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How does principals transformational leadership affect teachers' continuing professional development? The mediating role of teachers innovative leadership

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Abstract This study explores the impact of the principal's transformational leadership, teachers' innovative leadership, and teachers' continuing professional development. Theoretical frameworks highlight transformational leadership as a key element of contemporary leadership theory, especially in promoting school reform and enhancing teachers' professional development. Principals' transformational leadership profoundly impacts teachers' professional development, with teachers' innovative leadership acting as a mediating factor in their growth. This study proposes that principals' transformational leadership directly influences teachers' professional development and indirectly enhances it through promoting innovative leadership. The results indicate that principals' transformational leadership significantly improves teachers' innovative leadership, which acts as an important mediating variable. Therefore, principals' transformational leadership effectively supports teachers' continuing professional development by fostering innovative leadership. These findings offer theoretical support for educational management, emphasizing the core roles of principals' transformational leadership and teachers' innovative leadership in fostering professional growth.

Keywords: principal transformational leadership, teachers' innovative leadership, Teachers' professional development, educational management, leadership style, professional development model

1. Introduction

Teaching is a challenging profession involving various tasks, such as classroom responsibilities, campus collaboration, and administrative duties (Carver, 2018). Teacher professional development is crucial for meeting these demands and fulfilling educational responsibilities (Bragg et al., 2021). Teacher professional learning is widely recognized in school improvement research, as high-quality teaching is essential for student learning. A school culture that supports continuous teacher development has become recognized globally for promoting sustainable student education (Galtseva et al., 2020). Without the organizational structures, values, and norms that support teacher learning, schools struggle to meet evolving and ambitious student learning goals (Nabella et al., 2022). Extensive research shows a critical link between teacher competence and the leadership style of school leaders, with a focus on strategic factors that influence professional learning (Oppi et al., 2023).

Additional studies emphasize that leadership behavior, particularly transformational leadership, is crucial for teachers' continuing professional development (TCPD) (Darling-Hammond et al., 2017). Transformational leaders inspire and empower their followers to engage in higher-order thinking and innovative practices, which are crucial for ongoing professional growth. This study examined two strategic factors influencing teacher professional learning: PTL and TIL (Simonović, 2021). For nearly half a century, research has concluded that principals play a key role and significantly impact both teacher and student learning (Sancar et al., 2021). Principals, as the educational leaders within schools, set the tone for the organizational culture and climate, which in turn, influences teachers' motivation and commitment to their professional development (Fernández-Batanero, 2021). Researchers have also recognized the positive impact of learning-centered leadership approaches, such as instructional leadership and transformational leadership, on TCPD (Moreno-Guerrero, 2020). Researchers have identified the positive impact of learning-centered leadership (such as instructional leadership and transnational leadership) on TCPD (Li et al., 2022). Correspondingly, current research has identified the efforts of principal leadership in motivating and supporting teacher learning (Nkundabakura et al., 2024). Principals who exhibit transformational leadership traits are more likely to create a supportive environment that encourages teachers to take risks, experiment with new teaching strategies, and engage in reflective practice (González-Fernández, 2024).

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However, despite the wealth of research on the individual effects of PTL and TIL, there remains a significant gap in the literature regarding their combined influence on TCPD. To address this gap, the study contributes to the field by providing a comprehensive examination of the interplay between PTL, TIL, and TCPD. By analyzing data from a diverse sample of educators, we aim to uncover the mechanisms through which PTL influences TCPD, and the role that TIL plays in mediating this relationship. The findings have the potential to inform educational policy and practice, enabling school leaders to foster a more supportive and innovative learning environment that promotes teachers' continuous professional growth.

The education system in China has undergone large-scale educational reforms over the past few decades, highlighting the necessity of involving and supporting TCPD (Sancar et al., 2021). However, various conceptual models have been studied in educational leadership research. Transformational leadership is one of the main methods, as it is considered ideal leadership that is relevant to the challenges of education in the 21st century (Fairman et al., 2022). The *Thirteenth Five Year Plan for the Development of National Education* issued in 2017 clearly stated that it supports school leaders in fulfilling their duties in accordance with laws and regulations, encourages bold exploration and innovation in practice, and promotes teaching characteristics and educational styles. The primary objective of this study is to examine how PTL influences TCPD, with a focus on the mediating role of TIL. By identifying this relationship, we aim to address a significant research gap in understanding the mechanisms through which school leadership impacts teachers' professional growth and, ultimately, student outcomes. Thus, it is worth further exploring whether the teaching leadership style of principals can lead teachers to achieve school teaching goals and how teachers can improve their own teaching quality and professional practice.

2. Theoretical background

Leadership is the ability to influence others to achieve their goals. The theory of transformational leadership has become a hot topic in contemporary leadership theory since its inception. During the Reconstruction Movement in the West, transformational leadership was introduced in education to drive school reform. This study's theoretical model is based on research exploring the relationship between principal change leadership and teacher professional development (Rahmi et al., 2019). Additionally, leadership is essential for teacher achievement and is a crucial factor in school progress (Jacob et al., 2020). School leadership significantly influences school organizational characteristics and positively impacts teaching quality and student learning (Leithwood et al., 2021). Previous research on principal leadership and teacher professional development (Freeman et al., 2023) has suggested that leadership practices directly impact teacher learning and indirectly influence organizational characteristics such as trust, collaboration, self-efficacy, collective efficacy, and commitment. This study proposes that PTL directly and indirectly impacts TCPD, which is mediated by TIL. Furthermore, the model examines whether the impact of leadership on teachers' professional development is direct, indirect, or both and how TIL dimensions interact with PTL to create these effects. The conceptual model situates principal leadership and teachers' continuing professional development within the school context (as shown in Figure 1).

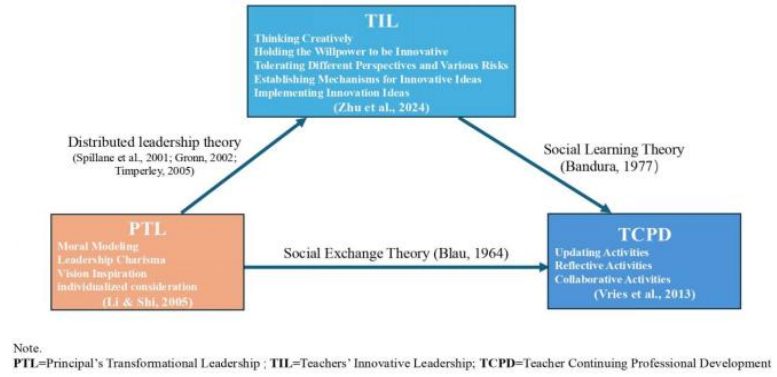

Figure 1 Theoretical Framework.

3. Hypotheses

3.1. PTL

Transformational leaders focus on empowering and influencing individual teachers and teacher teams to undergo organizational change (Choi et al., 2016). These leaders interact with teachers through a bottom-up approach to increase their motivation and ability to improve teaching quality (Kim et al., 2019). Teachers led by transformational leaders are active decision-makers who participate in guiding, planning, and overseeing professional development (Purwanto & Agus, 2020). Prasetia et al. (2020) argued that teachers who support transformational leaders are more likely to seek feedback from each other. The transformational leadership dimension of four principals has been found to be crucial for strengthening teachers' professional development. First, moral modeling refers to the principal setting an example for teachers and students through their own behavior and character and influencing and driving their behavior and attitudes through their own actions. The

second is vision inspiration, which is the extent to which the principal initiates and determines the vision and communicates these priorities and goals to teachers and students, thereby giving people a sense of overall purpose. Next, individualized consideration is that principals provide moral support and pay attention to the personal needs, feelings, and opinions of teachers. Teachers should feel capable of communicating with each other and sharing tasks and responsibilities (Xie et al., 2021). Finally, leadership charisma refers to the principal becoming a role model for teachers and students, gaining their recognition and emulation. These leaders typically have high moral standards, articulate values, and communicate with teachers with enthusiasm and optimism. Purwanto and Agus (2022) reported that PTL can stimulate teacher learning and bring about changes in teaching practices. Empirical research has shown that transformational leadership directly affects collective teacher effectiveness and teacher learning, but these effects are inconsistent (Purwanto et al., 2013). In addition, PTL can enhance teacher collaboration and trust (Coban et al., 2023). Hence, the following hypothesis is constructed.

H1: Principal transformational leadership positively correlates with teachers continuing professional development.

3.2. TIL

On the basis of previous literature analysis, the leadership style of principals has a significant effect on various aspects of school organization. Effective leadership focuses not only on achieving organizational goals but also on individual teacher development and job satisfaction. Organizational goals provide a rich teaching resource environment and reasonable innovative mechanisms for teachers (Susilawati et al., 2021). PTL has a positive effect on guiding innovation throughout organizations (Badrun et al., 2022). In addition, PTL supports the organization's innovative learning process and emphasizes building mutual trust with teachers. The principal takes himself as an example to pursue organizational change and innovation, giving full encouragement to proactive and adventurous change behaviors, thereby inspiring teachers to actively explore teaching methods and content and leading teachers to achieve the school's common vision in a constantly seeking new and changing learning environment (Nuswandoro et al., 2023). Hence, the following hypothesis is formulated:

H2: The principal’s transformational leadership positively correlates with the teacher’s innovative leadership.

3.3. TCPD

TIL is not a simple psychological activity but rather a unified entity that combines multiple functions, such as innovative teaching thinking, innovative teaching concepts, and innovative teaching behaviors. Teacher teaching innovation is influenced by personality traits, family factors, growth experiences and educational levels, school organization and management, and other factors (Garzon Artacho et al., 2020). TIL refers to the creativity and innovation of teachers in the teaching process, applying the latest research and development results to teaching practices and thereby enhancing TCPD. In addition, TCPD can enhance professional knowledge through a wider range of teaching activities (Haryani et al., 2021). Teachers need to engage in continuous professional learning to adapt to the rapidly changing educational environment. Therefore, this study constructed three dimensions: (a) Updates; (b) Reflection; (c) Collaboration (Yao et al., 2024). Hence, the following hypothesis is constructed.

H3: Teachers’ innovative leadership positively correlates with teachers’ continuing professional development.

3.4. Mediating role of TIL

School leaders encourage their subordinates to constantly surpass themselves through their own behavior, leading teachers to improve teaching from a new perspective and promoting teacher professional development (Van der Vyver et al., 2020). Empirical research has shown that TIL is one of the important ways to enhance TCPD (Karacabey et al., 2022). A culture and atmosphere of innovation can promote teaching innovation, give teachers autonomy in teaching, value their personal development, and emphasize management strategies such as teamwork (Bellibas et al., 2023). Hence, the hypothesis is formulated as follows.

H4: Teachers’ innovative leadership mediates the relationship between the principal’s transformational leadership and teachers’ continuing professional development.

4. Results

4.1. Procedure

The study employed a stratified random sampling method to select participants from a pool of demonstrative high schools in Guangxi, China. Schools were stratified based on size, location, and socioeconomic status, ensuring a diverse representation. A total of 125 teachers were selected for the study (79% women and 21%-men, age range 25–65 years). Eligible for participation were teachers that met the following criteria: Teaching at the high school level, having a minimum workload of 10 lessons per week, and working at a school with a formal school principal. After providing informed consent, the participants completed questionnaires. Potential limitations of this sampling approach include the possibility of bias introduced by the stratification criteria and the potential non-representativeness of the sample to the broader population of schools.

4.2. Source of questionnaire questions

The questionnaire design adopted in this study aims to explore in depth the relationships among PTL, TIL, and TCPD. To comprehensively understand the impact and interaction of these variables, the questionnaire content is divided into three main aspects, each covering relevant measurement items. The first part focuses on teachers' views on PTL, which is one of the core aspects of the research. This section includes four dimensions: moral modeling, vision inspiration, individualized consideration, and leadership charisma (Li & Shi, 2005). The second part is the TIL, which includes thinking creatively, holding the willpower to be innovative, tolerating different perspectives and various risks, establishing mechanisms for innovative ideas, and implementing innovation ideas (Zhu et al., 2024). The third part is the TCPD, which is an important part of this study. This section includes update activities, reflection activities, and collaboration activities (Vries et al., 2013). The design of this questionnaire not only draws on research results in related fields but also conducts extensive surveys in Guangxi, China, to ensure the representativeness and comprehensiveness of the data. The data collection period was from July 2024 to September 2024, during which a total of 125 valid questionnaires were collected. For detailed measurement items and their sources in this study, please refer to Table 1.

Table 1 Sources of measurement items in the questionnaire.

Constructs		Number of Measurement Items		Sources
PTL	Moral modeling	7	24	Li & Shi (2005)
	Vision inspiration	5		
	Leadership charisma	6		
	Individualized consideration	6		
TIL	Thinking creatively	5	23	Zhu et al., (2024)
	Holding the willpower to be innovative	5		
	Tolerating different perspectives and various risks	5		
	Establishing mechanisms for innovative ideas	4		
	Implementing innovation ideas	4		
TCPD	Update activities	6	22	Vries et al., (2013)
	Reflection activities	6		
	Collaboration activities	10		

4.3. Questionnaire analysis

4.3.1. Basic situation analysis

Figure 2 presents the statistical analysis of basic questionnaire information, including gender, age, educational background, professional title, and teaching experience. With respect to gender distribution, females made up 52% (65 participants) and males 48% (60 participants) of the sample, indicating a relatively balanced sample. In terms of age, the largest group of teachers was aged 30--39 years (51 participants), followed by those aged 25--30 years (39 participants), indicating a younger demographic. With respect to educational background, 62 teachers held a bachelor's degree, followed by 35 with a college degree, reflecting some diversity in qualifications. Most teachers held intermediate professional titles (71 participants), followed by junior titles (33 participants). Teachers with 6–10 years of experience composed the largest group, with a total of 46 participants. Additionally, slightly more teachers have worked in private schools (66) than in public schools (59), suggesting active recruitment in private education.

Figure 2 Basic statistical results of the questionnaire.

4.3.2. Basic analysis of PTL

Figure 3 shows that most teachers gave high ratings to their principals' personal characteristics and professional ethics. In particular, many teachers strongly agreed with statements such as "My principal will not encroach on others' achievements" and "My principal shares challenges with teachers." Additionally, many teachers agreed with the principal's integrity and selflessness. However, for the statement "My principal does not retaliate or unfairly treat teachers," although most of the responses were positive, a notable proportion of the teachers expressed neutral or dissenting views. With respect to principals' role in promoting professional development, teachers' feedback was mixed. For example, most teachers agreed or strongly agreed with the statement "My principal points out clear goals and directions for teachers." However, in statements such as "My principal helps teachers understand the school's development prospects" and "My principal clarifies the school's philosophy and goals," a notable proportion of the responses were neutral or somewhat disagree, indicating potential gaps in communication and transparency.

Figure 3 Statistical results of PTL.

4.3.3. Basic analysis of TIL

As shown in Table 2, the results indicate that the majority of teachers hold a positive attitude toward innovative leadership behavior. In statements such as 'I can come up with unique or innovative ideas', 'I am good at learning from teaching practices and proposing new ideas', and 'I have the ambition to pursue educational change', responses that choose' agree 'and' strongly agree' account for a greater proportion. In particular, for the two questions "I am able to creatively raise questions and propose innovative solutions" and "I can think about problems from different perspectives", the teacher's positive response demonstrates their creative and multiangle thinking ability in solving teaching problems. Second, for statements related to practical actions and team collaboration, such as "I organize professional exchange activities to share new ideas and practices" and "I establish a platform for colleagues to communicate and discuss", teachers have also shown high enthusiasm. However, although most teachers expressed support for innovation, the proportion of those who chose "somewhat disagree" and "disagree" on issues such as "I can tolerate the potential risks brought by teaching innovation" and "I can tolerate errors and failures in the process of teaching innovation" was relatively high. This may indicate that a certain proportion of teachers are still concerned about risk-taking and tolerance for failure in innovation practice.

Table 2 Statistical results of TIL.

Items	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
1. I am able to come up with unique or original ideas.	2	13	8	11	27	39	25
2. I am good at drawing experience from teaching practice and proposing new ideas.	7	10	7	5	28	38	30
3. I can anticipate changes and developments that may occur in my work.	4	7	12	6	31	41	24
4. I am able to ask questions creatively and come up with innovative solutions.	3	7	12	11	31	38	23
5. I can think about problems from different perspectives.	6	8	8	6	33	40	24
6. I have ambitions to pursue educational change.	1	8	10	11	32	41	22
7. I have a challenging spirit and the courage to innovate teaching routines.	6	10	3	10	29	41	26
8.I can be creative and pursue unique teaching concepts or methods.	7	5	6	9	24	40	34
9. I firmly believe in the value of teaching innovation and dare to face doubts.	8	4	8	7	31	42	25
10. I make every effort to ensure that teaching innovations are implemented.	7	7	5	10	22	43	31
11. I am open-minded and listen to suggestions from all sides.	9	10	10	5	26	40	25
12. I am open to opinions that differ from my own.	4	9	12	8	24	38	30
13. I encourage colleagues to follow their own ideas and work styles.	4	9	13	10	22	39	28
14. I can tolerate the potential risks brought about by teaching innovation.	4	12	10	10	27	41	21
15. I can tolerate mistakes and failures in the process of teaching	7	10	13	7	24	38	26
16. I organize professional exchange events to share new ideas and practices.	13	7	8	6	42	30	19
17. I provide opportunities for my colleagues to learn new things and explore new things.	6	7	10	9	28	38	27
18. I create a platform for colleagues to communicate and discuss	4	12	6	10	28	36	29
19. I expand/develop multiple mechanisms and channels to obtain instructional ideas.	5	13	10	6	36	28	27
20. I develop feasible educational plans to implement innovative ideas.	5	15	6	9	20	38	32
21. I regularly evaluate the progress of implementing innovative ideas for teaching.	4	6	13	12	27	43	20
22. I actively communicate with colleagues and school management to gain their support for the implementation of innovative ideas.	9	8	9	8	32	36	23
23. I actively try to turn innovative ideas into practical applications.	8	6	13	7	23	43	25

4.3.4. Basic analysis of TCPD

According to the results of questionnaire 4, most teachers exhibit high levels of participation and enthusiasm in continuing education and professional development activities. In projects such as 'I read the latest educational materials', 'I participate in professional development activities both on and off campuses, and' I share new teaching concepts with colleagues', a significant proportion of respondents choose 'agree' and 'strongly agree'. In addition, teachers have a positive attitude toward participating in digital communities and professional conferences, which not only helps them access the latest

educational information and teaching methods but also expands their professional networks. In addition, teachers have shown a high level of participation in reflecting on and improving their teaching practices. For example, in the two options of "After class, I reflect on my own course" and "I study students' assignments to understand the effectiveness of my teaching methods," most teachers choose "agree" or "strongly agree. At the same time, teachers also demonstrate a strong spirit of collaboration in their interactions with colleagues, such as the high proportion of positive responses in projects such as "I prepare lessons with colleagues" and "I teach with colleagues (team teaching)", indicating that teachers value teamwork and believe it is an effective way to improve teaching quality and effectiveness as shown in Figure 4.

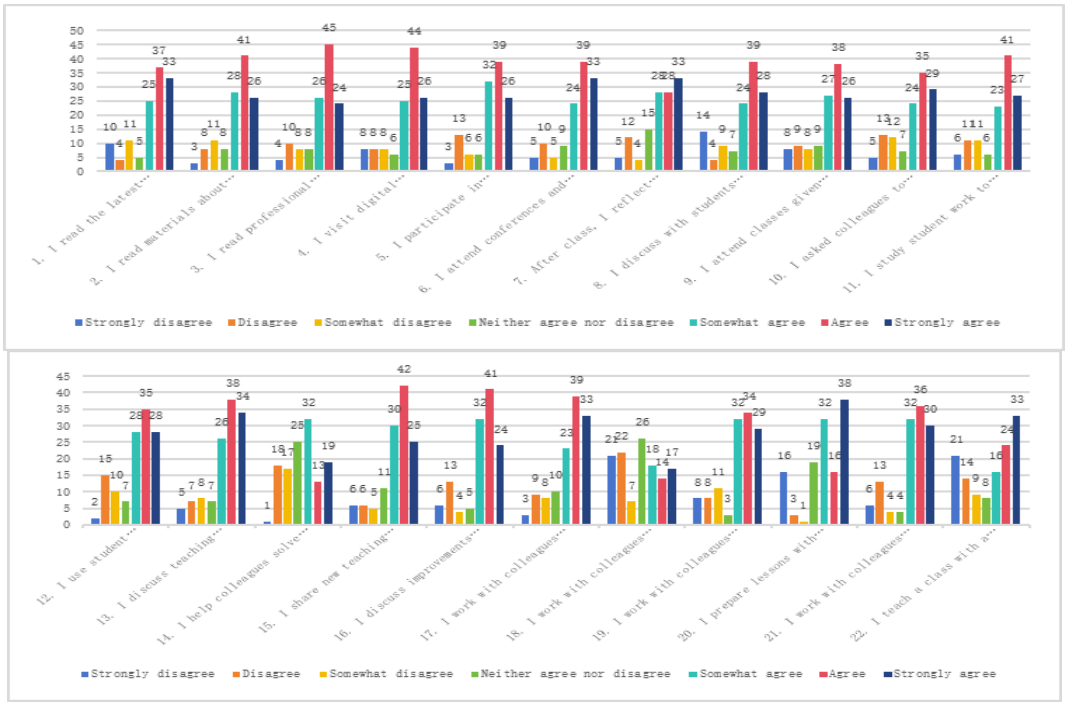

Figure 4 Statistical results of TCPD.

4.4. Factor analysis confirmatory factor analysis

4.4.1. Reliability and validity analysis

Detailed reliability and validity analyses were conducted in this study. First, the Cronbach's alpha coefficient of the questionnaire is 0.958, as shown in Table 4, indicating that the internal consistency of the questionnaire is extremely high and that the reliability of the measurement tool is fully guaranteed. The high Cronbach's alpha coefficient of 0.958 indicates that this questionnaire has very high reliability in terms of PTL, TIL, and TCPD. For the validity analysis, the Kaiser–Meyer–Olkin value of 0.810 shows that the data are suitable for factor analysis. In addition, Table 2 also shows that the factor analysis approach chi-square is 8663.841, with a degree of freedom (df) of 2346 and a corresponding p-value of 0.000. Thus, the model has excellent adaptability, and the results of factor analysis are statistically significant.

Table 4 Reliability and validity.

Item	Alpha	Number of Items	KMO Value	Approx. Chi-Square	df	p-value
Value	.958	69	.810	8663.841	2346	.000

4.4.2. Factor analysis

In factor analysis, the initial factors of the questionnaire were first extracted via principal component analysis. In Table 5, the goal is to divide it into three categories, and the initial eigenvalue of the first category (1--4) components is 3.843, which explains 5.569% of the variance and cumulatively explains 49.090% of the total variance. The initial eigenvalue of the second category (5--9) components is 2.157, explaining 3.126% of the variance and cumulatively explaining 68.504%. The initial eigenvalue of the third category (10--12) components is 1.701, explaining 2.465% of the variance and cumulatively explaining 76.866%. These factors have important representativeness in the questionnaire. The factor analysis after rotation further optimized the explanatory power of the factors. The sum of the squared rotational loads indicates that the explanatory power of the first few factors remains strong after rotation. After rotation, the variance explained by the first category (1--4) components is 7.347%, that explained by the second category (5--9) components is 6.048%, and that explained by the third category (10--12) components is 4.656%, cumulatively explaining 76.259% of the variance.

Table 5 Results of factor analysis.

Component	Extract the sum of squared loads			Extract the sum of squared loads		
	Total	Variance percentage	%	Total	Variance percentage	%
1	19.234	27.875	27.875	5.316	7.705	7.705
2	6.121	8.871	36.746	5.187	7.517	15.222
3	4.674	6.774	43.521	5.120	7.420	22.642
4	3.843	5.569	49.090	5.069	7.347	29.989
5	3.526	5.110	54.200	4.436	6.429	36.418
6	2.777	4.024	58.224	4.275	6.196	42.614
7	2.647	3.837	62.061	4.264	6.179	48.794
8	2.289	3.317	65.378	4.188	6.070	54.863
9	2.157	3.126	68.504	4.173	6.048	60.911
10	2.062	2.989	71.493	4.111	5.958	66.870
11	2.007	2.908	74.402	3.267	4.734	71.604
12	1.701	2.465	76.866	3.212	4.656	76.259

4.4.3. Convergence validity analysis

For convergent validity analysis, the average variance extracted (AVE) and composite reliability (CR) values of each variable are used to evaluate the convergence validity of the measurement model. According to the analysis in Table 6, first, the AVE is used to measure whether the measurement indicators of the variable can explain the variance of the variable. In this study, the AVE value of the TIL was 0.500, the AVE value of the PTL was 0.520, and the AVE value of the TCPD was 0.530, indicating that the questionnaire measurement indicators have good convergent validity in explaining the variance of the corresponding variables. Moreover, the CR is used to evaluate the overall reliability of variable measurement, that is, whether the measurement of variables is consistent. According to the research results, the CR value of the TIL is 0.855, the CR value of the PTL is 0.870, and the CR value of the TCPD is 0.890. C indicates that the CR values of each variable are all above 0.7, indicating that the measurement tool has high internal consistency.

Table 6 Results of Convergence Validity Analysis.

Variable	TIL	PTL	TCPD
AVE	0.500	0.520	0.530
CR	0.855	0.870	0.890

4.5. Model path analysis

4.5.1. Structural equation modeling path analysis

This study uses structural equation modeling (SEM) to conduct a detailed analysis of the path relationships between variables and verify whether the assumed path coefficients in the model are significant. Table 7 shows the impact of TIL on PTL, with a path coefficient of 0.256, standard error of 0.063, critical value (CR) of 4.092, and p-value of * * (less than 0.001), indicating that the impact of this path is statistically significant. Second, the impact of TIL on TCPD was examined. The path coefficient is 0.423, the standard error is 0.160, the critical value is 2.647, and the p-value is 0.008, indicating that the path relationship is also statistically significant. Finally, we analyze the impact of PTL on TCPD. The path coefficient is 0.104, the standard error is 0.050, the critical value is 2.068, and the p-value is 0.039. The results show that the path is statistically significant.

Table 7 Path coefficient test of structural equation model.

Path			Estimate	S.E.	C.R.	P Label	Std.Coef.	Conclusion
TIL	<---	PTL	.256	.063	4.092	***	0.26	Supported
TCPD	<---	TIL	.423	.160	2.647	.008	0.42	Supported
TCPD	<---	PTL	.104	.050	2.068	.039	0.10	Supported

* p<0.05 ; ** p<0.01 ; *** p<0.001.

4.5.2. Analysis of the mediating effect path in structural equation modeling

This study provides a detailed analysis of the mediating role of TIL in the relationship between PTL and TCPD. According to the results in Table 8, the estimated direct effect of TIL on TCPD is 0.108, with a lower confidence interval of 0.028, an upper confidence interval of 0.342, and a p-value of 0.002. This finding indicates that the transformational leadership style of principals has a significant positive direct effect on the continuing professional development of teachers. Next, the estimated total effect of TIL on TCPD is 0.212, with a lower confidence interval of 0.068, an upper confidence interval of 0.569, and a P-value of 0.001. This finding indicates that the transformational leadership style of principals has a significant effect on the

sustained professional development of teachers. Finally, the study analyzes the indirect effects of PTL. The estimated value of the indirect effects is 0.510, with a lower confidence interval of 0.213, an upper confidence interval of 1.013, and a P-value of 0.002. The mediating effect of teacher innovative leadership on the relationship between principal transformational leadership style and teacher sustained professional development is significant.

Table 8 Results of the Mediating Effect of TIL between PTL and TCPD.

Parameter	Estimate	Lower	Upper	P
Direct effect	.108	.028	.342	.002
Total effect	.212	.068	.569	.001
Indirect effect	.510	.213	1.013	.002

5. Discussion

This study delves into the interconnections between PTL, TIL, and TCPD through exploratory factor analysis (EFA) and structural equation modeling (SEM), addressing potential limitations and enhancing its universal applicability. Within this framework, transformational leadership theory underscores the pivotal role of leaders in substantially elevating subordinates' job performance and fostering innovation by establishing inspiring visions and offering support. Notably, PTL not only directly bolsters TIL but also fosters TCPD through this enhanced innovative capacity, thereby validating the efficacy of transformational leadership in educational settings. This underscores its capacity to ignite teachers' innovative potential and propel their professional growth.

Regarding hypothesis testing, H1 and H4 exhibit significant path coefficients of 0.42 and 0.51, respectively, with P-values below 0.05, as detailed in Table 9. These findings possess robust statistical significance and practical implications. Conversely, the relatively modest path coefficients and significance levels observed for H2 (0.26) and H3 (0.10) suggest that while these effects are present, their impact is constrained, potentially due to the intricacies and diversity inherent in real-world contexts (Szelei et al., 2020). Specifically, the strong path coefficients in H1 and H4 highlight the profound influence of PTL and TIL on TCPD (Andriani et al., 2018), emphasizing the significance of the variable relationships studied. The magnitude of these path coefficients mirrors the intensity of the influence between variables, with PTL, as the central leader in schools, exerting a notable direct effect on TCPD (Kang, 2021). Principals play a particularly crucial role in establishing and supporting career development goals (Bektaş et al., 2022).

Table 9 Hypothesis.

No.	Hypothesis	Remark	P	Path coefficient
H1	Principal's transformational leadership positively correlates with teachers continuing professional development.	Supported	.008	0.42
H2	Principal's transformational leadership positively correlates with teacher's innovative leadership.	Supported	***	0.26
H3	Teacher's innovative leadership positively correlates with teachers continuing professional development.	Supported	.039	0.10
H4	Teacher's innovative leadership mediates the relationship between principal's transformational leadership and teachers continuing professional development.	Supported	0.002	0.51

Educational administrators should prioritize strategies to augment teachers' innovation capabilities and career development levels through effective support and guidance within a transformational leadership paradigm, aiming for superior educational outcomes. From a broader vantage point, principals' transformational leadership directly enhances teachers' work environments and development prospects while nurturing their innovative prowess. This dual-function mechanism transcends the education sector, extending its relevance to other organizations demanding innovation and change. For instance, in corporate management, transformational leaders can catalyze sustained innovation and competitiveness by fostering employees' innovation and career advancement (Lomineishvili, K., 2021).

The universal applicability of this mechanism underscores the profound impact of leadership style on organizational innovation and development (Naveed et al., 2022). Furthermore, grounded in theoretical foundations, this study proposes that transformational leadership can propel employees' career development by stimulating their innovative abilities (Bakker et al., 2023). This theory offers a novel perspective for organizational management, emphasizing that leaders can drive employees' holistic development by nurturing innovation capabilities, thereby achieving organizational objectives. This provides a fresh approach for cross-disciplinary organizational management, aiming to foster the long-term success and development of organizations through refined leadership styles and enhanced innovation capabilities.

6. Inspiration

6.1. Theoretical implications

This study investigated the impact of PTL on TIL and TCPD and validated the relevant hypotheses through a questionnaire survey model. Research results indicate that PTL significantly enhances teachers' continuing professional development by fostering and supporting their innovative leadership, which is highly consistent with the core viewpoint of transformational leadership theory (Serin et al., 2020). The effectiveness of this leadership style has not only been validated in the field of education but also provided a reference for other organizations, such as businesses. In the corporate environment, transformational leaders can stimulate employees' creativity and motivation, thereby driving organizational innovation and competitiveness (Schiuma et al., 2022). In addition, this study emphasizes the dual role of transformational leadership in promoting individual development, namely, directly enhancing abilities and indirectly promoting career development through innovative abilities. This mechanism has broad application prospects for the development of society and all humanity (Gad David et al., 2023). Organizations can not only achieve long-term development by optimizing leadership styles and stimulating employee potential but also promote overall social progress and enhance human well-being. Therefore, the theory of transformational leadership is highly important in the field of education and provides valuable guidance for cross-industry management practices.

6.2. Practical implications

This research provides insightful practical implications and serves as a valuable reference for management practices in various industries. First, PTL significantly enhances TIL, further promoting teachers' professional development.

The study emphasized the crucial role of leaders in driving team development. For business managers, adopting transformational leadership—setting a clear vision, providing incentives, and offering support—enhances employees' innovation and overall performance (Fernandez et al., 2021). Second, leaders should focus on employees' personal development. The results show that principals directly influence teachers' innovation and professional growth by supporting career development goals. This mechanism also applies to businesses, where managers should focus on employees' career goals and provide necessary support and resources for their personal and professional development (Fernandez-Cruz et al., 2022). Finally, the study reveals the broad impact of leadership style on teams and organizations. Effective transformational leadership not only enhances individual abilities but also drives organizational progress by fostering team innovation. Organizations should optimize leadership styles to promote teamwork and innovation, thereby driving long-term organizational development (Yukl, 2013). This study provides strong guidance for educational management and offers practical strategies for leadership in other sectors.

7. Conclusion

This study revealed that PTL has a significant effect on TCPD and offered educators clear and actionable insights. Firstly, it underscores the substantial impact of PTL on TCPD. Specifically, the principal's performance in moral modeling, vision inspiration, individualized consideration, and leadership charisma is directly associated with teachers' professional growth. Notably, a robust correlation emerges between positive evaluations of leadership and heightened enthusiasm for professional development among teachers, indicating that transformational leadership effectively fosters professional learning. Secondly, TIL plays a pivotal role in teachers' professional development. The questionnaire analysis reveals that teachers' creativity, innovation, openness to diverse perspectives and risks, and implementation of innovative ideas are positively correlated with their eagerness for professional development. Teachers' individual innovative capabilities and willingness significantly influence their sustained professional growth. Furthermore, the surveyed teachers were predominantly younger and held intermediate professional titles, enhancing the generalizability of the study's results. Collectively, PTL and TIL contribute to TCPD, showcasing the intricate relationship between leadership behavior and teacher self-improvement. These findings provide valuable implications for educational practice, particularly in devising strategies and policies for teacher professional development. Therefore, educators should prioritize attending to principals' leadership styles and nurturing teachers' innovative abilities to elevate educational quality.

8. Limitations

While our findings suggest a significant relationship between PTL, TIL, and TCPD, it is crucial to acknowledge that alternative explanations should also be considered. For instance, the observed effects of PTL, TIL, and their impact on TCPD could be partially attributed to other leadership styles or school-level factors that were not fully captured or analysed in this study. These might include the influence of administrative support, peer collaboration, or even the specific educational policies implemented at different schools. Additionally, the applicability of our findings may vary considerably across different cultural and institutional contexts, given that leadership dynamics and their outcomes can be significantly shaped by societal norms, educational traditions, and organizational structures. Therefore, future research should systematically explore these potential moderators and contextual factors to further validate and generalize our findings, ensuring that they are relevant and useful in a diverse range of educational settings.

Ethical considerations

In terms of ethical considerations, the study has been formally approved by the Human Research Ethics Committee of Sultan Idris Education University.

Conflict of Interest

The authors declare no conflicts of interest.

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