin, C., & Ho, F. C. (2017). Improving teachers' self-efficacy in applying teaching and learning strategies and classroom management to students with special education needs in Hong Kong. *Teaching and Teacher Education, 66*, 360–369. https://doi.org/10.1016/j.tate.2017.05.004

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal, 14*(3), 464–504. https://doi.org/10.1080/10705510701301834

Dicke, T., Elling, J., Schmeck, A., & Leutner, D. (2015). Reducing reality shock: The effects of classroom management skills training on beginning teachers. *Teaching and Teacher Education, 48*, 1–12. https://doi.org/10.1016/j.tate.2015.01.013

Djigić, G., Stojiljković, S., & Dosković, M. (2014). Basic personality dimensions and teachers' self-efficacy. *Procedia - Social and Behavioral Sciences, 112*, 593–602. https://doi.org/10.1016/j.sbspro.2014.01.1206

Duan, S., Bissaker, K., & Xu, Z. (2024). Correlates of teachers' classroom management self-efficacy: A systematic review and meta-analysis. *Educational Psychology Review, 36*, 43. https://doi.org/10.1007/s10648-024-09881-2

Enders, C. K. (2010). *Applied missing data analysis*. Guilford Press.

Fackler, S., Malmberg, L.-E., & Sammons, P. (2021). An international perspective on teacher self-efficacy: Personal, structural and environmental factors. *Teaching and Teacher Education, 99*. https://doi.org/10.1016/j.tate.2020.103255. Article 103255.

Fackler, S., & Malmberg, L.-E. (2016). Teachers' self-efficacy in 14 OECD countries: Teacher, student group, school and leadership effects. *Teaching and Teacher Education, 56*(56), 185–195. https://doi.org/10.1016/j.tate.2016.03.002

Fantilli, R. D., & McDougall, D. E. (2009). A study of novice teachers: Challenges and supports in the first years. *Teaching and Teacher Education, 25*(6), Article 814e825. https://doi.org/10.1016/j.tate.2009.02.021

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record: The Voice of Scholarship in Education, 103*(6), 1013–1055.

Flora, D. B. (2008). Specifying piecewise latent trajectory models for longitudinal data. *Structural Equation Modeling, 15*(3), 513–533. https://doi.org/10.1080/10705510802154349

Franz, S., Fackler, S., & Paetsch, J. (2022). Profiles of pre-service teachers' personality traits and cognitive abilities: Relations with graduation and teacher self-efficacy. *European Journal of Teacher Education*. https://doi.org/10.1080/02619768.2022.2114896

Garvis, S., Fluckiger, B., & Twigg, D. (2012). Exploring the beliefs of commencing early childhood education graduate students: Providing insights to improve teacher education programs. *Australian Journal of Teacher Education, 37*(1), 93–105. https://doi.org/10.14221/ajte.2012v37n1.3

George, S. V., Richardson, P. W., & Watt, H. M. (2018). Early career teachers' self-efficacy: A longitudinal study from Australia. *Australian Journal of Education, 62*(2), 217–233. https://doi.org/10.1177/0004944118779601

Gold, B., Hellermann, C., & Holodynski, M. (2017). Effekte videobasierter Trainings zur Förderung der Selbstwirksamkeitsüberzeugungen über Klassenführung im Grundschulunterricht [Effects of video-based training to promote self-efficacy beliefs about classroom management in elementary school teaching]. *Zeitschrift für Erziehungswissenschaft, 20*(S1), 115–136. https://doi.org/10.1007/s11618-017-0727-5

Grammatikopoulos, V., Tsigilis, N., Gregoriadis, A., & Bikos, K. (2013). Evaluating an induction training program for Greek teachers using an adjusted level model approach. *Studies In Educational Evaluation, 39*(4), 225–231. https://doi.org/10.1016/j.stueduc.2013.09.002

Gratacós, G., Mena, J., & Ciesielkiewicz, M. (2023). The complexity thinking approach: Beginning teacher resilience and perceived self-efficacy as determining variables in the induction phase. *European Journal of Teacher Education, 46*(2), 331–348. https://doi.org/10.1080/02619768.2021.1900113

Grossman, P., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching: Theory and Practice, 15*(2), 273–289. https://doi.org/10.1080/13540600902875340

Hartl, A., & Holzberger, D. (2022). Identifying teachers' motivational profiles and their changes from teacher education into practice: A longitudinal study. *Zeitschrift für Erziehungswissenschaft, 25*(2), 427–451. https://doi.org/10.1007/s11618-022-01093-0

Hayes, R., Titheradge, D., Allen, K., Allwood, M., Byford, S., Edwards, V., Hansford, L., Longdon, B., Norman, S., Norwich, B., Russell, A. E., Price, A., Ukoumunne, O. C., & Ford, T. (2020). The incredible years® teacher classroom management programme and its impact on teachers' professional self-efficacy, work-related stress, and general well-being: Results from the STARS randomized controlled trial. *British Journal of Educational Psychology, 90*(2), 330–348. https://doi.org/10.1111/bjep.12284

Holzberger, D., Philipp, A., & Kunter, M. (2014). Predicting teachers' instructional behaviors: The interplay between self-efficacy and intrinsic needs. *Contemporary Educational Psychology, 39*(2), 100–111. https://doi.org/10.1016/j.cedpsych.2014.02.001

Hoogendijk, C., Tick, N. T., Hofman, W. H. A., Holland, J. G., Severiens, S. E., Vuijk, P., & Van Veen, A. F. D. (2018). Direct and indirect effects of Key2Teach on teachers' sense of self-efficacy and emotional exhaustion, a randomized controlled trial. *Teaching and Teacher Education, 76*, 1–13. https://doi.org/10.1016/j.tate.2018.07.014

Hox, J. J. (2010). *Multilevel analysis* (2nd ed.). Routledge.

Hoy, W. K., & Woolfolk, A. E. (1990). Socialization of student teachers. *American Educational Research Journal, 27*(2), 279–300.

Hußner, I., Lazarides, R., Symes, W., Richter, E., & Westphal, A. (2023). Reflect on your teaching experience: Systematic reflection of teaching behaviour and changes in student teachers' self-efficacy for reflection. *Zeitschrift für Erziehungswissenschaft, 26*(5), 1301–1320. https://doi.org/10.1007/s11618-023-01190-8

Hußner, I., Lazarides, R., & Westphal, A. (2022). COVID-19-bedingte Online- vs. Präsenzlehre: Differentielle Entwicklungsverläufe von Beanspruchung und Selbstwirksamkeit in der Lehrkräftebildung? [COVID-19-related online vs. face-to-face teaching: Differential development trajectories of stress and self-efficacy in teacher training?]. *Zeitschrift für Erziehungswissenschaft, 25*(5), 1243–1266. https://doi.org/10.1007/s11618-022-01072-5

Ingersoll, R. M., & Strong, M. (2011). The impact of induction and mentoring programs for beginning teachers: A critical review of the research. *Review of Educational Research, 81*(2), 201–233. https://doi.org/10.3102/0034654311403323

Jerrim, J., Prieto-Latorre, C., Marcenaro-Gutierrez, O. D., & Shure, N. (2025). Teacher self-efficacy, instructional practice, and student outcomes: Evidence from the TALIS video study. *American Educational Research Journal*. https://doi.org/10.3102/00028312241300265

Kim, Lisa E., Jörg, Verena, & Klassen, Robert M. (2019). A Meta-Analysis of the Effects of Teacher Personality on Teacher Effectiveness and Burnout. *Educational Psychology Review, 31*(1), 163–195. https://doi.org/10.1007/s10648-018-9458-2. http://link.springer.com/10.1007/s10648-018-9458-2. (Accessed 2 January 2019)

Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of Educational Psychology, 102*(3), 741–756. https://doi.org/10.1037/a0019237

Klassen, R. M., & Durksen, T. L. (2014). Weekly self-efficacy and work stress during the teaching practicum: A mixed methods study. *Learning and Instruction, 33*, 158–169. https://doi.org/10.1016/j.learninstruc.2014.05.003

Klassen, R. M., & Tze, V. M. (2014). Teachers' self-efficacy, personality, and teaching effectiveness: A meta-analysis. *Educational Research Review, 12*, 59–76. https://doi.org/10.1016/j.edurev.2014.06.001

Klusmann, Uta, Kunter, Mareike, Trautwein, Ulrich, Lüdtke, Oliver, & Baumert, Jürgen (2008). Teachers' occupational well-being and quality of instruction: The important role of self-regulatory patterns. *Journal of Educational Psychology, 100*(3), 702–715. https://dx.doi.org/10.1037/0022-0663.100.3.702. https://dx.doi.org/10.1037/0022-0663.100.3.702, 8 2008.

Knoblauch, D., & Chase, M. A. (2015). Rural, suburban, and urban schools: The impact of school setting on the efficacy beliefs and attributions of student teachers. *Teaching and Teacher Education, 45*, 104–114. https://doi.org/10.1016/j.tate.2014.10.001

Künsting, J., Neuber, V., & Lipowsky, F. (2016). Teacher self-efficacy as a long-term predictor of instructional quality in the classroom. *European Journal of Psychology of Education, 31*(3), 299–322. https://doi.org/10.1007/s10212-015-0272-7

Kraft, M. A., & Papay, J. P. (2014). Can professional environments in schools promote teacher development? Explaining heterogeneity in returns to teaching experience. *Educational Evaluation and Policy Analysis, 36*(4), 476–500. https://doi.org/10.3102/0162373713519496

Kuznetsova, Alexandra, Brockhoff, Per B., & Christensen, Rune H. B. (2017). lmerTest Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software, 82*(13). https://doi.org/10.18637/jss.v082.i13. http://www.jstatsoft.org/v82/i13/, 2017.

Lazarides, R., Buchholz, J., & Rubach, C. (2018). Teacher enthusiasm and self-efficacy, student-perceived mastery goal orientation, and student motivation in mathematics classrooms. *Teaching and Teacher Education, 69*, 1–10. https://doi.org/10.1016/j.tate.2017.08.017

Ma, K., Chutiyami, M., Zhang, Y., & Nicoll, S. (2021). Online teaching self-efficacy during COVID-19: Changes, its associated factors and moderators. *Education and Information Technologies, 26*(6), 6675–6697. https://doi.org/10.1007/s10639-021-10486-3

Mackinnon, S., Curtis, R., & O'Connor, R. (2022). A tutorial in longitudinal measurement invariance and cross-lagged panel models using lavaan. *Meta-Psychology, 6*. https://doi.org/10.15626/MP.2020.2595

Martins, M., Costa, J., & Onofre, M. (2015). Practicum experiences as sources of pre-service teachers' self-efficacy. *European Journal of Teacher Education, 38*(2), 263–279. https://doi.org/10.1080/02619768.2014.968705

Mather, B. R., & Visone, J. D. (2024). Peer observation to improve teacher self-efficacy. *Journal of Educational Research and Practice, 14*(1). https://doi.org/10.5590/JERAP.2024.14.01

Mintzes, J. J., Marcum, B., Messerschmidt-Yates, C., & Mark, A. (2013). Enhancing self-efficacy in elementary science teaching with professional learning communities. *Journal of Science Teacher Education, 24*(7), 1201–1218. https://doi.org/10.1007/s10972-012-9320-1

Morris, D. B., Usher, E. L., & Chen, J. A. (2017). Reconceptualizing the sources of teaching self-efficacy: A critical review of emerging literature. *Educational Psychology Review, 29*, 795–833. https://doi.org/10.1007/s10648-016-9378-y

Munshi, A. (2018). *Induction programs, teacher efficacy, and inquiry practices in novice teachers*. [Doctoral Dissertation, San Jose State University]. https://doi.org/10.31979/etd.pk8d-cyvt

NEPS Network. (2024). National educational panel study, scientific use file of starting cohort first-year students. *Leibniz Institute for Educational Trajectories (LIfBi), Bamberg*. https://doi.org/10.5157/NEPS:SC5:19.0.0

OECD. (2005). *Attracting, developing and retaining effective teachers – Final report: Teachers matter*. Paris: OECD.

Ortenburger, A., Gäckle, S., Menge, C., & Franz, S. (2023). Skalenhandbuch Lehramtsstudierenden-Panel: Dokumentation des Erhebungsprogramms der LAP-Zusatzstudie zur NEPS-Längsschnittuntersuchung der Studienanfängerinnen und Studienanfänger des Wintersemesters 2010/2011 (NEPS-Startkohorte 5) [Scale Manual for the Teacher Education Student Panel: Documentation of the survey program for the LAP supplementary study of the NEPS longitudinal study of first-year university students in the 2010/2011 winter semester (NEPS Cohort 5)]. *LIfBi Working Papers*. https://doi.org/10.5157/LIFBI:WP111:1.0

Palmer, D. (2011). Sources of efficacy information in an inservice program for elementary teachers. *Science Education, 95*(4), 577–600. https://doi.org/10.1002/sce.20434

Pfitzner-Eden, F. (2016). Why do i feel more confident? Bandura's sources predict preservice teachers' latent changes in teacher self-efficacy. *Frontiers in Psychology, 7*. https://doi.org/10.3389/fpsyg.2016.01486

Pohlmann, B., & Möller, J. (2010). Fragebogen zur Erfassung der Motivation für die Wahl des Lehramtsstudiums (FEMOLA) [Questionnaire to determine motivation for choosing to study teaching]. *Zeitschrift fur Pädagogische Psychologie, 24*(1), 73. https://doi.org/10.1024/1010-0652.a000005

Ponnock, A. R., Torsney, B. M., & Lombardi, D. (2018). Motivational differences throughout teachers' preparation and career. *New Waves-Educational Research and Development Journal, 21*(2), 26–45.

Pressley, T., & Ha, C. (2021). Teaching during a pandemic: United States teachers' self-efficacy during COVID-19. *Teaching and Teacher Education, 106*, Article 103465. https://doi.org/10.1016/j.tate.2021.103465

Prilop, C. N., Weber, K. E., Prins, F. J., & Kleinknecht, M. (2021). Connecting feedback to self-efficacy: Receiving and providing peer feedback in teacher education. *Studies In Educational Evaluation, 70*, Article 101062. https://doi.org/10.1016/j.stueduc.2021.101062

R Core Team. (2025). R: A Language and environment for statistical computing. https://www.R-project.org/.

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-Item short version of the big five inventory in English and German. *Journal of Research in Personality, 41*(1), 203–212. https://doi.org/10.1016/j.jrp.2006.02.001

Richter, D., Kunter, M., Lüdtke, O., Klusmann, U., Anders, Y., & Baumert, J. (2013). How different mentoring approaches affect beginning teachers' development in the first years of practice. *Teaching and Teacher Education, 36*, 166–177.

Richter, E., Lucksnat, C., Redding, C., & Richter, D. (2022). Retention intention and job satisfaction of alternatively certified teachers in their first year of teaching. *Teaching and Teacher Education, 114*, Article 103704. https://doi.org/10.1016/j.tate.2022.103704

Robitzsch, A., & Lüdtke, O. (2023). Why full, partial, or approximate measurement invariance are not a prerequisite for meaningful and valid group comparisons. *Structural Equation Modeling: A Multidisciplinary Journal, 30*(6), 859–870. https://doi.org/10.1080/10705511.2023.2191292

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5– 12 (BETA). *Journal of Statistical Software, 48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. Wiley.

Rushby, J. V., Klassen, R. M., Durksen, T. L., Pfaffel, A., & Bardach, L. (2025). Longitudinal effects of a scenario-based learning intervention on preservice teacher self-efficacy. *Teaching and Teacher Education, 154*, Article 104859. https://doi.org/10.1016/j.tate.2024.104859

Ryan, A. M., Kuusinen, C. M., & Bedoya-Skoog, A. (2015). Managing peer relations: A dimension of teacher self-efficacy that varies between elementary and middle school teachers and is associated with observed classroom quality. *Contemporary Educational Psychology, 41*, 147–156. https://doi.org/10.1016/j.cedpsych.2015.01.002

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology, 61*, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Savolainen, H., Malinen, O.-P., & Schwab, S. (2022). Teacher efficacy predicts teachers' attitudes towards inclusion – A longitudinal cross-lagged analysis. *International Journal of Inclusive Education, 26*(9), 958–972. https://doi.org/10.1080/13603116.2020.1752826

Schaeper, H., Ortenburger, A., Franz, S., Gäckle, S., Menge, C., & Wolter, I. (2023). The German panel of teacher education students: Surveying (prospective) teachers from higher education into working life. *Journal of Open Psychology Data, 11*(1), Article 7. https://doi.org/10.5334/jopd.76

Schleicher, A. (2018). Educating learners for their future, not our past. *ECNU Review of Education, 1*(1), 58–75. https://doi.org/10.30926/ecnuroe2018010104

Schlosser, A., & Paetsch, J. (2023). The role of emotion and reflection in the development of student teachers' self-efficacy when analyzing video lessons. *Frontiers in Psychology, 14*, Article 1080883. https://doi.org/10.3389/fpsyg.2023.1080883

Schwarzer, R., & Schmitz, G. S. (1999). Kollektive Selbstwirksamkeitserwartung von Lehrern: Eine Langsschnittstudie in zehn Bundesländern [Collective efficacy of teachers: A longitudinal study in ten German states]. *Zeitschrift für Sozialpsychologie, 30*(4), 262–274.

Senler, B., & Sungur-Vural, S. (2013). Pre-service science teachers' teaching self-efficacy in relation to personality traits and academic self-regulation. *Spanish Journal of Psychology, 16*. https://doi.org/10.1017/sjp.2013.22

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis*. Oxford Univ. Press.

Skaalvik, E. M., & Skaalvik, S. (2007). Dimensions of teacher self-efficacy and relations with strain factors, perceived collective teacher efficacy, and teacher burnout. *Journal of Educational Psychology, 99*(3), 611–625. https://doi.org/10.1037/0022-0663.99.3.611

Skaalvik, E. M., & Skaalvik, S. (2016). Teacher stress and teacher self-efficacy as predictors of engagement, emotional exhaustion, and motivation to leave the teaching profession. *Creative Education, 7*(13), 1785–1799. https://doi.org/10.4236/ce.2016.713182

Smith, E. C., Starratt, G. K., McCrink, C. L., & Whitford, H. (2020). Teacher evaluation feedback and instructional practice self-efficacy in secondary school teachers. *Educational Administration Quarterly, 56*(4), 671–701. https://doi.org/10.1177/0013161X19888568

Snijders, T. A. B., & Bosker, R. J. (2012). *Multilevel analysis* (2nd ed.). Sage.

Sterba, S. K. (2014). Fitting nonlinear latent growth curve models with individually varying time points. *Structural Equation Modeling, 21*(4), 630–647. https://doi.org/10.1080/10705511.2014.919828

Swan, B. G., Wolf, K. J., & Cano, J. (2011). Changes in teacher self–efficacy from the student teaching experience through the third year of teaching. *Journal of Agricultural Education, 52*(2), 128–139. https://doi.org/10.5032/jae.2011.02128

Thiel, F., Böhnke, A., Barth, V. L., & Ophardt, D. (2023). How to prepare preservice teachers to deal with disruptions in the classroom? Differential effects of learning with functional and dysfunctional video scenarios. *Professional Development in Education, 49*(1), 108–122. https://doi.org/10.1080/19415257.2020.1763433

Thornberg, R., Wänström, L., Lindqvist, H., Weurlander, M., & Wernerson, A. (2025). Motives for becoming a teacher, coping strategies and teacher efficacy among Swedish student teachers. *European Journal of Teacher Education, 48*(2), 365–383. https://doi.org/10.1080/02619768.2023.2175665

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*, 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23*(6), 944–956. https://doi.org/10.1016/j.tate.2006.05.003

Tschannen-Moran, M., & McMaster, P. (2009). Sources of self-efficacy: Four professional development formats and their relationship to self-efficacy and implementation of a new teaching strategy. *The Elementary School Journal, 110*(2), 228–245. https://doi.org/10.1086/605771

Täschner, J., Dicke, T., Reinhold, S., & Holzberger, D. (2024). "Yes, I Can!" A systematic review and meta-analysis of intervention studies promoting teacher self-efficacy. *Review of Educational Research, 95*(1), 3–52. https://doi.org/10.3102/00346543231221499

Tynjälä, P., & Heikkinen, H. L. T. (2011). Beginning teachers' transition from pre-service education to working life: Theoretical perspectives and best practices. *Zeitschrift für Erziehungswissenschaft, 14*(1), 11–33. https://doi.org/10.1007/s11618-011-0175-6

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). Mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software, 45*(3), 1–68. https://doi.org/10.18637/jss.v045.i03

Van der Scheer, E. A., & Visscher, A. J. (2016). Effects of an intensive data-based decision making intervention on teacher efficacy. *Teaching and Teacher Education, 60*, 34–43. https://doi.org/10.1016/j.tate.2016.07.025

Vieluf, Svenja, Kunter, Mareike, & van de Vijver, Fons J. R. (2013). Teacher self-efficacy in cross-national perspective. *Teaching and Teacher Education, 35*, 92–103. https://doi.org/10.1016/j.tate.2013.05.006. https://linkinghub.elsevier.com/retrieve/pii/S0742051X13000954

Voss, T., & Kunter, M. (2020). "Reality Shock" of beginning teachers? Changes in teacher candidates' emotional exhaustion and constructivist-oriented beliefs. *Journal of Teacher Education, 71*(3), 292–306. https://doi.org/10.1177/0022487119839700

Wang, Z., & Shen, L. (2022). The effects of personality traits on teaching efficacy of english teachers in Fujian-Taiwan cooperative universities in China. *International Journal of Academic Research in Business and Social Sciences, 12*(7), 1785–1796. https://doi.org/10.6007/IJARBSS/v12-i7/14419

Watt, Helen M. G., & Richardson, Paul W. (2007). Motivational Factors Influencing Teaching as a Career Choice: Development and Validation of the FIT-Choice Scale. *The Journal of Experimental Education, 75*(3), 167–202. https://doi.org/10.3200/jexe.75.3.167-202. http://www.tandfonline.com/doi/abs/10.3200/JEXE.75.3.167-202

Weber, K. E., Prilop, C. N., & Kleinknecht, M. (2019). Effects of blended and video-based coaching approaches on preservice teachers' self-efficacy and perceived competence support. *Learning, Culture and Social Interaction, 22*. https://doi.org/10.1016/j.lcsi.2019.100318. Article 100318.

Weinstein, C. S. (1989). Teacher education students' preconceptions of teaching. *Journal of Teacher Education, 40*(2), 53–60. https://doi.org/10.1177/002248718904000210

White, I. R., Royston, P., & Wood, A. M. (2011). Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine, 30*(4), 377–399. https://doi.org/10.1002/sim.4067

Wickham, H., Chang, W., & Wickham, M. H. (2016). Package 'ggplot2'. *Create elegant data visualisations using the grammar of graphics, 2*(1), 1–189.

Wohlkinger, F., Ditton, H., von Maurice, J., Haugwitz, M., & Blossfeld, H.-P. (2011). 10 motivational concepts and personality aspects across the life course. *Zeitschrift für Erziehungswissenschaft, 14*, 155–168. https://doi.org/10.1007/s11618-011-0184-5

Wolters, C. A., & Daugherty, S. G. (2007). Goal structures and teachers' sense of efficacy: Their relation and association to teaching experience and academic level. *Journal of Educational Psychology, 99*(1), 181–193. https://doi.org/10.1037/0022-0663.99.1.181

Woolfolk Hoy, A. W., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education, 21*(4), 343–356. https://doi.org/10.1016/j.tate.2005.01.007

Zee, M., Klassen, R. M., & Hanna, F. (2025). Navigating urban classrooms: The role of diversity-related stress and intentions to leave in preservice teachers' self-efficacy. *Teaching and Teacher Education, 160*, Article 105018. https://doi.org/10.1016/j.tate.2025.105018

Zee, M., Koomen, H. M. Y., Jellesma, F. C., Geerlings, J., & De Jong, P. F. (2016). Inter- and intra-individual differences in teachers' self-efficacy: A multilevel factor exploration. *Journal of School Psychology, 55*, 39–56. https://doi.org/10.1016/j.jsp.2015.12.003

Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research, 86*(4), 981–1015. https://doi.org/10.3102/0034654315626801

Zizhan, S., & Rafols, J. (2024). Determinants of primary school teachers' level of self-efficacy. *Journal of Interdisciplinary Perspectives, 2*(4), 138–147. https://doi.org/10.69569/jip.2024.0060