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Assessing the Impact of Teachers' Tacit Knowledge Acquisition on Pedagogical Innovation of Professional Learning Communities: Do Awareness and Sharing of Tacit Knowledge Mediate the Relationship?

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Abstract

The acquisition and application of tacit knowledge are critical processes for driving organizational innovation. Employing structural equation modeling (SEM), this study explores how secondary teachers' different ways of tacit knowledge acquisition influence their tacit knowledge awareness, tacit knowledge sharing, and pedagogical innovation of professional learning communities (PLCs). Both a basic model and an alternative model are examined to deepen the comprehension of these relationships. The findings reveal that ways of tacit knowledge acquisition, including "learning by doing" and "learning by interaction," significantly impact teachers' tacit knowledge awareness and sharing, which subsequently enhance the pedagogical innovation of PLCs. "Learning by doing" and process innovation in teaching serve as mediators in the model. Additionally, the quality of shared knowledge exerts a significant moderating effect on the link between tacit knowledge sharing and product and service innovation. Consequently, the organizers of teaching and research activities should give teachers several corresponding guidelines.

Keywords: Tacit knowledge acquisition, Tacit knowledge awareness, Tacit knowledge sharing, Product and service innovation, Process innovation

1. Introduction

Knowledge has become a pivotal source of innovative advantage in a variety of fields worldwide (Darroch and McNaughton, 2002; Zhang *et al.*, 2010). Amid rapid technological advances and intensifying competitiveness, the acquisition and utilization of critical knowledge constitutes a central function for organizations such as enterprises and research institutions (Garcia-Perez, 2020). Consequently, knowledge management has emerged as a significant field of research within the discipline of management. Based on the Dynamic Theory of Organizational Knowledge Creation (Nonaka, 1994; Liao *et al.*, 2007), researchers examine how individual knowledge is generated and acquired, how it is converted into organizational knowledge, and the relationship between individual knowledge and organizational innovation by studying the acquisition, recognition, sharing, transformation, and application of knowledge (Kucharska,

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2021a), ultimately seeking to enhance the overall competitiveness of professional organizations, such as enterprises and research institutions (Kucharska and Erickson, 2023; Ávila, 2022; Eidizadeh *et al*., 2017), thereby support their sustainable development.

Knowledge comes in several types, each with unique properties. Perspectives on the nature of knowledge vary significantly: either highlighting its absoluteness, static, and objectivity, or focusing on the relationship between knowledge and action, emphasizing its dynamic and subjective, rooted in individual "belief" and "commitment"(Nonaka, 1994). Knowledge was divided into two categories by Polanyi (1966): explicit knowledge and tacit knowledge. Explicit knowledge is generally acknowledged as knowledge that can be readily articulated, codified, and expressed through language or written forms. Tacit knowledge, conversely, refers to knowledge that is difficult or impossible to represent linguistically. It is rooted in the actions, commitments, and involvement of individuals within specific contexts, as well as in their comprehensive understanding of their own physical and mental states. Knowledge of experience and the diversity of individual experiences significantly influence tacit knowledge. In this context, the term "knowledge of experience" refers to an individual's knowledge derived from a reflection in which body and mind have been brought together (Varela, 1991). In other words, it constitutes the cognitive outcome arising from an individual's experiences, shaped by their beliefs and value systems, which form a unique perspective for comprehending and interpreting practical experiences. This implies that the conventional subject-object divisions are transcended by the subject's intentional interaction and integration with the object and surroundings. Within this framework, tacit knowledge is conceptualized by some scholars as encompassing skills and techniques accumulated through individual experience (Reed and DeFillippi, 1990). It is subsequently internalized through critical understanding and practice (Oliva, 2014), embodied in knowledge that is 'in use' or 'in communication' (Wagner and Sternberg, 1985). This perspective, drawing upon Schön's theory of "reflection in action" (Schön, 1983), has exerted a significant impact on the theoretical and practical frameworks of professional development for teachers (Stanley, 1998).

Despite their differences, explicit and tacit knowledge are not binary opposites. From the perspective of information theory, the sequence of knowledge acquisition encompasses data/information, explicit knowledge, tacit knowledge, and insight (Kurtz and Snowden, 2003). This sequence reveals a hierarchical understanding of the connection between explicit and tacit knowledge. In recent years, researchers have become more inclined to understand their relationship from the perspective of the degree of knowledge implicitness. The 'Onion model' makes the assumption that there are different layers of tacit knowledge, positing that explicit and tacit knowledge exist on opposite ends of a continuum, rather than being separated. Knowledge closer to the explicit end is easier to articulate, while knowledge nearer to the tacit end becomes progressively more challenging to express (Asher and Popper, 2019).

Explicit knowledge and tacit knowledge are mutually convertible, and their conversion is accompanied by knowledge sharing and innovation. Polanyi posited that all knowledge is rooted in tacit knowledge, which provides the foundation for the conversion between explicit and tacit knowledge. Knowledge can only be created by individuals, and at the individual level, explicit and tacit knowledge can be converted into each other through internalization and externalization under particular settings. From an organizational perspective, individual explicit and tacit knowledge can be transformed into organizational knowledge through processes such as sharing and dissemination. The transformation of individual explicit and tacit knowledge, as well as the conversion of individual knowledge into organizational knowledge, is not only a process of internalization, externalization, sharing, and dissemination but also a process of knowledge innovation. The Dynamic Theory of Organizational Knowledge Creation argues that organizations do not passively solve problems following a linear "input-process-output" sequence but instead dynamically and proactively process information, make decisions, and create knowledge within specific contexts. Epistemologically, organizational knowledge is generated through the continuous dialogue between tacit and explicit knowledge. The conversion between tacit and explicit knowledge includes four patterns: Socialization (from tacit knowledge to tacit knowledge) refers to sharing and creating tacit knowledge through direct experience. Externalization (from tacit knowledge to explicit knowledge) involves articulating tacit knowledge through dialogue and reflection. Combination (from explicit knowledge to explicit knowledge) refers to systematically applying explicit knowledge. Internalization (from explicit knowledge to tacit knowledge) entails learning and acquiring new tacit knowledge through practice and application. Ontologically, interpersonal social interaction may lead to the expansion of knowledge. Synthesizing these two dimensions, there is an upward "spiral" model of knowledge creation, encompassing phases such as the sharing of tacit knowledge, the creation and validation of concepts, the construction of prototypes, and the cross-layer transfer of knowledge (Nonaka, 1994; Takeuchi and Nonaka, 2004).

Research on tacit knowledge has predominantly employed qualitative methodologies; however, quantitative approaches are also feasible. While the sharing and dissemination of explicit knowledge can be facilitated through formal communication and structured training programs, the inherent subjectivity and unstructured nature of tacit

knowledge present significant challenges for its acquisition and sharing. Consequently, existing studies have predominantly employed qualitative methodologies (Thomas and Gupta, 2021). However, as tacit knowledge is rooted more in individual, rather than collective, experience and reflection (Hau and Evangelista, 2007), individuals can still acquire it through practical experience and social interaction (Insch *et al*., 2008). Although quantitative research on tacit knowledge remains comparatively underdeveloped (Edwards, 2022; Thomas and Gupta, 2021), recent studies suggest that it is feasible to investigate tacit knowledge using quantitative approaches (Kucharska and Erickson, 2023).

Teaching and research activities provide discussion themes, interactive spaces, and practical opportunities for teachers' professional development, serving as platforms to enhance the collective capacity of Teaching Research Groups. It is a crucial form and opportunity for teachers as subjects to scrutinize, criticize, draw from, and examine the knowledge of others, thereby developing their own knowledge. Consequently, these activities have attracted significant research attention (Liu and Xie, 2021; Yang, 2023). Teachers' knowledge can also be categorized as explicit and tacit knowledge. As a professional organization devoted to teacher development, Professional Learning Communities (PLCs) possess knowledge conversion mechanisms encompassing the acquisition, identification, sharing, and application of tacit knowledge. However, relevant research remains at a nascent stage. Therefore, exploring the mechanisms underlying teachers' tacit knowledge acquisition and the innovative capacity of PLCs holds urgent theoretical and practical significance, both for the individual professional development of teachers and for cultivating the construction of a highly qualified, specialized, and innovative teaching workforce.

Based on the theories of tacit knowledge and the Dynamic Theory of Organizational Knowledge Creation, this study examines how individual teachers' tacit knowledge acquisition affects PLCs' innovation. Simultaneously, it explores the mediating role of tacit knowledge awareness and tacit knowledge sharing, as well as the moderating effect of knowledge quality.

2. Literature Review

2.1. Acquisition of Teachers' Tacit Knowledge

Tacit knowledge, such as experience and techniques, often exists at the unconscious level (Bennet and Bennet, 2008a). When an individual's tacit knowledge transitions from an unconscious to a conscious state, it becomes possible to be shared with others in certain ways, thereby providing opportunities for both organizations and individuals to learn from it (Bennet and Bennet, 2008b). This transition frequently takes place in circumstances where tacit knowledge is shared, created, and utilized (known as "ba moments") (Nonaka *et al.*, 2000; El-Den and Sriratanaviriyakul, 2019; Tyagi *et al.*, 2015). In this context, tacit knowledge awareness refers to an individual's recognition of the existence of tacit knowledge.

According to Eraut (2000) and Muñoz *et al.* (2015), tacit knowledge is typically acquired subconsciously, primarily through "learning by doing" and "learning by interaction" (Eraut, 2000; Muñoz *et al.*, 2015; Ryan and O'Connor, 2013). To effectively facilitate the acquisition of tacit knowledge, organizations should emphasize these conditions and strive to create concrete, specific contexts for individuals (Asher and Popper, 2021). Existing studies indicate that tacit knowledge can be activated during processes of knowledge exchange and practice, such as brainstorming, storytelling, context-based analysis, reflective interviews, and case studies (El-Den and Sriratanaviriyakul, 2019). In other words, interpersonal interactions help trigger the externalization of tacit knowledge (Asher and Popper, 2019).

Thus, the following hypothesis is formulated:

H_1: *"Learning by interaction" positively influences teachers' tacit knowledge awareness.*

An Individual's tacit knowledge can originate from shared experiences through interaction, as well as from direct experiences such as personal practice (Ranft, 1997), simulation, and observation. According to existing research, "learning by doing" is a significant source of tacit knowledge (Olaisen and Revang, 2018) and promotes individuals' self-identification with new knowledge (Insch *et al*., 2008).

Based on this, the following hypothesis is proposed:

H2: *"Learning by doing" positively influences teachers' tacit knowledge awareness.*

2.2. Sharing of Teachers' Tacit Knowledge

Knowledge sharing includes the behavior of individuals disseminating their knowledge to other members within an organization (Ryu *et al*., 2003), and the behavior of organizational members, including the sharers, engaging in the re-cognition and re-integration of pertinent knowledge. These behaviors can facilitate the transformation of individual knowledge into organizational knowledge. Research has shown that factors such as extrinsic and intrinsic motivation

(Chen *et al.*, 2018; Jiang and Xu, 2020), intention to share knowledge (Chow and Chan, 2008), attitude toward knowledge sharing (Chow and Chan, 2008; Bock *et al.*, 2005), and social capital (Lee *et al.*, 2021) positively influence individuals' knowledge-sharing behavior. Crucially, the awareness of having acquired tacit knowledge and its subsequent internalization enhance an individual's self-efficacy, which in turn further affects their tacit knowledge sharing (Wipawayangkool and Teng, 2016a; Wipawayangkool and Teng, 2016b).

Building on this, the following hypothesis is proposed:

H3: Teachers' tacit knowledge awareness positively influences their tacit knowledge sharing.

2.3. Tacit Knowledge Sharing Among Teachers and Pedagogical Innovation in PLCs

The OECD defines pedagogical innovation as "a new or improved product or process (or combination thereof)" (OECD, 2019). Such innovation can be categorized into "product and service innovation" and "process innovation". The former refers to innovation in goods and services, such as new textbooks, teaching strategies, or educational resources, while the latter primarily denotes innovations in the processes of educational activities, such as new modes of teacher collaboration or student grouping practices (OECD, 2019).

When individuals acquire tacit knowledge, they are more likely to share it with other members of the organization and apply it within their professional practice. As noted previously, tacit knowledge resides closer to the "insight" end of the knowledge acquisition continuum and can foster the formation of novel ideas through critical thinking. Consequently, compared to explicit knowledge, tacit knowledge holds greater potential for stimulating creativity (Islam and Chadee, 2021; Kucharska, 2021b; Kucharska, 2021c)

Research indicates a linkage between tacit knowledge and creativity within the innovation process. Efficient knowledge management—particularly the management of tacit knowledge—facilitates innovation at both organizational and individual levels (Jisr and Maamari, 2017; Kodama, 2019; Sakellariou et al., 2017). Given its subjective and unstructured nature, tacit knowledge is more likely to be associated with product and service innovation (Kucharska, 2021c).

Therefore, the following hypothesis is put forth:

H4: Teachers' tacit knowledge sharing positively influences the product and service innovation of PLCs.

Tacit knowledge may also be associated with incremental, process-based advancements in routine professional practice. Studies have suggested that process innovation is influenced by the sharing of tacit knowledge (Kucharska, 2021c; Kucharska and Erickson£¬2023).

In light of this, the following hypothesis is proposed:

H5: Teachers' tacit knowledge sharing positively influences the process innovation of PLCs.

2.4. Hypotheses on the Mediation Effect

Tacit knowledge is closely related to individual experience and practice. On the one hand, individuals can acquire tacit knowledge directly through their own practice and experience. On the other hand, knowledge derived from socialization and sharing may prompt individual practice, which in turn may result in the acquisition of tacit knowledge (Jisr and Maamari, 2017). Additionally, "Learning by Interaction" can enable individuals to recognize knowledge from their existing experiences (Mascarenhas, 2019).

As a result, the following hypotheses are proposed:

H6: "Learning by Interaction" of teachers positively influences their "Learning by Doing."

H7: "Learning by Doing" of teachers mediates the relationship between "Learning by Interaction" and tacit knowledge awareness.

An interdependence exists between process innovation and product innovation. The accumulation of process innovations can result in innovations for products and services (Kucharska, 2021b, 2021c; Edwards-Schachter, 2018), and process improvements may enhance the overall innovation capability of organizations (Wong and Chin, 2007).

Accordingly, the following hypotheses are put forth:

H8: Teachers' process innovation in teaching positively influences their product and service innovation.

H9: Teachers' process innovation in teaching mediates the relationship between tacit knowledge sharing and product and service innovation.

2.5. Hypotheses on the Moderating Effect

2.5.1. Quality of Shared Knowledge

Knowledge Quality refers to the degree of satisfaction individuals derive from the knowledge they acquire (Ghobadi and D'Ambra, 2012). It can be measured through six dimensions, including adaptable, applicable, expandable, true, innovative, and justified (Waheed and Kaur, 2016).

The success of knowledge sharing hinges on the satisfaction of recipients with the knowledge they acquire (Ghobadi and D'Ambra, 2012). Furthermore, an organization's capacity for action is contingent upon the quality of shared tacit knowledge (Erden *et al.*, 2008), while the quality of innovative ideas may stem from the quality of shared knowledge (Björk and Magnusson, 2009). Enhancements in knowledge quality elevate an organization's innovation capability (Kyoon Yoo *et al.*, 2011). These findings collectively highlight the inherent connections among knowledge quality, knowledge sharing, and innovation capability (Ganguly *et al.*, 2019; Bulut *et al.*, 2022).

Accordingly, the following hypotheses are proposed:

H10: *Knowledge quality positively moderates the relationship between teachers' tacit knowledge sharing and process innovation in the teaching of PLCs.*

H11: *Knowledge quality positively moderates the relationship between teachers' tacit knowledge sharing and product and service innovation in the teaching of PLCs.*

2.6. Alternative Model

Due to the inherent qualities of tacit knowledge, individuals may acquire tacit knowledge in practice without being aware of it (Eraut, 2000). In such cases, individuals may directly share and apply the tacit knowledge they have gained. Research indicates that ways of tacit knowledge acquisition may directly influence the sharing of tacit knowledge. In other words, regardless of conscious awareness, the acquisition of tacit knowledge may affect its sharing (Asher and Popper, 2021).

Consequently, the following hypotheses are put forth:

H12: *"Learning by interaction" positively influences teachers' tacit knowledge sharing.*

H13: *"Learning by doing" positively influences teachers' tacit knowledge sharing.*

As established, ways of tacit knowledge acquisition directly influence tacit knowledge awareness, which in turn directly affects tacit knowledge sharing. Therefore, the following hypotheses are proposed:

H14: *Teachers' tacit knowledge awareness plays a mediating role between "learning by doing" and their tacit knowledge sharing.*

H15: *Teachers' tacit knowledge awareness plays a mediating role between "learning by interaction" and their tacit knowledge sharing.*

Using the variables of individual tacit knowledge acquisition, tacit knowledge awareness, tacit knowledge sharing, process innovation of PLCs, and product and service innovation of PLCs, this study builds on the aforementioned hypotheses to develop a basic model to examine the impact of teachers' tacit knowledge acquisition on pedagogical innovation of PLCs. Furthermore, an alternative model is constructed without the variable of tacit knowledge awareness. The basic model and the alternative model are presented in Figure 1.
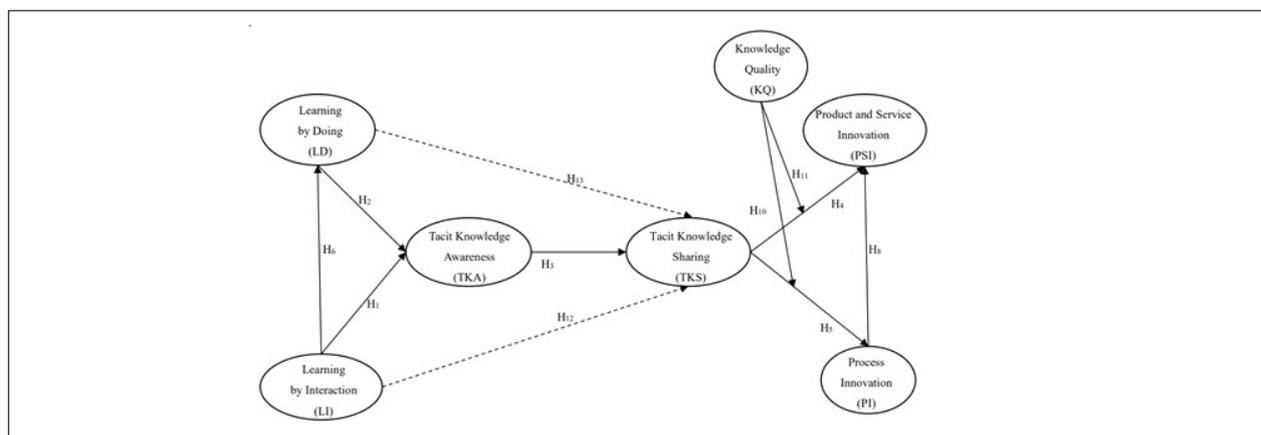
Figure 1: The Basic Model and the Alternative Model

3. Research Design

3.1. Data

This study distributed questionnaires to secondary teachers, collecting a total of 1,230 responses, of which 1,002 were valid (81.5% validity rate). Among the respondents, 449 (44.8%) were male teachers, and 553 (55.2%) were female teachers. Regarding years of teaching experience, 132 teachers (13.2%) had 1–5 years of experience, 98 teachers (9.8%) had 6–10 years, 229 teachers (22.9%) had 11–20 years, and 543 teachers (54.2%) had over 21 years of experience. In terms of educational qualifications, 856 teachers (85.4%) held a bachelor's degree, 126 (12.6%) held a master's degree, and 20 (2.0%) had other qualifications. Regarding professional titles, 238 teachers (23.8%) held the title of "Second-grade Teacher or Below in Primary and Secondary Schools," 423 (42.2%) held the title of "First-grade Teacher in Primary and Secondary Schools," and 341 (34.0%) held the title of "Senior Teacher or Above in Primary and Secondary Schools."

3.2. Measurement Instruments

3.2.1. Confirmatory Factor Analysis of Measurement Models

The study utilized scales developed by Kucharska and Erickson (2023) for "learning by doing" "learning by interaction" "tacit knowledge awareness" "tacit knowledge sharing" "process innovation" and "product and service innovation", as well as the "knowledge quality" scale developed by Chiu *et al.* (2006). These scales were adapted to align with the context of educational settings and used a 5-point Likert scale, where 1 represents "Never" and 5 represents "Always." After calculations, the confirmatory factor analysis (CFA) for each measurement model is presented in Table 1, demonstrating a good fit of the measurement models and allowing further research to proceed.

Table 1: Results of Confirmatory Factor Analysis

Scale	Item Quantity	χ^2	df	CFI	TLI	RMSEA	SRMR
Learning by doing(LD)	4	5.036	1	0.999	0.992	0.050	0.004
Learning by interaction(LI)	4	4.349	1	1.000	0.997	0.031	0.003
Tacit knowledge awareness(TKA)	3	0.000	0	1.000	1.000	0.000	0.000
Tacit knowledge sharing(TKS)	4	2.342	1	1.000	1.000	0.011	0.002
Process innovation(PI)	3	0.000	0	1.000	1.000	0.000	0.000
Product and service innovation(PSI)	3	0.000	0	1.000	1.000	0.000	0.000
Knowledge quality(KQ)	4	5.819	2	0.999	0.998	0.044	0.003

3.2.2. Analysis of Reliability and Validity

Using Mplus 8.3, we calculated the composite reliability (CR), convergent validity, and discriminant validity of the constructs, including "learning by doing" (LD), "learning by interaction" (LI), tacit knowledge awareness (TKA), tacit knowledge sharing (TKS), process innovation (PI), product and service innovation (PSI), and knowledge quality (KQ). The results are presented in Table 2.

Table 2: Composite Reliability, Convergent Validity, and Discriminant Validity

	Composite Reliability (CR)	Convergent Validity AVE	Discriminant Validity						
			LD	LI	TKA	TKS	PI	PSI	KQ
LD	0.860	0.750	**0.866**						
LI	0.892	0.804	0.802	**0.897**					
TKA	0.872	0.694	0.668	0.665	**0.833**				
TKS	0.860	0.749	0.749	0.799	0.844	**0.865**			

Table 2 (Cont.)

	Composite Reliability (CR)	Convergent Validity AVE	Discriminant Validity						
			LD	LI	TKA	TKS	PI	PSI	KQ
P I	0.929	0.815	0.617	0.658	0.695	0.824	**0.903**		
PSI	0.922	0.797	0.613	0.654	0.690	0.818	0.846	**0.893**	
KQ	0.960	0.858	0.538	0.671	0.446	0.536	0.441	0.438	**0.926**

Note: The diagonal bold is the square root value of AVE, and the lower triangle is the Pearson correlation of the corresponding constructs.

As shown in Table 2, the composite reliability of all constructs is greater than 0.7, and the convergent validity exceeds 0.5, meeting the standards proposed by Hair *et al*. (2019) and Fornell and Larcker (1981). According to the criteria of Fornell and Larcker (1981), Table 2 also demonstrates good discriminant validity. Collectively indicating adequate reliability and validity of the measurement models.

4. Results

The theoretical model developed in this study was validated using Mplus 8.3, and the results of the model fit indices and hypotheses testing are shown below.

4.1. Model Fit Indices

The structural model demonstrated good fit with the following indices: X²/df = 4.606, CFI =0.971, TLI =0.966, RMSEA =0.060, SRMR =0.037.

4.2. Research Hypotheses Testing

4.2.1. Basic Hypotheses Testing

The relationships between the variables proposed in the study were tested, and the results are presented in Table 3. As shown, H_2, H_3, H_5, H_6, and H8 were supported. The testing of H_1 and H_4 will be addressed in the subsequent analysis of mediating effects.

Table 3: Results of Basic Hypotheses Testing

	Dependent Variable	Independent Variable	Estimate	SE	Estimate/SE	*p*-Value	
H2	TKA	LD	0.413	0.076	5.443	0.000	Support
H3	TKS	TKA	0.550	0.046	11.925	0.000	Support
H5	P I	TKS	0.823	0.018	45.180	0.000	Support
H6	LD	LI	0.796	0.032	24.897	0.000	Support
H8	PSI	P I	0.539	0.050	10.798	0.000	Support

4.2.2. Mediation Effects Testing

Using Mplus 8.3, this study examined the hypothesized mediation effects by performing 5,000 Bootstrap samples. Table 4 presents the total effects, direct effects, and indirect effects of "learning by interaction" on tacit knowledge awareness, tacit knowledge sharing on product and service innovation, "learning by doing" on tacit knowledge sharing, and "learning by interaction" on tacit knowledge sharing.

Table 4: Results of Mediation Effects Testing

Mediation Effect		Estimate	SE	Estimate/SE	*p*-Value	95%CI		Type
						Lower	Upper	
LI→LD→TKA	Total effect	0.649	0.040	16.260	0.000	0.564	0.719	Partial
	Direct effect	0.320	0.082	3.924	0.000	0.147	0.466	
	Indirect effect	0.329	0.068	4.819	0.000	0.214	0.481	
TKS→PI→PSI	Total effect	0.817	0.018	45.007	0.000	0.779	0.850	Partial
	Direct effect	0.374	0.050	7.460	0.000	0.273	0.471	
	Indirect effect	0.444	0.044	10.139	0.000	0.360	0.532	
LD→TKA→TKS	total effect	0.349	0.069	5.033	0.000	0.215	0.490	Partial
	direct effect	0.122	0.050	2.408	0.016	0.023	0.221	
	indirect effect	0.227	0.045	5.096	0.000	0.151	0.326	
LI→TKA→TKS	total effect	0.781	0.033	23.577	0.000	0.707	0.836	Partial
	direct effect	0.327	0.058	5.629	0.000	0.215	0.443	
	indirect effect*	0.176	0.046	3.812	0.000	0.085	0.267	

Note: * Here are three indirect effects of "LI→TKS", respectively, are "LILD→TKS", "LI→TKA→TKS", and "LI→LD→TKA→TKS". In compliance with research requirements, only the particular indirect effect "LI→TKA→TKS" is reported.

As presented in Table 4, the total effect of "learning by interaction" on tacit knowledge awareness is significant (P<0.05, 95% CI does not include 0), supporting hypothesis 1, which posits that "learning by interaction" has a significant positive effect on teachers' tacit knowledge awareness (TKA). Both the indirect effect (P<0.05, 95% CI does not include 0) and the direct effect ($p < 0.05$, 95% CI does not include 0) are significant, indicating that "learning by doing" plays a significant mediating role in the relationship between "learning by interaction" and tacit knowledge awareness, the mediating effect is partial. Thus, hypothesis 7 is supported.

In the effect of tacit knowledge sharing on product and service innovation, the total effect is significant ($p < 0.001$, 95% CI excludes zero), supporting hypothesis 4, tacit knowledge sharing positively influences the product and service innovation of PLCs. Both the direct and indirect effects are significant, indicating that process innovation mediates the TKS-PSI relationship, thereby validating hypothesis 9.

In the effect of "learning by doing" on tacit knowledge sharing, the total effect is significant, supporting H_{13}; both the direct and indirect effects are significant, confirming H_{14}. Similarly, in the effect of "learning by interaction" on tacit knowledge sharing, the total effect is significant, supporting H_{12}; both the direct effect and the specific indirect effect are significant, confirming H_{15}.

4.2.3. Moderation Effects Testing

The moderating effect of knowledge quality was tested. In the path of "tacit knowledge sharing ¡ú product and service innovation", the estimated value of the interaction term is 0.031 ($p = 0.014$), which is statistically significant at the 0.05 level. This indicates that knowledge quality positively moderates the effect of teachers' tacit knowledge sharing on product and service innovation, supporting H_{11}. However, in the path of "tacit knowledge sharing ¡ú process innovation", the estimated coefficient for the interaction term is -0.002, with $p = 0.845 > 0.05$, which is not statistically significant.

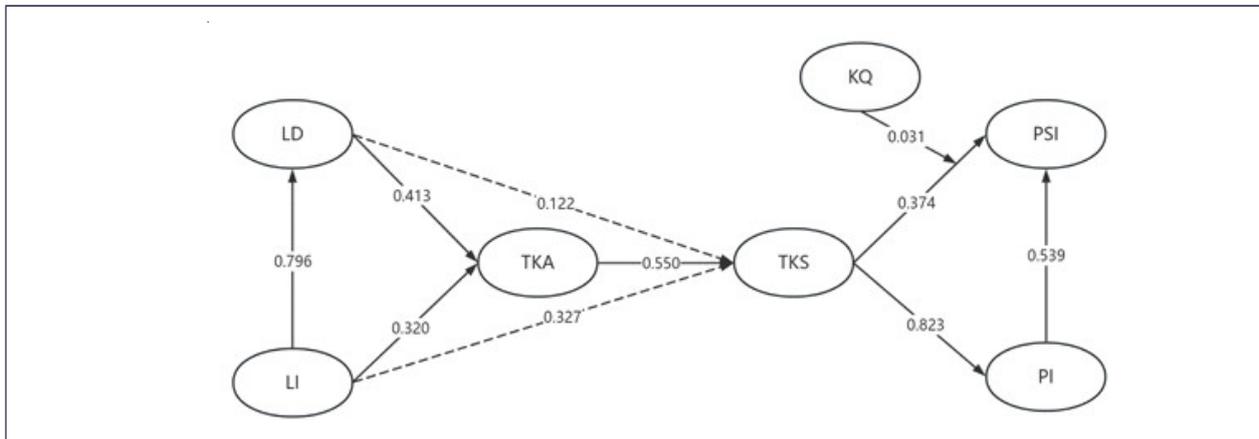Based on these findings, the results of this study are presented in Figure 2.

Figure 2: Visual Presentation of Model Results

5. Discussion and Conclusion

5.1. Internal Mechanisms and Specific Pathways: How Teachers' Ways of Tacit Knowledge Acquisition Affect the Pedagogical Innovation of PLCs

In general, the pathway through which teachers' tacit knowledge acquisition impacts pedagogical innovation within PLCs unfolds as follows: teachers' tacit knowledge acquisition enhances their tacit knowledge awareness, which in turn heightens their tacit knowledge sharing; ultimately, teachers' tacit knowledge sharing positively influences pedagogical innovation within the PLCs.

This study primarily discusses two ways of teachers' tacit knowledge acquisition: "learning by doing" and "learning by interaction". Furthermore, pedagogical innovation is categorized into process innovation and product and service innovation according to existing theories. Therefore, the specific pathways are reflected as follows:

(1) "learning by doing" → tacit knowledge awareness → tacit knowledge sharing→process innovation of PLCs.

(2) "learning by doing" → tacit knowledge awareness → tacit knowledge sharing→product and service innovation of PLCs.

(3) "learning by interaction" → tacit knowledge awareness → tacit knowledge sharing → process innovation of PLCs.

(4) "learning by interaction" → tacit knowledge awareness → tacit knowledge sharing → product and service innovation of PLCs.

This suggests that teachers' awareness of the tacit knowledge they acquire through "learning by doing" and/or "learning by interaction" (internalization) facilitates their sharing of this tacit knowledge with peers in the PLCs during teaching and research activities (socialization or externalization). Subsequently, teachers' tacit knowledge sharing further influences process innovation and/or product and service innovation within the PLCs.

These conclusions are consistent with existing research findings in the IT industry (Kucharska and Erickson, 2023).

5.2. The Mediating Role of "Learning by Doing" and Process Innovation

"Learning by doing" partially mediates the relationship between "learning by interaction" and tacit knowledge awareness. This signifies that LI, as a way of tacit knowledge acquisition, influences teachers' TKA. Concurrently, LI also impacts TKA indirectly through LD. This finding not only validates the hypotheses put out, but it also demonstrates that tacit knowledge acquired through interpersonal interaction stimulates teachers' engagement in practical activities to obtain further tacit knowledge, subsequently influencing their TKA. This conclusion aligns with established research in enterprises and academic institutions (Kucharska and Erickson, 2023)

Process innovation partially mediates the relationship between tacit knowledge sharing and product and service innovation in teaching. This implies that tacit knowledge sharing within PLCs has a direct impact on organizational product and service innovation. At the same time, TKS also exerts an indirect effect on PSI through PI. These findings are in line with research conclusions in other fields.

5.3. The Moderating Role of "Knowledge Quality"

The quality of shared knowledge exerts a positive moderating effect on the relationship between teachers' tacit knowledge sharing and product and service innovation within PLCs. This indicates that the more timely, audience-aligned, and

high-quality the shared knowledge, the stronger the link between tacit knowledge sharing of PLC members and product and service innovation.

5.4. Alternative Model

"Learning by doing" and "learning by interaction" directly influence tacit knowledge sharing, which subsequently affects both process innovation and product and service innovation within PLCs. In other words, teachers may engage in tacit knowledge sharing without awareness of they have acquired the tacit knowledge, thereby further promoting pedagogical innovation in PLCs. Crucially, this conclusion should not be interpreted as negating the vital role of tacit knowledge awareness within this mechanism.

Furthermore, the model demonstrates that tacit knowledge awareness plays a partial mediating role in the relationship between "learning by doing" and tacit knowledge sharing, as well as in the relationship between "learning by interaction" and tacit knowledge sharing.

6. Recommendations

The acquisition, identification, and sharing of tacit knowledge by individual teachers, as well as the development of the overall capability of PLCs, including pedagogical innovation, are critical topics in the field of teacher education research. Pertinent studies hold significant value for promoting the professional development of individual teachers and enhancing the overall quality of the teaching workforce. Grounded in the findings of this empirical research, the following implications and recommendations are proposed.

First, guide teachers to acquire and identify tacit knowledge through diverse ways. "Learning by doing" and "learning by interaction" serve as primary pathways for teachers to acquire tacit knowledge, constituting the "input end" of this process. Tacit knowledge often transitions from the unconscious to the conscious level when teachers engage in interactions with others, conduct teaching practices, or critically reflect on their own practical activities. Identifying the tacit knowledge they have acquired forms the foundation for subsequent knowledge sharing and application. To this end, organizers of teaching and research activities should guide teachers to reflect in practice, encouraging them to consciously acquire tacit knowledge through various methods and actively recognize the corresponding knowledge. Specifically, this can involve encouraging teachers to engage in teaching practices at various levels, participate deeply in the sharing and discussing of teaching experiences, reflect on their own practices, and critically analyze, synthesize, and evaluate their experiences. This facilitates the process described by Nonaka et al. as the internalization and externalization of tacit knowledge.

Second, organizers of teaching and research activities should establish platforms and provide opportunities for the sharing of tacit knowledge. Unlike explicit knowledge, which can be acquired through formal learning and training, tacit knowledge—characterized by its contextuality and subjectivity—can be shared through tacit-to-tacit knowledge transfer, which is socialization, or tacit-to-explicit knowledge conversion, which is externalization (Philipson & Kjellström, 2020), both take place within context-specific teaching and research settings. As a result, organizers of teaching and research activities should meticulously select core topics of mutual interest and critical challenges faced by members of the community, guide members to engage deeply in problem-solving processes, and consciously observe, experience, and evaluate peers' behaviors and perspectives. Within this shared context of problem-solving, tacit knowledge sharing can be facilitated, enabling individuals to effectively transform tacit knowledge gained through sharing into their own understanding, achieving the internalization of shared knowledge.

Third, guide teachers to share high-quality tacit knowledge. The sharing of high-quality tacit knowledge is more conducive to organizational innovation. Therefore, organizers of teaching and research activities should guide teachers to recognize the following: (1) Teachers should actively share knowledge generated from their own critical refinement and summarization of practical experience, which has been validated. Such knowledge is more effective in addressing the actual pedagogical problems faced by recipients, thereby enhancing their professional competence. (2) Teachers should share knowledge that is urgently needed by the recipients; in other words, the tacit knowledge shared should be applicable to the audience. (3) Teachers should share their tacit knowledge in specific contexts and at appropriate times. A shared teaching context ensures that both the sharer and the recipient are operating within the common frame of reference, while timely sharing further ensures effective connection and relevance. (4) Teachers should concentrate on sharing tacit knowledge that is actionable for others. High-quality knowledge sharing contributes to the improvement of others' professional literacy, and procedural, actionable tacit knowledge is particularly effective in directly facilitating imitation, adaptation, and assimilation by others.

Fourth, strengthen the pedagogical innovation capabilities of individual teachers and PLCs through practical activities. From the perspective of knowledge management, the process of pedagogical innovation is a process of individuals acquiring, identifying, and applying tacit knowledge, as well as an organizational process of absorbing and integrating individual tacit knowledge to improve teaching processes and outcomes. Therefore, organizers of teaching and research activities ought to advise teachers to: (1) Identify the core and critical challenges faced by the members of PLCs in teaching practice. (2) Proactively share knowledge and viewpoints regarding these challenges, internalizing others' knowledge effectively through collaborative discussion. (3) Synthesize, refine, and explicitly articulate corresponding strategies from multiple perspectives. (4) Test the effectiveness of these strategies in teaching and make further improvements as necessary. (5) Systematically promote these validated strategies across relevant contexts.

7. Limitations and Future Directions

The limitations of this study are presented as follows. First, current research emphasizes that knowledge quality is a moderating variable, and other influencing factors should be identified in further investigations. Moreover, future research can compare teachers in different countries to see whether cultural differences affect the relationships. At last, it is critical to employ multi-method research, which combines quantitative research with qualitative research, to explore deeper mechanisms of tacit knowledge's management.

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