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The influence of professional identity on learning engagement among teacher education students: a latent profile analysis

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Introduction: This study investigates the influence of latent categories of professional identity on learning engagement among teacher education students.

Methods: Latent Profile Analysis (LPA) was employed with a sample of 1,059 teacher education students.

Results: Three distinct groups were identified: high, medium, and low professional identity groups. Gender and voluntary choice of teacher education major showed clear variations across groups. Females were more prevalent in the medium professional identity group, whereas involuntary students were disproportionately represented in the low and medium professional identity groups. The impact of professional identity on learning engagement showed a descending trend from high to the medium to low groups. Notably, in the medium and high professional identity groups, professional values and efficacy exerted a strong influence on learning engagement. By contrast, in the low professional identity group, overall professional identity demonstrated a significant impact on learning engagement.

Discussion: This study reveals the heterogeneity of teacher education students' professional identity and its underlying mechanisms influencing learning engagement, offering insights for the design of differentiated teacher education and professional development programs.

KEYWORDS

teacher education students, professional identity, learning engagement, Teacher Professional Development (TPD), latent profile analysis (LPA)

1 Introduction

Teacher Professional Development (TPD) is widely regarded as a lifelong and systematic process that begins with pre-service education and continues throughout a teacher's career via Continuing Professional Development (CPD) (Kasemsap, 2017). Contemporary theoretical perspectives emphasize that TPD should not be considered a one-time training but rather a continuous process that supports teachers' sustained growth and responsiveness to emerging educational demands (AbdulRab, 2023). Moreover, effective TPD requires the integration of theoretical understanding with practical opportunities (Lim et al., 2020). At the policy level, UNESCO (2017) explicitly states that the core objective of teacher education is to cultivate teachers' capacity for ongoing professional development, which is a cornerstone for ensuring educational quality and achieving Sustainable Development Goal 4 (SDG4). Within this

framework, learning engagement becomes particularly critical, as it not only represents the external manifestation of teachers' developmental motivation but also serves as a key driving force for the continuous advancement of both CPD and TPD (Ji, 2023).

Learning engagement is commonly defined as active participation and psychological investment in learning tasks (Kuh et al., 2008). This concept has received widespread attention not only because it is an important predictor of academic success and professional competence (Fredricks et al., 2016), but also because it is regarded as a key mechanism for ensuring learning quality and sustaining motivation (Zepke, 2014). Existing studies have shown that learning engagement can significantly enhance students' perception of core competencies (Kim, 2017), promote the development of problem-solving ability (Lee et al., 2019), strengthen psychological capital (Tang and He, 2022), improve academic well-being (Cazan and Stan, 2019), and ultimately lead to positive learning outcomes and academic achievement (Guo et al., 2017; Wang, 2011). Therefore, learning engagement is not only a predictor of learning outcomes but also an important bridge connecting individual learning motivation with subsequent professional growth.

Professional identity plays a key role in this process. On the one hand, higher levels of learning engagement often translate into teachers' active participation in professional development (Ji, 2023), while professional identity directly drives teacher development (Pi et al., 2024) and is continuously reconstructed through mechanisms such as professional learning communities and role transitions (Van Dusen and Otero, 2012). On the other hand, numerous empirical studies have confirmed the close connection between professional identity and learning engagement: not only are the two significantly correlated (Beijaard, 1995; Cai et al., 2022; Chen et al., 2022), but professional identity can also indirectly promote learning engagement through mediating variables such as achievement motivation (Wang and Dong, 2022) and learning motivation (Xie and Yin, 2022), further influencing teaching practicum competence (Wang, 2021) and professional maturity (Lei and Zhang, 2023). Taken together, these findings indicate that professional identity is not only an important antecedent of learning engagement but also a core mechanism for enhancing the quality of teacher education and fostering teacher growth.

It is noteworthy that professional identity is not static. The studies by Lo and To (2023a, 2023b) demonstrated that, under the disruptive context of the pandemic, teacher roles and identity narratives were constantly reshaped through digital transformation and pedagogical adjustments (Lo and To, 2023a). At the same time, teachers' understanding of and commitment to CPD also shifted, with Information and Communication Technology (ICT) competence increasingly recognized as a core element, while school-based resources and support often remained insufficient. Within this tension, teachers often relied on experience sharing and collaboration to sustain their professional identity and self-efficacy (Lo and To, 2023b). In this process, learning engagement gradually emerged as an important external manifestation of identity construction: teachers actively engaged in teaching, learning, and collaboration to cope with uncertainties in identity and development, and such engagement, in turn, reshaped their professional identity and future developmental possibilities (Ye et al., 2025). These findings suggest that, within the institutional and technological context of the post-pandemic era, both professional identity and TPD face new challenges and uncertainties, which are particularly significant for teacher education students at a critical stage of identity construction.

In studies on the relationship between teacher education students' professional identity and learning engagement, some scholars have examined differences in levels across different groups (e.g., publicly funded vs. non-funded, targeted vs. non-targeted) (Lei and Zhang, 2023; Wang and Dong, 2022). However, such research has largely been conducted from a variable-centered perspective, which assumes sample homogeneity and thus risks obscuring potential differences among groups (Wang and Hanges, 2011). By contrast, person-centered approaches can identify heterogeneity within the sample and provide a more nuanced depiction of the characteristics and developmental pathways of different subgroups (Mäkikangas and Kinnunen, 2016; Schmiede et al., 2018).

Common person-centered approaches include mean split, cluster analysis, and Latent Profile Analysis (LPA). Among these, the mean split is intuitive and easy to use, but because it relies on artificially set thresholds (e.g., M , $M \pm SD$), it often leads to information loss and classification errors, making it more suitable as a descriptive tool (MacCallum et al., 2002). Cluster analysis can group individuals based on similarity, but it is sensitive to outliers, lacks the ability to handle measurement error or provide probabilistic classification, and depends heavily on data quality and researcher-defined subjective standards, which limits its statistical inference power (Ketchen and Shook, 1996). By contrast, LPA is a model-driven finite mixture method that determines the optimal number of classes through objective indicators such as information criteria (AIC, BIC) and likelihood ratio tests (LMR-LRT, BLRT), while providing individuals with probabilistic classification results and explicitly accounting for classification uncertainty (Gabriel et al., 2015; Nylund et al., 2007). Consequently, LPA has been widely applied in educational psychology to reveal latent heterogeneity in learners' identity construction and learning behaviors (Morin et al., 2016; Wei et al., 2021).

In summary, existing research on teacher education students' professional identity and learning engagement has predominantly adopted a variable-centered approach, while person-centered studies have been limited to mean split or cluster analysis (Canrinus et al., 2011; Zhang et al., 2021), with a lack of empirical investigations based on latent categories. To address this gap, the present study employs LPA to provide a more nuanced examination of the relationship between teacher education students' professional identity and learning engagement. Specifically, this study aims to: (a) identify the latent categories of professional identity among teacher education students; (b) compare learning engagement levels across categories and examine the influence of demographic factors; and (c) analyze how the dimensions of professional identity predict learning engagement within each category. The study thus seeks to reveal a more layered mechanism underlying the relationship between professional identity and learning engagement while offering practical guidance for the differentiated design of teacher education and TPD programs.

2 Methods

2.1 Participants

A total of 1,059 teacher education students from Liaoning and Hebei Provinces participated in this study, including 138 males and 921 females. By major, 527 students were in the humanities, 448 in science, and 84 in arts and sports. Regarding place of origin, 611

students came from urban areas and 448 from rural areas. In terms of the voluntary choice of teacher education major, 830 students reported choosing the major voluntarily, while 229 reported doing so involuntarily.

2.2 Procedure

This study adopted a cluster sampling method, and samples were randomly selected through the “Wenjuanxing (a professional online survey platform in China)” platform. The research team distributed the questionnaire link to the target classes, where students were informed of the research purpose and participation procedures by their course instructors and completed the questionnaire online under their guidance. Participation was entirely voluntary, and anonymity and confidentiality were strictly ensured throughout the research process. Ethical approval for this study was obtained from the Ethics Review Committee of the college (No. EDU-ERC-2024-001).

2.3 Measures

2.3.1 Teacher professional identity scale

The study employed the Teacher Professional Identity Scale, developed by Wang et al. (2010) comprising 12 items distributed across four dimensions: professional aspirations and expectations, professional will, professional value, and professional efficacy, using a 5-point scale. The Cronbach's α coefficient for the scale was 0.88. Confirmatory factor analysis (CFA) revealed a well-fitting model [$\chi^2/df = 5.08$, normed fit index (NFI) = 0.97, relative fit index (RFI) = 0.95, incremental fit index (IFI) = 0.97, Tucker–Lewis index (TLI) = 0.96, comparative fit index (CFI) = 0.98, root mean square error of approximation (RMSEA) = 0.062, standardized root mean square residual (SRMR) = 0.049].

2.3.2 Learning engagement scale

This study employed the Learning Engagement Scale adapted from Schaufeli et al. (2002) and revised by Li and Huang (2010). Comprising 17 items, the scale measures three dimensions: motivation, energy, and focus, using a 7-point scoring system. The Cronbach's α coefficient for this scale was 0.97. CFA revealed a well-fitting model ($\chi^2/df = 6.13$, NFI = 0.97, RFI = 0.96, IFI = 0.96, TLI = 0.96, CFI = 0.97, RMSEA = 0.070, SRMR = 0.025).

2.4 Data analysis

This study employed Mplus and SPSS to conduct the data analyses.

Firstly, Mplus 8 was employed to conduct LPA on teacher education students' professional identity. Model selection was guided by multiple fit indices. Specifically, the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample size-adjusted Bayesian Information Criterion (aBIC) were used, with smaller values indicating better model fit. Entropy, ranging from 0 to 1, was used to assess classification accuracy, with values ≥ 0.80 considered desirable and ≥ 0.60 as the suggested minimum. The Lo–Mendell–Rubin (LMR) test and the bootstrap likelihood ratio test (BLRT) compared k -class models with $k-1$ class models, with significant p -values indicating improved model fit. In addition, category probabilities (ranging between 0 and 1) were examined, with values below 0.05 considered problematic, as they suggest insufficient representation of that class in the sample (Bauer, 2022; Wang and Bi, 2018). Following the LPA, a one-way ANOVA was conducted to further examine the differences among the identified latent profile groups across the four dimensions of professional identity.

Secondly, based on the selected LPA solution, multinomial logistic regression was performed in SPSS 29 to examine the demographic predictors of class membership. Independent variables included gender (male = 0, female = 1), place of origin (urban = 0, rural = 1), voluntary choice of teacher education major (voluntary = 0, involuntary = 1), and academic major (humanities = 0, science = 1, arts/sports = 2). The dependent variable was the latent class membership, with the high professional identity group serving as the reference category.

Finally, an analysis of variance (ANOVA) and linear regression analysis were conducted to test the effects of professional identity categories on learning engagement and to explore the predictive role of the four dimensions of professional identity across different latent groups.

3 Results

3.1 LPA of teacher education students' professional identity

The analysis began with an independence model and progressively increased the number of categories to compare alternative latent profile models. As shown in Table 1, the AIC, BIC, and aBIC values decreased monotonically with additional categories. The Entropy indices of each model were all above 0.80, and the BLRT values were all significant ($p < 0.001$). In the four-category model, the LMR was not significant ($p > 0.05$), and the smallest category had an average membership probability of 0.01, which was below the acceptable threshold of 0.05 and thus lacked credibility. Compared to the two-category model, the three-category model had a higher Entropy value. Therefore, the

TABLE 1 Fit indices for the LPA model of learning engagement among teacher education students ($N = 1,059$).

Model	AIC	BIC	aBIC	Entropy	LMR (p)	BLRT (p)	Category probability (%)
1	30625.45	30744.62	30668.39	–	–	–	–
2	27979.73	28163.44	28045.92	0.857	0.013	<0.001	0.61/0.39
3	26019.37	26267.62	26108.81	0.937	0.045	<0.001	0.09/0.62/0.29
4	24053.76	24366.56	24166.46	1.000	0.331	<0.001	0.54/0.18/0.01/0.28

three-category model was ultimately selected as the latent profile of professional identity among teacher education students.

The average membership probabilities of each category range from 97 to 98% in the three-category model (Table 2), indicating the credibility of the three identified latent categories of professional identity.

Figure 1 illustrates the distribution of scores across four dimensions for the latent categories of professional identity among teacher education students. Based on distinct score patterns, the categories are named as follows: the “low professional identity group” (class 1), comprising 9.4% of the sample (99 individuals), exhibits the lowest scores. The “medium professional identity group” (class 2) includes 61.6% of the sample (649 individuals). The “high professional identity group” (class 3) represents 29.1% of the sample (311 individuals) with the highest scores.

To further verify the accuracy of the latent profile classification of teacher education students’ professional identity, a one-way ANOVA was conducted with latent profile groups as the independent variable and the four dimensions of professional identity (professional aspirations and expectations, professional will, professional value, and professional efficacy) as the dependent variables. The results showed significant differences among the three latent groups across all four dimensions of professional identity ($F = 612.364, p < 0.001$; $F = 149.454, p < 0.001$; $F = 376.460, p < 0.001$; $F = 1462.713, p < 0.001$).

TABLE 2 Average membership probability of research subjects (in lines) in each latent category (in rows).

Latent category	C1 (%)	C2 (%)	C3 (%)
C1	0.97	0.03	0
C2	0.01	0.98	0.01
C3	0	0.03	0.97

Post-hoc tests (Tukey’s HSD) revealed that teacher education students in the high professional identity group scored significantly higher than those in the medium and low professional identity groups on all four dimensions, while the medium professional identity group also scored significantly higher than the low professional identity group (Table 3). These results indicate that the latent profile classification demonstrates heterogeneity and effectively distinguishes students with different levels of professional identity.

3.2 Demographic characteristics associated with the latent categories of professional identity among teacher education students

To examine the demographic characteristics associated with the latent categories of professional identity, a multinomial logistic regression analysis was performed (see Table 4). The results indicated no significant differences across categories with respect to place of origin or major ($p > 0.05$), whereas significant differences were observed for gender and voluntary choice of teacher education major.

Compared to the high professional identity group, gender did not show significant differences in the low professional identity group but did show significant differences in the medium professional identity group. Males were about half as likely as females to be in the medium professional identity group ($OR = 0.49, 95\% \text{ CI } [0.33, 0.73], p < 0.001$), indicating that females are more likely to belong to the medium professional identity group. Further analysis revealed that the distribution of males in the low, medium, and high professional identity groups was 13.05, 44.20, and 42.75%, respectively. For females, the distribution was 8.80, 63.84, and 27.36%, respectively.

Compared to the high professional identity group, the voluntary choice of teacher education major showed significant differences in both

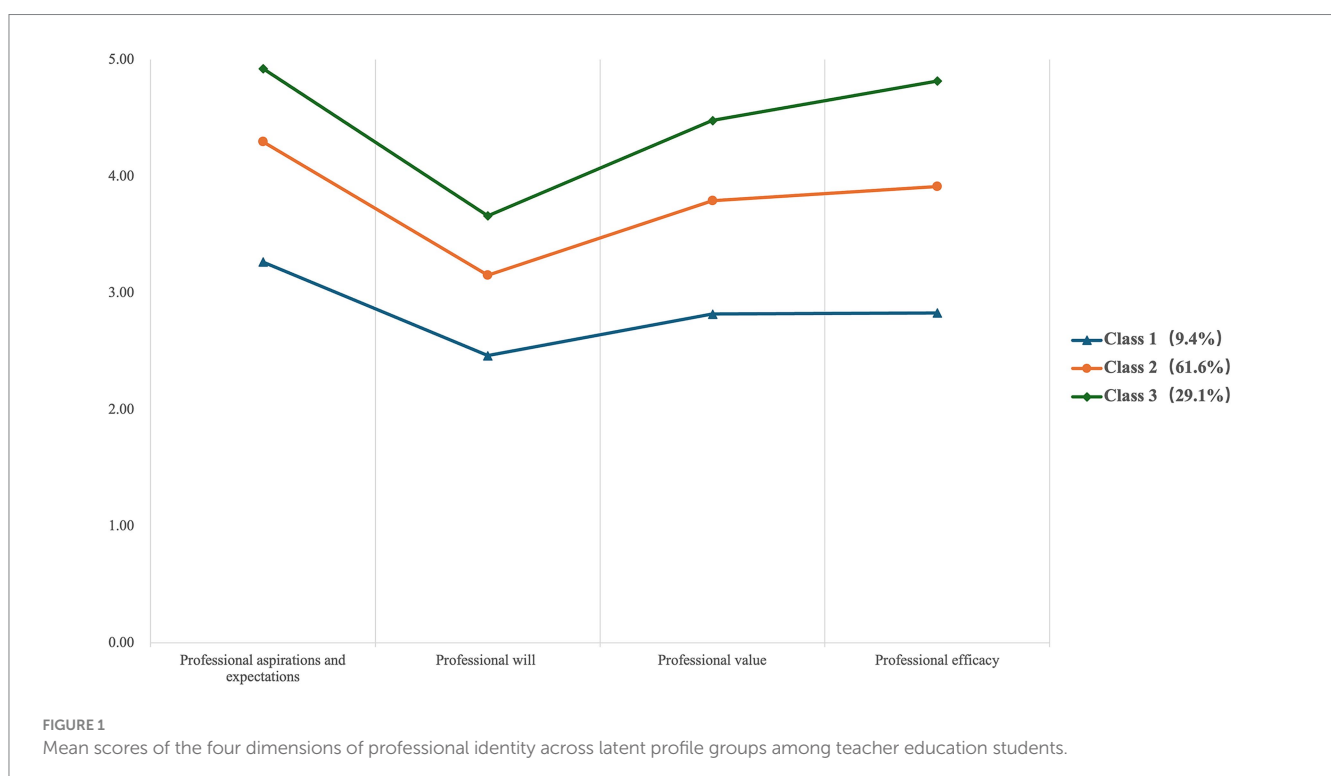


TABLE 3 Differences in the four dimensions of professional identity across latent category groups among teacher education students.

		1 Low professional identity group (99)	2 Medium professional identity group (649)	3 High professional identity group (311)	<i>F</i>	<i>Post hoc</i>
Professional aspirations and expectations	<i>M</i>	3.27	4.30	4.92	612.364***	3 > 2 > 1
	<i>SD</i>	0.84	0.41	0.17		
Professional will	<i>M</i>	2.46	3.15	3.66	149.454***	3 > 2 > 1
	<i>SD</i>	0.72	0.58	0.71		
Professional value	<i>M</i>	2.82	3.79	4.48	376.46***	3 > 2 > 1
	<i>SD</i>	0.79	0.50	0.56		
Professional efficacy	<i>M</i>	2.83	3.91	4.82	1462.713***	3 > 2 > 1
	<i>SD</i>	0.64	0.31	0.25		

*** $p < 0.001$.

TABLE 4 Logistic regression analysis of demographic variables on latent categories of professional identity.

		Low professional identity group			Medium professional identity group		
		OR	CI (95%)	<i>p</i>	OR	CI (95%)	<i>p</i>
Gender	Male	1.06	0.55–2.02	0.867	0.49	0.33–0.73	<0.001
	Female	1.00	–	–	1.00	–	–
Place of origin	Urban	1.10	0.68–1.79	0.699	0.89	0.67–1.18	0.409
	Rural	1.00	–	–	1.00	–	–
Major	Humanities	0.80	0.34–1.86	0.602	1.45	0.86–2.46	0.168
	Science	0.58	0.25–1.36	0.211	0.95	0.56–1.62	0.862
	Art/Sport	1.00	–	–	1.00	–	–
Voluntary choice of teacher education major	Voluntary	0.08	0.05–0.14	<0.001	0.38	0.25–0.58	<0.001
	Involuntary	1.00	–	–	1.00	–	–

OR, odds ratio; CI, confidence interval.

the low and medium professional identity groups. Students who voluntarily chose a teacher education major were significantly less likely to belong to the low or medium professional identity groups compared to those who choose involuntarily ($OR_{low} = 0.08$, 95% CI [0.05, 0.14], $p < 0.001$; $OR_{medium} = 0.38$, 95% CI [0.25, 0.58], $p < 0.001$). This indicated that students who involuntarily chose a teacher education major were more likely to belong to the medium and low professional identity groups. Further analysis showed that the distribution of students who voluntarily chose a teacher education major in the low, medium, and high professional identity groups was 5.18, 60.96, and 33.86%, respectively. For students who chose involuntarily, the distribution was 24.45, 62.45, and 13.10%, respectively.

3.3 Influence of the latent categories of professional identity on learning engagement among teacher education students

Initially, an analysis of variance (ANOVA) was performed to compare learning engagement across the latent categories of

professional identity. The results are presented in Table 5. The main effect of motivation was significant, $F(2, 1,056) = 122.32$, $p < 0.001$, with latent professional identity categories explaining 18.8% of the total variance in motivation ($\eta^2 = 0.188$). The main effect of energy was significant, $F(2, 1,056) = 102.15$, $p < 0.001$, with latent professional identity categories explaining 16.2% of the total variance in energy ($\eta^2 = 0.162$). The main effect of focus was significant, $F(2, 1,056) = 102.25$, $p < 0.001$, with latent professional identity categories explaining 16.2% of the total variance in focus ($\eta^2 = 0.162$). The main effect of total learning engagement was significant, $F(2, 1,056) = 120.50$, $p < 0.001$, with latent professional identity categories explaining 18.6% of the total variance in total learning engagement ($\eta^2 = 0.186$). These results indicated that latent professional identity categories exerted a stronger influence on overall learning engagement. *Post hoc* tests indicated that the high professional identity group had significantly higher learning engagement and scores in each dimension compared to the medium professional identity group, and the medium professional identity group was significantly higher than the low professional identity group.

To further examine the influence of latent categories of professional identity on learning engagement among teacher

TABLE 5 Comparison of learning engagement among different latent categories of professional identity.

Latent category	Motivation (<i>M</i> ± <i>SD</i>)	Energy (<i>M</i> ± <i>SD</i>)	Focus (<i>M</i> ± <i>SD</i>)	Total learning engagement (<i>M</i> ± <i>SD</i>)
1 Low professional identity group (99)	4.30 ± 1.13	3.90 ± 1.07	4.01 ± 1.16	4.07 ± 1.08
2 Medium professional identity group (649)	4.73 ± 0.75	4.26 ± 0.82	4.32 ± 0.80	4.44 ± 0.74
3 High professional identity group (311)	5.56 ± 1.01	5.11 ± 1.17	5.18 ± 1.16	5.28 ± 1.06
<i>F</i>	122.32***	102.15***	102.25***	120.50***
η^2	0.188	0.162	0.162	0.186
<i>Post hoc</i>	3 > 2 > 1	3 > 2 > 1	3 > 2 > 1	3 > 2 > 1

****p* < 0.001.

TABLE 6 Linear regression analysis of the effects of different dimensions on learning engagement across latent categories of professional identity.

	Low professional identity group (99)			Medium professional identity group (649)			High professional identity group (311)		
	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>
Professional aspirations and expectations	0.04	0.26	0.793	0.03	0.85	0.394	0.01	0.17	0.864
Professional will	0.17	1.62	0.108	0.01	0.02	0.983	0.04	0.78	0.437
Professional value	0.13	0.99	0.327	0.09	2.19	0.029	0.28	5.09	<0.001
Professional efficacy	0.28	1.69	0.095	0.19	4.93	<0.001	0.22	3.96	<0.001
<i>F</i>	1.36			7.47***			12.30***		
<i>R</i> ²	0.06			0.04			0.14		

****p* < 0.001.

education students, a linear regression analysis was conducted using the four dimensions of professional identity as independent variables and total learning engagement as the dependent variable, as shown in Table 6. For the low professional identity group, the overall regression model was not significant, $F(4, 94) = 1.36$, $p > 0.05$. For the medium professional identity group, the overall regression model was significant, $F(4, 644) = 7.47$, $p < 0.001$, explaining 4% of the total variance in learning engagement ($R^2 = 0.04$). For the high professional identity group, the overall regression model was significant, $F(4, 306) = 12.30$, $p < 0.001$, explaining 14% of the total variance in learning engagement ($R^2 = 0.14$). Additionally, the effects of the four dimensions of professional identity on learning engagement varied across different latent categories. In the low professional identity group, none of the four dimensions of professional identity significantly predicted learning engagement. However, in the medium and high professional identity groups, professional value significantly predicted learning engagement ($\beta_{\text{medium}} = 0.09$, $t = 2.19$, $p < 0.05$; $\beta_{\text{high}} = 0.28$, $t = 5.09$, $p < 0.001$), and professional efficacy also significantly predicted learning engagement ($\beta_{\text{medium}} = 0.19$, $t = 4.93$, $p < 0.001$; $\beta_{\text{high}} = 0.22$, $t = 3.96$, $p < 0.001$), while the predictive effects of professional will and professional aspirations and expectations were not significant.

4 Discussion

4.1 Latent categories of professional identity among teacher education students

This study, through LPA, found that teacher education students' professional identity exhibited heterogeneous characteristics and had varying effects on learning engagement. Students in the medium and high professional identity groups showed higher levels of learning engagement, whereas those in the low professional identity group demonstrated relatively insufficient engagement. The low professional identity group also displayed the lowest scores across all four dimensions, with professional will being the weakest dimension and significantly lower than that of the medium and high groups. This suggests that insufficient motivational commitment may hinder sustained learning engagement and professional growth. Similarly, Cheng and Zhao (2023) provided empirical evidence that professional commitment exerts a significant positive effect on learning engagement. Their study demonstrated that pre-service teachers with higher levels of professional commitment, reflected in stronger career intention, greater interest in professional development, and higher personal time investment, displayed greater persistence and active participation in teaching-related learning activities. This result also

complements the findings of Yang et al. (2025) and Ye et al. (2025). The former indicated that professional identity could indirectly promote learning engagement through occupational identity and emotional resilience, explaining why students in the medium and high professional identity groups were able to maintain higher engagement by relying on internal psychological resources. The latter found that learning engagement, in turn, enhanced professional identity by improving adaptability and self-concept, highlighting the key role of engagement in the process of identity construction. Together, these findings suggest a reciprocal and reinforcing relationship between professional identity and learning engagement, which not only explains the differences across professional identity groups but also underscores the importance of institutional support and individual engagement in teacher education students' professional growth. It can be inferred that for those in the low professional identity group, relying solely on individual motivation may be insufficient to sustain long-term learning engagement and professional development. Therefore, future training practices should provide more support at the societal, institutional, and individual levels to help them build a stable professional identity and enhance their learning engagement.

4.2 Demographic influences on the latent categories of professional identity among teacher education students

This study found that gender and voluntary choice of teacher education major exerted category-specific effects.

Compared with the high professional identity group, gender differences were not significant in the low professional identity group. However, they were evident in the medium group, where male students were significantly less likely than female students to enter this category. This finding helped explain the inconsistency in previous research on gender differences, such as results showing that females had higher professional identity than males (Ding and Jiang, 2011) or that no gender differences were observed (Wang and Hu, 2013). From a variable-centered perspective, overall mean comparisons may obscure category-level differences, whereas person-centered latent class approaches reveal the heterogeneity masked by aggregation (Schmiede et al., 2018). In addition, the overrepresentation of females in teacher education programs has been repeatedly documented in international research and has been linked to differences in motivation and regulation patterns (Mašková et al., 2022). The present findings resonate with this broader pattern: male students face a risk of "identity absence" in the medium professional identity group, whereas female students may encounter a "plateau-like stagnation" when progressing to the high professional identity group. This does not suggest that educational interventions should be directly based on gender divisions; rather, it indicates that training strategies should be tailored to the differentiated needs of groups in their identity construction processes. Specifically, microteaching, peer assessment, and high-quality feedback can help female students accumulate experiences of competence under structured support, thereby facilitating the transition from recognizing professional values to affirming professional efficacy (Fernandez Deocampo, 2024). At the same time, male students should be provided with earlier and more frequent practical opportunities and a safe community of support to reduce entry barriers and foster positive experiences (Van Dusen and

Otero, 2012). Therefore, TPD programs should integrate these interventions to form a support system that accommodates diverse needs and better addresses the heterogeneity of teacher education students' professional identity.

It is also noteworthy that voluntary choice of teacher education major showed strong predictive effects in both low and medium professional identity groups, with effect sizes clearly exceeding those of gender. This indicates that voluntary choice is closely related to professional identity, aligning with Kula's (2022) findings on teacher education students' self-efficacy, attitudes and teaching motivation, as well as Mašková et al.'s (2022) findings on the influence of the quality of career choice motivation on identity development. Thus, motivation quality serves as an important foundation for identity construction and learning engagement. In addition, contextual and institutional factors, such as tuition-free versus self-funded tracks and practicum experience as program characteristics, may also influence individual motivation and the development of professional identity through different commitment mechanisms. This view is supported by la Velle (2025), who highlighted that teacher identity formation is shaped by the interaction of policy, curriculum, and practice, and by Zuo et al. (2017), who demonstrated that tuition-free teacher candidates in China often develop distinct perceptions of professional responsibility and commitment compared with their self-funded counterparts. Accordingly, admission and training should work in tandem: at the entry stage, by strengthening motivation clarification and professional fit assessment; and at the training stage, by establishing "early identification, early intervention" support pathways for students with non-voluntary or unclear motivation, to mitigate the sustained impact of initial motivational disadvantages on identity and engagement.

4.3 Influence of professional identity on learning engagement among teacher education students

This study found that, within the medium and high professional identity groups, professional value and professional efficacy were the key factors driving learning engagement. This difference reflects distinct psychological mechanisms: recognition of professional value encourages teacher education students to maintain stable learning motivation, while professional efficacy enhances their belief in their own abilities, thereby increasing their level of learning engagement (Wu et al., 2021). Therefore, teacher education programs should both enhance students' recognition of the value of the teaching profession through social campaigns and curriculum design (Huang and Chai, 2021). They should also provide greater affirmation and support in teaching and practicum, helping students build teaching confidence and continuously strengthen professional competence through the integration of theory and practice, thereby fostering a virtuous cycle of increased learning engagement and professional growth (Zhang and Zhao, 2018).

In terms of training pathways, the design of teacher education programs should take into account both developmental stages and differentiation. For the medium and high professional identity groups, seminars, reflective practice, and action research can be employed to further strengthen their professional value and professional efficacy, which enables learning engagement to translate into deeper professional growth (Ye et al., 2025; Yang et al., 2025). For the low

professional identity group, however, more structured support is required, such as mentorship programs, individualized guidance, and contextualized practicum, to help them gradually accumulate positive experiences and enhance both identity and learning engagement (Pi et al., 2024).

At the same time, institutional support is equally critical. Lo and To (2023b) noted that, in the post-pandemic context, the lack of ICT resources and institutional support in schools limited teachers' motivation to participate in professional development. This finding highlights that teacher education programs should not only provide pre-service teachers with technology training and resource support but also foster a collaborative atmosphere through the construction of professional learning communities (Van Dusen and Otero, 2012), thereby enabling learning engagement to translate into the enhancement of professional identity construction and self-efficacy.

More broadly, shifts in the external environment—such as digital transformation and the reshaping of CPD during the COVID-19 pandemic—have become important drivers of change in teacher identity (Lo and To, 2023a). For teacher education students, both educational systems and learning contexts also play a significant role in shaping professional identity. Positive supports during training, including practicum opportunities, preparation for digital teaching, and the development of professional learning communities (Flores and Swennen, 2020; Lo, 2020; Lo and To, 2023b), can help students gradually build a stable and positive professional identity while also strengthening their learning engagement and future teaching participation. Taken together, these findings point to a dynamic interaction among professional identity, learning engagement, and TPD.

Existing research also corroborates this mechanism: Lo and To (2023b) revealed the moderating role of institutional and resource support in the relationship between professional identity and learning engagement. Ji (2023) emphasized that teachers' participation in professional development depends not only on individual motivation but is also constrained by institutional contexts and school culture. Pi et al. (2024) further demonstrated that professional identity promotes teachers' continuous growth through professional development mechanisms. Van Dusen and Otero (2012) illustrated how teacher-driven communities can achieve dual enhancement through role transitions and identity reconstruction. In light of the findings of this study, it can be inferred that when teacher education students' professional value and professional efficacy are fully fostered and supported within institutional structures and the supportive atmosphere of professional learning communities, their learning engagement will be more stable and enduring.

5 Conclusion

Based on LPA, this study revealed the group heterogeneity of teacher education students' professional identity, providing a new perspective for understanding its relationship with learning engagement and offering empirical evidence for designing differentiated educational interventions. Teacher education should adopt differentiated training pathways: strengthening the

professional value and efficacy of the medium and high professional identity groups, while supporting the low professional identity group through mentoring programs, individualized guidance, and contextualized practicum to help them accumulate positive professional experiences. At the same time, it is essential to emphasize the role of institutional and environmental support in shaping and developing teachers' professional identity. By ensuring resource provision, offering technology training, and building professional learning communities, teacher education programs can create positive developmental contexts in which teacher education students reconstruct and consolidate their professional identity through sustained support and interaction, thereby promoting a virtuous cycle between learning engagement and TPD.

This study still has certain limitations, which provide avenues for future improvement.

Firstly, the sample in this study was mainly drawn from a limited number of regions and institutions, and the demographic structure was somewhat unbalanced. The questionnaire did not include several key demographic variables such as age, grade level, practicum experience, and program characteristics (e.g., tuition-free or self-funded teacher education students), resulting in an incomplete description of the sample. This limitation may have reduced the external validity of the findings and restricted the analysis of developmental and institutional differences. Future research should broaden the sampling scope and incorporate additional demographic variables, particularly grade level and program characteristics, to provide a more comprehensive understanding of the latent structure of teacher professional identity and its influencing factors. Subsequent studies may, after conducting LPA, include grade level and program characteristics as covariates to predict class membership. In addition, multi-group LPA could be conducted based on these variables to examine whether the latent profile structures remain equivalent and developmentally stable across different academic stages and program characteristics.

Secondly, the measurement in this study mainly relied on self-reported questionnaires, which may be subject to social desirability bias and thus affect the objectivity of the evaluation results (Kwon and Lee, 2020). Future research should combine observations and interviews or introduce a social desirability scale to minimize the impact of such bias (Crowne and Marlowe, 1960; Patton, 2002).

Thirdly, the categories derived from LPA were unevenly distributed, which may have led to unstable parameter estimates for small categories, increased standard errors, and the dominance of large-category effects that masked those of smaller categories (Nylund-Gibson and Choi, 2018). In addition, the subsequent regression analysis classified individuals using maximum posterior probability without correcting for classification error, which may have further introduced bias (Bolck et al., 2004). Future research should consider adopting methods such as the three-step approach or sensitivity analysis to correct for classification errors and enhance the robustness of results (Asparouhov and Muthén, 2014; Vermunt, 2010).

Fourthly, as this study relied on cross-sectional data, it cannot address the stability or developmental progression of professional

identity (Nylund-Gibson and Choi, 2018). Future research should adopt longitudinal methods, such as Latent Profile Transition Analysis (LPTA), to explore its developmental trajectories and long-term effects on learning engagement (Collins and Lanza, 2009).

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Author contributions

YC: Data curation, Formal analysis, Investigation, Software, Writing – original draft, Writing – review & editing. XQ: Data curation, Formal analysis, Investigation, Software, Writing – review & editing. JZ: Funding acquisition, Writing – review & editing. MM: Funding acquisition, Writing – review & editing. XY: Funding acquisition, Supervision, Writing – review & editing, Writing – original draft. JB: Funding acquisition, Supervision, Writing – review & editing, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2025.1596827/full#supplementary-material>

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