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RESEARCH ARTICLE

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Measuring teachers' motivation, beliefs, leadership engagement, and networks: validation of instruments for teacher education and professional development programs

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ABSTRACT

This paper presents two empirically developed and validated instruments that can be used to conduct quantitative and/or qualitative research on teacher education or evaluate professional development (PD) programs for teachers. The first instrument is a survey composed of Likert-scale items to gather quantitative data that were adapted from previously developed and validated scales related to competence, autonomy, and relatedness domains of self-determination theory. The areas measured include teaching self-efficacy, school-work-environment, leadership engagement, and diversity dispositions – all deemed important in teacher education and retention. The survey instrument provides a short and manageable way of measuring these different but related domains. The second instrument is a set of interview protocols to gather qualitative data on motivations behind teacher retention/mobility, leadership engagement, and teachers' social networks. The two instruments can be utilised separately for quantitative or qualitative studies or together in mixed-method studies. They provide an efficient, valid, and reliable way for both researchers to study teacher education and PD and practitioners to evaluate PD programs for teachers.

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Self-determination theory; program evaluation; teacher education/development; validity/reliability; retention; leadership

Introduction

Teacher retention and persistence are crucial first steps towards remedying teacher burnout and turnover in educational settings, especially for novice teachers in response to the challenges faced in high-need schools (Ansley *et al.*, 2019, Zavelevsky and Lishchinsky 2020). Retention goes beyond just teacher commitment and is driven by motivation (intrinsic value and self-efficacy for teaching), school-work environment, leadership skills, diversity dispositions, and social networks (Youngs *et al.*, 2015, Webb 2018, Balgopal *et al.*, 2022, Egan 2022, Zhou *et al.*, 2023). Assessing these factors often

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requires the utilisation of multiple, long, and involved instruments. Therefore, there is a need for streamlined and efficient instrumentation that targets multiple factors (Takahashi *et al.*, 2020, Sánchez *et al.*, 2021). Such instrumentation must be reliable and validated to ensure that defensible conclusions are drawn to assist policymakers, district leaders, and school administrators in developing protocols to ensure teacher retention and development (Hurst and Brantlinger 2022).

Validated instrumentation protocols are also needed for assessing efficacy of professional development programs (PD) or simply for providing evaluation of programs funded by organisations such as the National Science Foundation's (NSF) Robert Noyce Teachers Scholarship Program (Noyce), National Institute for Excellence in Teaching (NIET), Knowles Science Teacher Leadership Program (Knowles), the Canadian Association of Physicists (CAP), Now Teach of UK, the Australian Academy of Science, or LUMA Centre Finland. Typically, programs like these or other teacher PD programs may not have the opportunity to administer lengthy surveys, especially given constraints on teachers' time, and to avoid taking time from training. Long surveys can also compromise data quality because of the response burden on survey participants (Beebe *et al.*, 2010, Rolstad *et al.*, 2011, Andreadis and Kartsounidou 2020). Interview protocols are also needed to provide insights into teacher motivation and social interactions that quantitative measures may not be enough to unpack.

Study goals and intended uses

We employ a distinct approach to produce instruments that can be used in evaluating PD programs and/or studying teacher development by investigating the factors related to teacher retention (such as self-efficacy, school-work environment, leadership, dispositions, and social networks) through the lenses of self-determination theory (SDT; Ryan and Deci 2017). Since the vast majority of the SDT literature focuses on student learning and self-regulation, numerous scales offered by the literature centre around extrinsic and intrinsic motivation and students (Howard *et al.*, 2017). Several dimensions proposed and studied in past research include contextual motivation, situational motivation, intrinsic/extrinsic motivation, and academic motivation (e.g. Chanal *et al.*, 2025). This study contributes to the field by not only offering instruments to be used by both practitioners and researchers but also by offering a different perspective on and utilisation of SDT for teacher development and retention introducing self-efficacy, school-work environment, leadership engagement, diversity dispositions, community connections, and social networks.

Our goals here were to: (a) produce a single survey instrument composed of different scales that related to teacher motivation, beliefs, and out-of-class actions, and (b) develop interview protocols that provide insights into teachers' motivation/retention, leadership, and social networks. The survey serves as a quantitative instrument, and the interview protocols serve as qualitative instruments. Researchers can use the survey in quantitative research and the interview protocols in qualitative research separately. They can also utilise these instruments together in mixed-method studies to compare or combine quantitative and qualitative data (i.e. convergent design; Creswell and Plano Clark 2018) or start with the survey followed by interviews (i.e. explanatory sequential design; Creswell and Plano Clark 2018).

In addition, the survey instrument and interview protocols can be used in specific teacher education and PD programs affiliated with organisations such as Noyce, Knowles, CAP, or LUMA to measure program impact (as a program evaluation or an impact study). For this purpose, project/program directors or program evaluators align their activities with priorities and expectations explicitly delineated by the sponsor or affiliated organisations sanctioning the PD programs, and typically share their reports primarily with the funding agency instead of outside stakeholders. These efforts are often more focused and narrow, intending to assess progress and satisfy external commitments only, and so are better described as evaluation rather than research studies (Wanzer 2021).

Quantitative and qualitative instruments tapping into several areas that relate to teacher persistence will be of value for teacher educators and researchers. When used together as in a mixed-method convergent design (see Creswell and Plano Clark 2018), results can be compared and combined to obtain a more complete understanding of the problem of teacher retention. When used together as in an explanatory sequential design (see Creswell and Plano Clark 2018), the interview protocols we present here are important to reach beyond the numerical data and provide further insight into teacher motivation, leadership, and social networks as they relate to teacher retention.

We consider these measurable areas and our context as centred in self-determination theory (SDT; Ryan and Deci 2017). Within the SDT realm, we argue that identifying high levels of intrinsic and autonomous motivation would enhance teacher retention. SDT is a broad psychological theory that provides a framework for organising person-centred perspectives about human concerns related to motivation and well-being (Ryan and Vansteenkiste 2023). From an educational perspective, SDT allows the organisation of relevant constructs related to teacher success, including self-efficacy, school-work environment, leadership, diversity dispositions, and social networks (Gagné and Deci 2005, Maryam *et al*., 2020).

Framework: self-determination theory

Self-determination theory (SDT; Ryan and Deci 2017) provides the theoretical lens for this study through which important teacher traits (both motivational and behavioural) are considered within the context of professional development of teachers (see Figure 1). The main components of SDT are *autonomy* (i.e. control of one's own life and choices), *competence* (i.e. feeling capable and effective in one's actions), and *relatedness* (i.e. connection to other people in a meaningful way). In the context of this study, teachers' views of their ability (i.e. self-efficacy) to support their students' learning align well with the construct of competence in SDT. Teachers' perceptions of how their principals support them to be autonomous agents (autonomy support) and how they see themselves as an important part of their school environment (person-organisation fit) align well with the principles of SDT's autonomy and relatedness domains. Teachers' engagement in leadership activities (decision-making, coaching, mentoring, etc.) and leadership experiences also correspond well with autonomy and relatedness. Teachers' perceptions of their interactions with diverse students in the classroom and adults outside the classroom (in the community) and social networks (for both teaching and leadership) fall in line with relatedness.

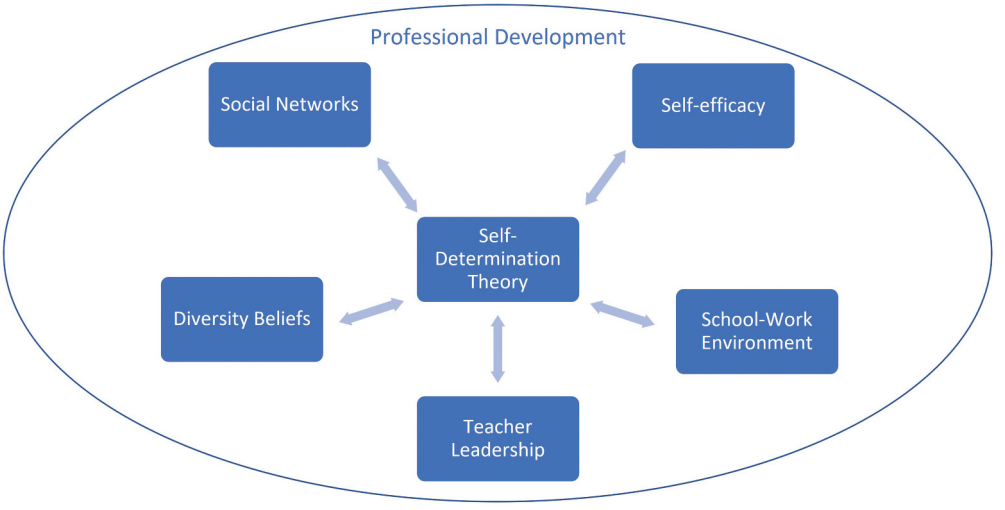

Figure 1. Conceptual framework linking teachers' psychological and behavioral traits to self-determination theory.

Literature review

Self-efficacy

Teaching self-efficacy (TSE) is a key element within the SDT perspective on *flourishing*—the enhanced performance that a teacher will show related to their teaching style from confidence in their own capacities and wellness (Ryan *et al.*, 2023). TSE has been defined as teachers' beliefs about their ability to successfully perform teaching tasks within particular contexts (Tschannen-Moran and Hoy 2001), or more generally as the 'confidence that teachers hold about their individual capability to influence student learning' (Klassen *et al.*, 2010, p. 21). Teachers' self-efficacy has important implications for both teaching and student learning as numerous studies indicate that high levels of TSE are associated with instructional approaches that foster constructivist learning and high student motivation and academic performance (e.g. Klassen and Tze 2014, Ryan *et al.*, 2023). TSE, aligning with SDT's competence dimension, thus influences personal instructional decisions, including the utilisation of modern technology (Udu *et al.*, 2021) and inquiry teaching (Perera *et al.*, 2022), which shape students' educational experiences and outcomes. In addition, the value of TSE in teacher retention has been shown by lower burnout in teachers with high TSE than those with low TSE, especially for novice compared with more experienced teachers (Hong 2010, Balgopal *et al.*, 2022).

Reviews of TSE studies have highlighted the need for more research on sources of teacher efficacy, alternative measurements, and relevance of TSE research to educational practice (Klassen *et al.*, 2010). More recently, studies of TSE using Tschannen-Moran and Hoy's (2001) 12-item instrument (or derivatives, e.g. Klassen *et al.*, 2009) have reinforced the positive value of *mastery experiences* (Morris *et al.*, 2017, Gale *et al.*, 2021) and PD programs (Yoo 2016, Yoon and Kim 2022), especially for novice teachers (Tschannen-Moran and Hoy 2007). A recent study (Zhou *et al.*, 2023) indicated that participation in PD and school climate had positive direct impacts on STEM teachers' self-efficacy and

job satisfaction. Moreover, professional development experiences in programs affiliated with, for example, Noyce, Knowles, CAP, or LUMA can improve the teaching self-efficacy of inexperienced teachers through program characteristics that include mentorship and participation in professional learning communities e.g. (Alemdar *et al.*, 2022). These studies exemplify the importance of measuring self-efficacy in relation to PD programs.

School-work environment

From the SDT theoretical perspective, school-work environment and autonomy can foster or inhibit work motivation, job satisfaction, and persistence (Gagné and Deci 2005). Research indicates that teachers' person-organisation fit (P-O fit) and principal autonomy support predict teacher mobility (Player *et al.*, 2017). P-O fit has been examined within K-12 education research to study the degree to which the school-work environment provides teachers with a sense of relatedness with other teachers within their schools. In this study, we use the term school-work environment deriving from the P-O fit theories rooted in industrial and organisational psychology to refer to 'teacher' P-O fit. According to the large and robust body of research on P-O fit, employees' sense of fit (compatibility and congruence) within their work environment predicts their job satisfaction, commitment to their occupation and positions, performance, and, in turn, retention (Youngs *et al.*, 2015). Similarly, teachers' individual perceptions of their school-work environment and how they feel about their fit within their schools are strong drivers of their turnover (Grant and Brantlinger 2022). Previous research indicates moderate to strong associations between the school-work environment and teachers' commitment to their school and to their teaching (Youngs *et al.*, 2015, Grant and Brantlinger 2022). This relationship seems to be even stronger for beginning teachers (Miller *et al.*, 2020). For example, Vekeman *et al.*, (2017) found a direct relation between the school-work environment and teachers' intention to move to another school (mobility) and a mediating role of job satisfaction for the relation between the school-work environment and the intention to leave or move. School leadership and climate are among the important drivers of job satisfaction. Improving school climate and positive and supportive attitudes of school principals help retain teachers (Grant and Brantlinger 2022).

An important component of the school-work environment is the support from school leadership for teacher autonomy. Autonomy can be described as having the power to choose one's behaviour (Gagné and Deci 2005). Teacher autonomy support includes opportunities for the provision of resources (e.g. PD, mentoring; Redding *et al.*, 2019) and providing a positive and democratic climate for the school community or establishing a shared vision. Moreover, providing teachers with choices and opportunities to make decisions, being receptive to teachers' perspectives, and demonstrating confidence in teachers' work are important components of autonomy support.

According to SDT, work environments that support autonomy promote one's intrinsic value for work, job satisfaction, high work performance, and persistence (Baard *et al.*, 2004). While prior studies demonstrate the importance of autonomy support in promoting intrinsic work motivation within business organisations, few studies have explored the effect of principal autonomy support on teachers' motivation for teaching, work

satisfaction, and commitment to teaching (Simon and Johnson 2015, Corkin *et al.*, 2018). Therefore, it is needed to include teacher autonomy in teacher development and PD.

Teacher leadership

Teacher leadership is a phenomenon that has become increasingly popular as an area of inquiry over the past twenty years (York-Barr and Duke 2004, Wenner and Campbell 2017). Although a consensus about the specific parameters and boundaries of teacher leadership across studies has not emerged, there is general agreement that teacher leadership involves roles, actions, dispositions, and identities that exist outside of an individual teacher's classrooms for positively influencing educational outcomes relating to autonomy and relatedness aspects of the SDT. Teachers engaging in leadership can do so from formal or informal positions, both of which afford opportunities and constraints distinct from each other. Relatively few studies have considered the relationship between teacher leadership and job satisfaction or organisational commitment. These studies have connected positive outcomes to teacher satisfaction across multiple dimensions (autonomy, empowerment, agency) with experiences that support their professional goals and their ability to effect change. For example, Egan (2022) found that classroom autonomy and leadership opportunities are important to those teachers willing to stay in challenging schools, as did Colak *et al.*, (2014) and Hulpia *et al.*, (2009). Somech (2005) proposed that administrative decisions that lead to empowerment or improved self-efficacy, consistent with the tenets of SDT (i.e. autonomy and competence), strengthen organisational commitment.

Teacher leadership provides lifelong learning and connection with peers, which improves mindset and motivation (LeBlanc and Shelton 1997). Teacher leaders' interest in improvement and their care for student learning have been found to be linked to their willingness to take risks, collaborate, and question their own and others' practice (Fairman and Mackenzie 2015). In the current study, we were interested in validating an instrument that includes measures of teacher leadership so that researchers can use it to understand leadership experiences of teachers and how they are tied to retention decisions.

Diversity dispositions and community connections

The teacher workforce in the U.S. consists mainly of white, middle-class, and monolingual females who come from predominantly different socioeconomic and cultural backgrounds compared to their students as is also the case in the UK, Germany, and Scandinavia (Flores and Smith 2009, Ingersoll *et al.*, 2021). As similar discrepancies exist in different ways around the world (OECD 2021), these disparities may lead to learning environments that lack inclusiveness and negatively impact minority student learning outcomes (Williams *et al.*, 2016). When teachers acknowledge the diversity of their students and meet their needs, students become more engaged and feel more self-determined. Specifically, and in the context of SDT, meeting students' psychological needs through autonomy, competence, and relatedness leads to their positive achievement (e.g. Taylor *et al.*, 2014, Ryan and Deci 2020). Students' sense of belonging and social connections can and need to be enhanced, for example, through collaborative work

and utilising student voice and interest (Ryan and Deci 2017). These teaching practices exemplify the strong connection between SDT and teachers' beliefs regarding diversity and inclusive teaching. Therefore, it is critical to develop teachers with knowledge, skills, and professional dispositions that enable them to teach their students with diverse backgrounds effectively (Major and Brock 2003, Williams *et al.*, 2016).

Despite the well-established frameworks for understanding and assessing teacher knowledge and skills (e.g. Shulman 1987), teacher disposition is a vague construct and difficult to assess (Truscott and Stenhouse 2022). It is crucial to understand teacher disposition as it impacts teachers' approach to situations, to make decisions about particular pedagogies, and to work with students, particularly those who are from different racial and cultural backgrounds (Dottin 2009, Truscott and Stenhouse 2022). The National Council for Accreditation of Teacher Education (2008) defined professional dispositions as 'professional attitudes, values, beliefs demonstrated through both verbal and non-verbal behaviors as educators interact with students, families, colleagues, and communities' (p. 89).

Schulte *et al.*, (2008) offered a self-assessment instrument to evaluate teachers' dispositions when working with diverse learners by focusing on skills that help students gain knowledge; on beliefs and attitudes about students and teaching and learning; and on connections with the community. Those with student-centred beliefs are more likely to persist compared to teachers with traditional and teacher-centred beliefs (Wong and Luft 2015). Also, teachers who are connected professionally to other diverse members of their schools and their larger community can grow professionally and feel a sense of belonging. Teachers' social connections can provide a support system that reduces their intentions to leave the profession (Minarik *et al.*, 2003, Struyve *et al.*, 2016, Webb 2018). These professional traits and beliefs of teachers align well with the SDT's all three main components of relatedness, competence, and autonomy.

Social networks

Networks define social systems through a set of nodes – typically the social actors (e.g. individual teachers, teams, or schools) and connecting ties – various relationships between them (e.g. social support between individuals, collaboration, or resource sharing; Borgatti and Ofem 2010). Functioning as the relatedness tenet of SDT, ties serve as conduits through which resources, information, and influence flow, so, different positions within a network can confer benefits, opportunities, and/or constraints for actors occupying those positions. Social networks have been used to study several educational phenomena. For example, Reid *et al.*, (2023) found that while early-career teachers' commitment to their profession was influenced by the number of bridging roles in their networks, this relationship was mediated by their self-image (science teacher identity) suggesting that being connected to multiple stakeholder groups, or bridging multiple stakeholder groups, fosters teacher and teacher-leader identity development. Therefore, teachers and teacher-leaders need to connect to multiple stakeholders beyond their peer groups to realise leadership in their current position, or they risk moving, shifting, or leaving.

Although several researchers investigated the relationships between teacher networks and other factors such as self-efficacy and identity (e.g. Moolenaar 2012, Polizzi *et al.*,

2021), they have not explored their direct relation to teacher retention or PD. To better understand the impacts of different characteristics of teacher networks on their retention or the impact of PD programs on teachers' social networks, particularly those who are not in their early years of teaching, including the social networks within SDT's relatedness dimension and understanding teachers' teaching and leadership networks would fill in an important gap in education research.

Methods

We administered a comprehensive survey and conducted extended cognitive interviews covering several motivational constructs and behavioural traits that correspond to SDT's three components with science and mathematics teachers from six U.S. states who were recruited for a larger study to investigate teacher retention. Although our larger study followed an explanatory sequential mixed-method design, the quantitative and qualitative instruments developed in this study can be used in a convergent mixed-method design (Creswell and Plano Clark 2018; see Figure 2).

Participants

The development of our survey instrument involved convenience sampling (Fricker 2016) of 167 K-12 science and mathematics teachers. Of these teachers, 85 were former Master Teaching Fellows (MTFs) – who participated in a five-year Robert Noyce Master Teaching Fellowship Program funded by the National Science Foundation in one of six states in the US: Arizona, California, Georgia, Illinois, New York, and Louisiana. These 85 teachers were recruited for a larger study on teacher retention (Ekmekci et al., 2025); thus, they were not randomly selected for the validation study; however, they are still expected to represent several of the characteristics of the teacher populations around the

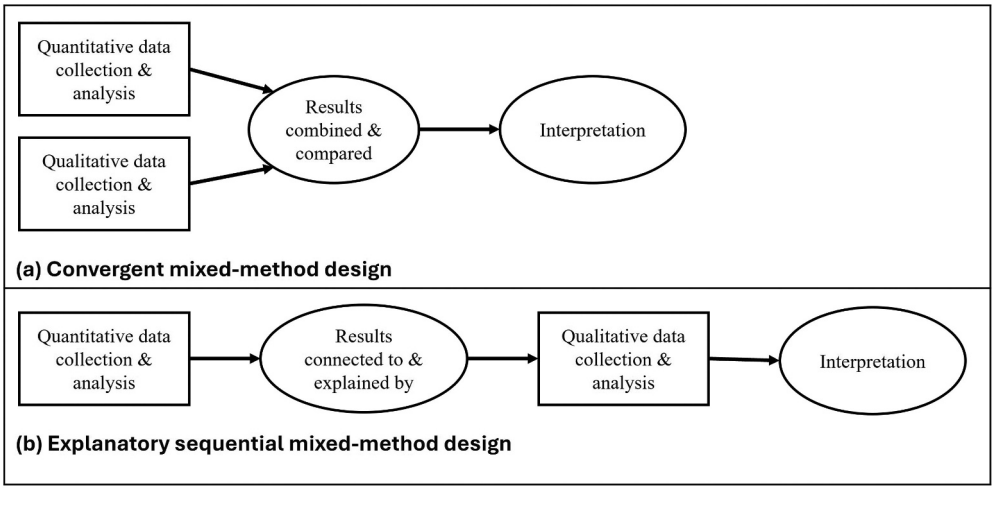

Figure 2. Mixed-method designs (adapted from Creswell and Plano Clark 2018).

Table 1. Demographic breakdown of teachers participated in the survey instrument validation.

		MTF ($n = 85$)	Non-MTF ($n = 87$)
Gender			
	Female	73%	73%
	Male	27%	27%
	Other	0%	0%
Ethnicity			
	White	86%	90%
	Non-White	14%	9%

world (e.g. retention, leadership, social networks, school-work environment) for which we anticipate the instrument to be used in future studies.

The remaining 82 teachers did not participate in such long-term teacher leadership programs but were from the same locations as the MTFs. All teachers were from high-need schools (as defined in section 201 of the Higher Education Act of 1965 [20 U.S.C. 1021]; NSF 2023). Demographic backgrounds of teachers are provided in Table 1. One of the areas of use for the instruments developed in this study relates to teacher retention. Therefore, we recruited teachers representing four different retention categories: stayer – actively teaching in the same school for the last few years; mover – actively teaching but recently changed schools; shifter – shifted from a teaching position to a non-teaching position; and leaver – left K-12 education. Among the 167 teachers surveyed, 104 were stayers (42 MTF and 62 non-MTF), 14 movers (9 MTF and 5 non-MTF), 37 shifters (24 MTF and 13 non-MTF), and 12 were leavers (10 MTF and 2 non-MTF).

Additionally, for interview protocol development, we conducted 12 cognitive interviews with K-12 teachers (eight from the Gulf Coast of Texas and four randomly selected from the pool of 167 teachers that were included in the survey development). Five of these cognitive interviews were conducted with MTFs (four female and one male; one Asian, one Black, one Hispanic, and two White), and the other seven with non-MTFs (seven female; one Black, two Hispanic, and four White) from high-need schools. According to Creswell and Plano Clark (2018), between 5 and 25 interviews are acceptable in qualitative studies, especially for protocol development.

Instruments

Quantitative instrument: survey

The survey items were adapted from previously developed and validated scales. The names of these scales, their original sources, and the number of items in each scale are provided in Table 2. Most of the items were kept from the original source verbatim, except for the school-work environment items that had slight wording changes. In the school-work environment items that were adapted from the P-O fit scale (Pogodzinski *et al.*, 2013), 'with other teachers' was replaced with 'throughout my school' to make it more comprehensive. The items that were adapted from the work climate questionnaire (Baard *et al.*, 2004) related to autonomy support were modified to assess teacher perceptions of their principal rather than a manager.

Table 2. Scales included in the survey development and validation.

Scale	Original Source	Number of items		
		Pilot Study	Main Study	*Final*
Teaching Self-Efficacy (TSE)	Tschannen-Moran and Hoy (2001)			
TSE-IS		4	4	*4*
TSE-SE		4	4	*4*
TSE-CM		4	0	*0*
Intrinsic Value for Teaching	Linnenbrink-Garcia *et al.*, (2010)	4	0	*0*
AVID	Watt *et al.*, (2009)	16	11	*6*
School-Work Environment (POFIT)	Pogodzinski *et al.*, (2013)	6	5	*3*
Principal Autonomy Support for Teachers (PAUT)	Baard *et al.*, (2004)	6	6	*5*
Diversity Dispositions (DD)	Schulte *et al.*, (2008)	16	16	*7*
Community Connectedness (CC)	Schulte *et al.*, (2008)	9	9	*8*
TOTAL		69	55	*37*

After a pilot study (Ekmekci *et al.*, 2022) with science and mathematics teachers in a metropolitan area in the southwest U.S., face and convergent validity suggested reducing the survey items from 69 to 55 and dropping intrinsic value and TSE-classroom management subscales (see Table 2). Teachers in this study were then administered a survey of 55 items covering several constructs, including self-efficacy, leadership engagement, school-work environment (renamed as teacher-school fit [TSF] in this study), and diversity dispositions (including community connections).

Following the face validation, we looked at the evidence based on the survey instrument's internal structure (American Educational Research Association [AERA] *et al.* 2014) through factor analysis results, which are presented in this paper. Regarding the response process, the consequence-based evidence comes from the reasonable response times, thoughtful responses to short-open-ended questions in the survey, and interviews with survey takers that did not conflict with individual survey responses (Bandalos 2018). Lastly, the convergent and divergent behaviour of the factors derived were investigated by measuring several (possibly related) but distinct constructs. The other sources of validity (e.g. criterion or divergent/convergent behaviour of the instrument as a whole) were not explored because they do not apply to the context of this study for reasons including that there is no meaningful and universal criterion/threshold for the outcome scores of each of these constructs. In other words, a high level of self-efficacy, for example, in a teaching context, can be considered not high enough for another teaching context, especially in different education contexts across the globe.

For the internal structure validity, we used a two-step approach to reduce the number of items into a meaningful and coherent total. First, we conducted a factor analysis for each subscale. This meant several initial factor analyses before the holistic factor analysis-one for each of self-efficacy for instructional strategies (TSE-IS); self-efficacy for student engagement (TSE-SE); leadership engagement (LEAD); person-organisation fit (POFIT); principal autonomy support for teachers (PAUT); diversity dispositions (DD); and community connectedness (CC). In the second step, we conducted a holistic factor analysis – including all the items. For each individual factor analysis and the holistic factor analysis, the number of factors to extract and retain for interpretation was determined by parallel analysis (Franklin *et al.*, 1995).

Qualitative instrument: interview protocols

Three authors of this paper drafted the interview questions by reviewing prior literature related to teacher leadership (e.g. York-Barr and Duke 2004, Danielson 2006), social networks, including teaching network and teacher leadership network (e.g. Moolenaar 2012, Lewis 2019), and teachers' persistence and retention (e.g. Rodriguez 2019, Mullen *et al.*, 2021). A team of more than 15 science and mathematics education faculty reviewed the interview questions on their own and during several one-hour-long meetings to establish the face validity. The team then decided to develop six separate interview protocols based on teachers' retention status and MTF status. Within this scenario, a teacher would receive the set of questions from one of four interview protocols (i.e. protocol A – stayer, protocol B – mover, protocol C – shifter, and protocol D – leaver) and one of two interview protocols based on their MTF status (i.e. protocol M – if teachers completed a NSF Noyce MTF program, and protocol N – if teachers did not participate in an MTF program). In all eight possible combinations (protocols A through D by protocols M and N), the total number of interview questions ranged from 41 to 47. For all these six separate protocols, the interview questions were grouped into three sections: (1) professional background and get to know (background), (2) teacher leadership (leadership), and (3) teaching and teacher leadership networks (networks). In these sections, we also included questions that directly asked about the participants' retention status. When the interview protocols were ready, all members of the research team reviewed and revised the interview questions with the goal of making the interview time shorter and the protocols more concise.

To conduct a cognitive interview, we began with one of the A, B, C, or D protocols, and after completing each section, we followed with the M or N protocols. The A, B, C, and D interview protocols included a brief description of the goals of the cognitive interviews and what the interviewees should expect. All protocols contained a list of interview questions to ask and some notes for the interviewer to remember.

For the validation of interview protocols, we conducted cognitive interviews with twelve teachers, which took about 40–70 minutes, via Zoom. We video-recorded these interviews and made notes during the interviews. Next, two authors of this paper watched all the recordings and made detailed notes regarding the wording and organisation of the interview questions. The whole research team, including the two authors, discussed these detailed notes and their experiences conducting the cognitive interviews, pointed out the redundancy among some of the interview questions and areas needing clarification, discussed ways of reducing the number of questions, and examined whether some interview questions reflected the primary goals of the research project.

Results

Survey instrument

As mentioned earlier, development and validation of both the survey instrument and the interview protocols started with establishing the face validity with

Table 3. Validity evidence for the survey instrument following Bandalos (2018) types of validity evidence based upon the AERA 2014) standards for educational and psychological Measurement.

Evidence based on	Validity argument	Methods of obtaining evidence
Content (face validity)	Sets of items appropriate for measuring the construct	Expert review
Internal structure	Relations among test items mirror those expected from theory	Factor analysis
Response processes	Items tap into intended cognitive processes	Response times, open-ended responses, and interviews
Consequences	Intended consequences are realized	Response rates, open-ended responses, and interviews
Relations to other variables	Relations of scale scores to other variables mirror those expected from theory	Subgroup analysis

evidence based on the content (AERA *et al.* 2014). A summary of all validity evidence is presented in Table 3. Evidence based on the internal structure and relation to other variables is presented with factor analysis results later in this section, and subgroup analysis (internal consistency) following the factor analysis results.

Following the face validation, we looked at the evidence based on the survey instrument's internal structure (AERA *et al.* 2014) through factor analysis. Factor analysis for teaching self-efficacy (TSE; all eight items) suggested a 2-factor solution where items perfectly aligned with their original domain. In other words, all TSE-IS (instructional strategies) items load onto the same factor, and all TSE-SE (student engagement) items load onto the same factor. For person-organisation fit (POFIT) and principal autonomy support (PAUT) – both representing the TSF, and community connectedness (CC), factor analyses suggested a one-factor solution for each construct. In addition, one item from each construct did not load significantly enough on the one-factor solution. Therefore, three items (one POFIT item, one PAUT item, and one CC item) were dropped. Factor analysis for teacher leadership engagement (LEAD) items also suggested a one-factor solution; however, four items did not load significantly ($\lambda < 0.4$) to this one-factor solution, and were, therefore, dropped. Finally, factor analysis for diversity dispositions (DD) items also suggested a one-factor solution – a similar case as in the factor analyses for the previous individual constructs. Two DD items, however, did not load significantly enough on the one-factor solution. This left the survey with 46 items after dropping the items that did not load significantly in the initial factor analyses for six individual constructs (TSE, POFIT, PAUT, CC, LEAD, and DD).

The final holistic factor analysis included 46 items relating to factors that may be associated with teacher retention based on the literature, using principal components analysis with varimax rotation and Kaiser normalisation. Parallel analysis suggested a five-factor solution for the initial holistic factor analysis. In the first five-factor solution, one POFIT item, one LEAD item, and six DD items were loading similarly to multiple factors. After these items were dropped altogether because of their cross loadings, the final holistic factor analysis included 37 items. Parallel analysis still suggested a five-factor solution with the 37 final items. Kaiser–Meyer–Olkin measure of sampling adequacy was 0.80, above the commonly recommended value of 0.60; therefore, the sample size was appropriate for the final analysis. Bartlett's test of sphericity was significant ($\chi 2\ (703) = 3651$, $p < .001$). The five-factor solution explained a total of 55.11% of the variance in the

data, which demonstrates a good model-data fit. Factor loadings for the final solution, as well as item-level descriptive statistics, are provided in Table 4.

To investigate the internal consistency, we conducted subgroup analysis by calculating Cronbach's alpha for each scale. The results revealed Crobbach's alphas that ranged from 0.72 to 0.91, indicating moderate-to-high reliability estimates for the scales used in the study (see Table 5). In addition, Table 5 also displays the correlations among the final factors, which vary from no significant correlation to moderate correlations.

Lastly, to investigate the divergent and convergent behaviour of the survey instrument, we used several external measures to explore any evidence for correlations between the survey constructs and these external constructs. Figure 3 provides a heat plot of correlations with external constructs relating to teacher retention, teaching network characteristics, and leadership network characteristics. The five factors significantly relate to other factors relating to teacher retention, teaching network characteristics, and leadership network characteristics. In addition, after validation of the instrument was completed, the instrument was used in a comprehensive study on teacher retention (Ekmekci *et al*., 2025). Among the five factors measured by the survey instrument, leadership engagement and teacher-school fit seem to be related to teacher retention (see Ekmekci *et al*., 2025 for details).

Interview protocols

Our interview protocols had three sections: (1) background, (2) leadership, and (3) networks. In the background section, we asked about the teachers' professional background and perspectives on teaching and/or education, as well as the relations between characteristics of the teachers' school or school districts and their decision on staying in the same school, moving to another school, shifting to a non-teaching position, or leaving the profession (see Supplemenatry material online). For example, we specifically asked, 'What made you decide to enter the teaching profession?' or 'What were the characteristics of the school and the school district you mostly worked with?' Additionally, we included questions based on whether the teachers were involved in the MTF program or not. For example, we asked those who participated in an MTF program: 'What was the impact of the Noyce MTF program on you as a teacher?'

In the leadership section, we focused on questions related to teacher leadership characteristics and practices, along with factors influencing the work of teacher leaders (see Supplemenatry material online). For example, we asked, 'What do you think the characteristics of a teacher leader are? What do you think teacher leaders do?' Similar to the background section, we asked MTFs about their MTF program, such as 'In what ways has participating in the Noyce MTF program contributed to your leadership skills and engaging in leadership activities in your current role?'

In the networks section, our questions were centred around teachers' teaching and leadership networks, such as the roles of contacts in their networks, descriptions of their roles as a bridge (if any), interactions in their networks, and topics discussed in their networks (see Supplemenatry material online). Examples of questions in this section are: 'Would you describe the nature of your bridging role?' and 'What topics do you discuss within your teaching (and leadership) network?' We also asked specific questions regarding their retention status (e.g. 'Has your teaching (and leadership) network influenced your decision on staying in the teaching profession and/or the same school? Explain why

Table 4. Item-level descriptive Statistics and factor loadings for the final rotated five-factor solution.

	Descriptive Statistics				Factor				
Items (*original designation*)	Min	Max	M	SD	1 TSF	2 CC	3 TSE	4 LEAD	5 DD
My principal encourages me to ask questions (*paut1*)	1	5	3.95	1.15	0.881				
I feel understood by my principal (*paut2*)	1	5	4.10	1.16	0.878				
My principal tries to understand how I see things before suggesting a new way to do things (*paut3*)	1	5	4.47	1.00	0.860				
My principal conveys confidence in my ability to do well at my job (*paut4*)	1	5	4.08	1.17	0.845				
I feel that my principal provides me with choices and options (*paut5*)	1	5	4.07	1.13	0.839				
I matter to other teachers throughout my school (*pofit1*)	1	5	4.19	0.96	0.626				
My professional goals are the same as those of other teachers throughout my school (*pofit2*)	1	5	3.93	0.99	0.591				
I identify with other teachers throughout my school (*pofit3*)	1	5	4.39	0.78	0.552				
I encourage my students to give back to their community (*cc1*)	1	5	3.16	1.27		0.763			
I work to establish positive school-community relationships (*cc2*)	1	5	3.59	1.10		0.730			
I am involved in the community where I teach (*cc3*)	1	5	3.74	1.00		0.722			
I help my students make connections in their community (*cc4*)	1	5	3.75	1.01		0.721			
It is important that I attend activities in my students' neighbourhoods (*cc5*)	1	5	3.98	0.94		0.717			
I see myself as a part of the community in my role as a teacher (*cc6*)	1	5	4.22	0.89		0.625			
I welcome community members into my classes to share their skills (*cc7*)	1	5	3.89	1.04		0.590			
I collaborate on providing community service opportunities for my students (*cc8*)	1	5	4.12	0.99		0.569			
I can motivate students who show low interest in school work (*tse-se1*)	2	5	3.89	0.82			0.754		
I can help students value learning (*tse-se2*)	2	5	4.11	0.74			0.750		
I can get students to believe they can do well in school work (*tse-se3*)	2	5	3.90	0.83			0.725		
I can provide an alternate explanation when students are confused (*tse-is1*)	3	5	4.57	0.64			0.720		
I can implement alternative strategies in my classroom (*tse-is2*)	2	5	4.25	0.85			0.655		0.435
I can craft good questions for students (*tse-is3*)	2	5	4.62	0.60			0.646		
I can assist families in helping their children do well in school (*tse-se4*)	2	5	3.53	0.86			0.594		
I can implement a variety of assessment strategies (*tse-is4*)	2	5	4.37	0.75			0.526		
I help design school policy (*avid1*)	1	5	3.22	1.00				0.848	
I am involved in selecting types of professional development (*avid2*)	1	5	3.72	1.23				0.718	
I help plan school improvement (*avid3*)	1	5	3.58	1.18				0.717	
I help make personnel decisions (*avid4*)	1	5	2.74	1.34				0.712	
I am involved in campus level decision-making (*avid5*)	1	5	3.36	1.31				0.710	
I influence school budgeting (*avid6*)	1	5	2.06	1.17				0.661	
I am passionate about my own learning (*dd1*)	3	5	4.86	0.36					0.663
I am responsible for creating an atmosphere where all students feel free to openly exchange ideas, thoughts, and opinions (*dd2*)	3	5	4.84	0.40					0.617
I believe that diversity enhances student knowledge (*dd3*)	3	5	4.60	0.54					0.579
I continually search for new knowledge within my content area (*dd4*)	4	5	4.89	0.32					0.573

(*Continued*)

Table 4. (Continued).

Items (*original designation*)	Descriptive Statistics				Factor				
	Min	Max	M	SD	1 TSF	2 CC	3 TSE	4 LEAD	5 DD
I look for new ways to teach difficult material (*dd5*)	4	5	4.90	0.30					0.547
I am reflective about how my actions affect student achievement (*dd6*)	3	5	4.74	0.48					0.441
I believe in setting high standards for all students (*dd7*)	3	5	4.84	0.42					0.415
Factor Statistics Eigenvalue					8.76	4.79	2.69	2.47	2.23*
Parallel Analysis Eigenvalue (Mean)					2.04	1.92	1.81	1.73	1.65
Variance Explained (%)					13.72	12.17	11.01	9.73	8.48

Note. N = 167. Factors: 1-Teacher-School Fit (TSF); 2-Community Connections (CC); 3-Teaching Self-Efficacy (TSE); 4-Leadership Engagement (LEAD); 5-Diversity Dispositions (DD). *Factor 6 value is 1.38, which is less than the Factor 6 value of 1.58 from the parallel analysis; hence, the 5-factor solution (Franklin *et al*., 1995).

Table 5. Reliability estimates, descriptive statistics, and intercorrelations for the five factors.

Scale	Number of items	Reliability[a]	M	SD	Correlations[b] CC	TSE	LEAD	DD
Teacher-School Fit (TSF)	8	.910	4.28	.62	.17*	.10	.29**	.21**
Community Connectedness (CC)	8	.865	3.82	.72		.41**	.25**	.42**
Teaching Self-Efficacy (TSE)	8	.863	4.19	.50			025**	.33**
Leadership Engagement (LEAD)	6	.862	3.12	.91				.31**
Diversity Dispositions (DD)	7	.722	3.82	.72				
Total	37							

Note. N = 167. [a] Cronbach's alpha. [b] Pearson's *r*. * $p < .05$. ** $p < .01$.

or why not?') or whether they were MTFs or non-MTFs (e.g. 'In what ways has participation in the Noyce MTF program contributed to developing and establishing your current teaching (and leadership) network? Explain.').

The main changes to the interview protocols during their validation process were (a) reducing the number of interview questions by removing the redundant questions and aligning them to the overall research project; (b) clarifying the ambiguity of and language used in the interview questions by rephrasing, including examples or follow-up questions (if needed); and (c) adjusting the order that the interview questions were presented for better flow. As a result, the number of interview questions was reduced from the range of 41 to 47 (across several protocols) to the range of 29 to 35 (a reduction by more than 25%). The number of interview questions in the first two sections (i.e. background and leadership) of the protocols primarily stayed the same. Most of the interview questions were cut down in the third section (i.e. networks; see Table 6). For example, in the third section, we removed the question about the structure of teaching and teacher leadership networks because they did not provide further insights into these areas. We also marked four questions in the networks section as optional questions (or if time permits). These interview questions focused on the type of interactions and benefits of interactions within the teaching or teacher leadership network (e.g. discussion, formal/informal; see the Supplemenatry material online). Without these four questions, the number of interview questions ranges from 25 to 31.

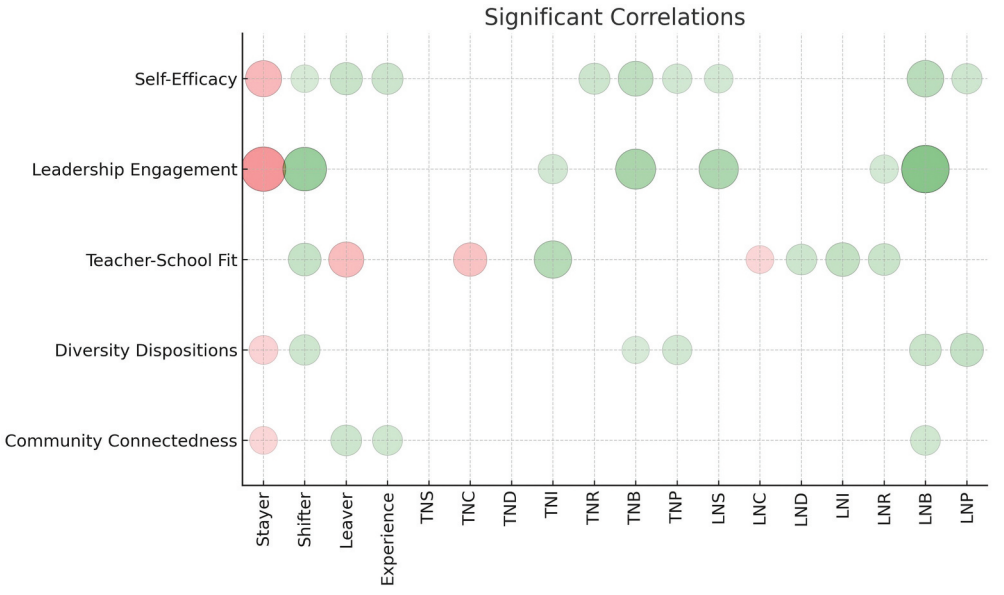

Figure 3. Heat plot for correlations of survey constructs with external factors. Notes. All circles represent significant correlations. Circle size and colour darkness are proportional with the correlation magnitude. Red denotes negative; and green denotes positive correlations. TNS: Teaching Network Size; TNC: Teaching Network Centrality; TND: Teaching Network Density; TNI: Teaching Network Interconnectedness; TNR: Teaching Network Reach; TNB: Teaching Network Bridging; TNP: Teaching Network Proximity; LNS: Leadership Network Size; LNC: Leadership Network Centrality; LND: Leadership Network Density; LNI: Leadership Network Interconnectedness; LNR: Leadership Network Reach; LNB: Leadership Network Bridging; LNP: Leadership Network Proximity

Most of the required clarification occurred in the first section of the interview protocol. For instance, we added examples for the question about characteristics of the school and school district, which were particularly related to our research project's goals (e.g. working conditions). Finally, we changed the order of some of the interview questions to improve the flow of the interviews. For example, we began the interview with questions about reasons for entering the teaching profession instead of teaching philosophy. The reason for the reordering was that we observed teachers struggling with the teaching philosophy question as the opener. The question about reasons for entering

Table 6. Changes in the number of questions in each interview protocol.

	Number of questions in the first version				Number of questions in the final version			
Interview protocols	Back-ground	Leadership	Network	Total	Back- ground	Leadership	Network	Total
A-stayer	10	3	24	37	9	3	14	26
B-mover	10	3	26	39	10	3	16	29
C-shifter	10	3	26	39	10	3	16	29
D-leaver	9	3	26	38	9	3	16	28
M-MTF	4	2	2	8	2	2	2	6
N-non-MTF	1	1	2	4	0	1	2	3

the teaching profession was a better warm-up because respondents were all comfortable addressing this experience, and therefore, the entry into the full interview improved.

After the validation of the interview protocols was completed, the protocols were used in two different studies to investigate the reasons for teachers to shift to a non-teaching position through lenses of agency, identity, and authority (McGraw *et al.*, 2025) and explore teachers' perceptions of teacher leaders (e.g. in terms of characteristics of teacher leaders and what they do in the role of a teacher leader). These studies provide additional support for the effectiveness of the interview protocols. The interviews with the final versions of the interview protocols took around 45 minutes.

Discussion

With this paper, we aimed to (a) produce a single survey instrument composed of different scales (but related within the SDT framework; see Table 4), and (b) develop interview protocols that provide insights into teachers' leadership, retention, and social networks (see Supplemenatry material online). The survey instrument is a quantitative data collection tool, and the interview protocols are qualitative instruments. Both instruments can be used separately in quantitative and qualitative research, respectively, or together in mixed-method studies. In addition, the survey instrument and interview protocols can be used in specific teacher education and professional development programs to measure their program impact (as a program evaluation tool). We designed and validated our survey instrument and interview protocols for use within the SDT framework for post-PD evaluation. However, we anticipate additional value regardless of the PD topic in teacher evaluation settings. For example, McGraw *et al.*, (2025) used these interview protocols in a qualitative study to investigate aspects of instructional leadership of teachers who shifted from teaching to leadership roles in their schools and found teachers viewed that teacher leaders as learned and trusted collaborators advocating on behalf of teachers and their schools for effective teaching and positive student outcomes.

We discuss the results and implications of these instruments separately below. Finally, limitations of our approach are discussed in the context of the study design and generalisability of interpretation beyond our sample population.

Survey instrument

The motivational and behavioural factors for STEM teachers included in this study were chosen for three reasons. First, they each represent and correspond to one of the three main components of SDT (i.e. relatedness, autonomy, and competence; Ryan and Deci 2017, 2020). Second, they all relate to teacher retention as described in detail in the literature (e.g. Whitfield *et al.*, 2021, Balgopal *et al.*, 2022, Thompson-Lee *et al.*, 2025). Lastly, these factors are also related to each other. For example, self-efficacy not only relates to teacher retention but also mediates the relationship between teacher school-fit and teacher retention (Zhou *et al.*, 2023).

Short and concise survey instruments for quantitative studies are highly valued by researchers because they save time and effort while still providing valid and reliable data to understand and describe a phenomenon or a practice using fewer items without losing the extent and depth of information needed (Rolstad *et al.*, 2011,

Sharma 2022). It is also common to see a 'short form' version of an instrument that was originally developed and validated before. Survey response rates decrease as the survey length increases, and the quality of survey response can be influenced by questionnaire length (Beebe *et al.*, 2010). For the ease of data collection and higher response rates, some strategies include a variety of survey administration (online, mobile device-compatibility, etc.), compensation for survey-taking, and truncating the survey to be administered (Saleh and Bista 2017). Here, we provide a short version of an instrument (37 items; see Table 4) that includes different (but related within the SDT framework) scales that originally had a total of 69 items (a reduction of by almost half).

Even though research indicates the constructs of interest in this study within the SDT framework (e.g. self-efficacy, school-work environment) may relate to other teacher-related outcomes such as effectiveness and retention (e.g. Balgopal *et al.*, 2022, Egan 2022), the measurement of these constructs and their relation to outcomes have been explored in isolation from each other (Ekmekci *et al.*, 2025). Looking at these constructs collectively both in terms of how they can be measured and how they relate to other teacher outcomes within the context of high-need schools is an important endeavour that can potentially contribute to teacher education and its research. However, the inclusion of all the constructs that may relate to an outcome, such as teacher retention, can be a daunting task. In addition, some constructs may be highly correlated with each other. The inclusion of highly correlated constructs in a program evaluation or research study instrument either is redundant or reduces the effectiveness of the survey by increasing its length unnecessarily (Beebe *et al.*, 2010).

Our final, five-factor structure represents a parsimonious outcome minimising the empirical redundancy (Le *et al.*, 2010) by reducing highly correlated constructs into a format aligned with our conceptual model (see Figure 1) centred around self-determination theory (SDT; Ryan and Deci 2017) within the context of professional development for teachers and teacher leadership. Factor 1 (teacher-school fit) includes items that investigate teachers' perceptions of their principals and peers and aligns well with the principles of relatedness and autonomy (Baard *et al.*, 2004, Youngs *et al.*, 2015). School principals can be perceived as supporting or thwarting teacher agency and autonomy, and peers can be seen as contributing to, or detracting from, a sense of professional community (relatedness). Of course, school-work environments can be very different in different education contexts. For example, several education systems around the world such as Finland, Canada, and Japan are widely recognised for fostering a strong school-work environment that supports teacher well-being, professional growth, and retention (OECD 2022). In addition, as school-based recruitment that exist in some education systems such as the U.S., Singapore, and Netherlands (unlike others including Turkey, Spain, South Korea etc.) allows teachers to choose their workplace, it can also result in higher job satisfaction and lower teacher turnover and attrition (OECD 2019).

Factor 2 (community connections) includes items about teachers' perceptions of their interactions with students and adults outside the classroom (Schulte *et al.*, 2008), which maps onto the value of relatedness. A perceived ability to connect with others is also aligned with teachers' sense of competence, as some of the professional duties require high functioning in informal settings. Factor 3 (teaching self-efficacy) includes items about teachers' perception of their ability to support their students' learning, which aligns

well with the construct of competence in SDT (Tschannen-Moran and Hoy 2001). Factor 4 (teacher leadership engagement) includes items that prompt teachers to consider their agency in decision-making, which align well with the constructs of autonomy and relatedness. When a teacher is invited into conversations with others in power, it promotes confidence in their ability to self-direct their future; at the same time, it is an opportunity for connection to others in their professional community (LeBlanc and Shelton 1997). Factor 5 (diversity dispositions) includes items related to teachers' perceptions of themselves as professionals, including their aspirations and goals related to diversity in education. This factor most closely aligns with the sense of competence towards teachers' roles as facilitators of diversity in their education community (Truscott and Stenhouse 2022, Harrison and Brown 2025).

Interview protocol

Although in our larger study design, interview protocols were conducted to complement the collected survey data, we did not follow up with cognitive interviews immediately after completing the survey items. Therefore, each instrument was shortened to be used as a unique stand-alone instrument in either a quantitative or qualitative research study. When conducting qualitative research studies, the developed interview protocols should provide insights into how teachers' perceive their congruence with peer groups (McDonald *et al.*, 2019, Miles and Haq 2025), their professional background and retention (i.e. reasons for entering, staying, moving, shifting, or leaving teaching), teacher leadership (e.g. who teacher leaders are from practitioners' perspective), and teaching networks and leadership networks (e.g. roles of contacts and topics of discussion in the networks). Similarly, when evaluating specific teacher education and professional development programs to measure their program impact on teachers' motivation for entering and retaining in or leaving teaching, leadership practices, and social networks, these interview protocols can be useful for program developers and evaluators. What makes these interview protocols that were distinctly designed for different retention outcomes useful for researchers and educators is that they address important universal areas for every educational system: retention, leadership, and social network (OECD 2019).

The changes made in the initial interview protocols created a short but critical and informative set of interview questions. Using the final interview protocols will help to tell a more comprehensive story of the reasons behind teacher retention and persistence, which can become a vehicle for reducing the problem of teacher shortage. Additionally, four interview protocols based on the retention status (stayer, leaver, shifter, and mover) and two interview protocols based on the MTF status (MTF and non-MTF) allow researchers across the world to adapt all or parts of these protocols related to their research or education contexts and designs with some limitations discussed next from the global perspective.

Limitations

This study has limitations that potentially constrain generalisability beyond the geographic region (i.e. six U.S. states) and population studied. Specifically, the predominantly white female sample, while typical of U.S. teachers in this context,

may not be broadly representative internationally. Moreover, the teacher population was restricted to science and mathematics teachers that may limit the generalisability to teachers in other disciplines. Finally, while our explanatory sequential mixed-method design (Creswell and Plano Clark 2018) was balanced and followed established protocols, teachers were surveyed post-hoc and not randomly assigned to the different groups at the onset (MTFs versus Non-MTFs). Moreover, due to convenience sampling (Fricker 2016), we did not have control over a balanced selection among stayers, movers, shifters, and leavers. However, both the survey instrument and interview protocols have potential in identifying differences among the retention subgroups. Therefore, we remain confident that the validated survey instruments and interview protocols we present in this paper have value in studying and assessing teacher education and PD programs under the context of self-determination theory (Ekmekci *et al.*, 2025, McGraw *et al.*, 2025). Researchers and education stakeholders in other education systems across the globe can adapt and make use of these instruments to fit/align within their education contexts by first acknowledging the limitations presented herein and critically thinking about how the context of this study differs/overlaps with their systems. The second step would be to think carefully about how to reconcile the differences and mitigate the limitations for the best possible benefit and effective use of the instruments.

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