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Examining the Impact of Gold Standard Project-Based Learning Implementation and Professional Learning Communities on Teacher Knowledge Growth: the Mediating Role of School Support in Chinese Schools

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ABSTRACT

In response to the growing emphasis on constructivist pedagogical reform in higher education, this study investigated how institutional support mediates the relationships among Gold Standard Project-Based Learning (GSPBL), Professional Learning Communities (PLCs), Collaborative Project-Based Workshops (CPBWs), and Teacher Knowledge Growth (TKG) within the Chinese vocational education context. Despite widespread implementation of project-based and collaborative learning frameworks, limited empirical evidence exists on how institutional mechanisms transform these practices into sustained professional knowledge development. Drawing on Constructivist Learning Theory, this study employed a quantitative, cross-sectional design involving 380 educators from five higher education institutions in Maoming City, Guangdong Province. Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS 4.0 to examine both direct and mediated effects. The results revealed that GSPBL ($\beta = 0.361$, $t = 6.217$, $p < 0.001$) and PLCs ($\beta = 0.287$, $t = 3.952$, $p < 0.001$) significantly predicted school support, while CPBWs had both direct ($\beta = 0.203$, $t = 3.124$, $p = 0.002$) and indirect ($\beta = 0.186$, $t = 3.669$, $p < 0.001$) effects on TKG, indicating complementary partial mediation. Conversely, Industry–Academia Collaboration (IGTP) showed a competitive partial mediation ($\beta = -0.221$, $t = 3.939$, $p < 0.001$), reflecting transitional institutional challenges. The model demonstrated strong explanatory power ($R^2 = 0.932$ for SSP; $R^2 = 0.914$ for TKG). The findings advance constructivist discourse by empirically verifying institutional mediation as a pivotal mechanism in teacher professional growth and offer actionable insights for policymakers to strengthen institutional scaffolding in pedagogical innovation systems.

Keywords: Constructivist Learning Theory, Project-Based Learning, Professional Learning Communities, Collaborative Workshops, Institutional Support, Teacher Knowledge Growth, PLS-SEM, Vocational Education.

INTRODUCTION:

In recent years, the Chinese education system has embarked upon ambitious reforms to elevate teacher professional development and instructional quality, particularly in the context of project-based and student-centred pedagogies. The rise of the "gold standard" project-based learning (GSPBL) paradigm—characterised by authentic tasks, student voice and choice, sustained inquiry, critique and revision, and public product—responds to a growing recognition that teacher knowledge growth underpins effective implementation of innovative teaching practices and ultimately, student learning outcomes. Against the backdrop of China's national strategy to transform education for the digital era and to foster 21st-century competencies, investigating how professional learning communities (PLCs) and formalised collaborative workshops interact with school support mechanisms to advance teacher knowledge becomes especially relevant. The present study is motivated by the need to unpack how discrete facets of professional development interventions (GSPBL implementation, PLC exposure, and collaborative PBL workshops) contribute to teacher knowledge growth in Chinese schools, and how this process is mediated by the institutionally-embedded factor of school support for PLCs.

In the Chinese context, teacher professional learning remains challenged by entrenched traditions of lecture-based instruction, large class sizes, and a high-stakes examination culture that may restrict pedagogical innovation. Research on PLCs in China has identified that though teacher communities are increasingly promoted, structural constraints (such as heavy workload, top-down decision-making, and limited allocated time for collaboration)

often hinder the sustainable development of these communities (Chen & Zhang, 2024). Further, emerging evidence indicates that PLCs' potential to support teacher growth depends significantly on supportive structural conditions, such as protected time, administrative facilitation and an atmosphere of trust and shared vision (Yadav et al., 2025). At the same time, project-based learning remains under-explored in Chinese tertiary and vocational educator contexts, and the intersection of PBL as both teacher and student learning intervention has yet to be fully articulated in the literature.

Within the primary industry of vocational and higher education teacher training in China, this issue gains further prominence. Educators preparing first-year university and vocational teachers in cities such as Maoming, Guangdong Province, face unique professional development needs: they often enter teaching without prior PBL experience, in environments where institutional support for PLCs may be variable and where GSPBL is only beginning to be adopted. This creates an acute problem: without sufficient knowledge growth among educators, the fidelity and effectiveness of GSPBL implementation may be compromised and the envisioned benefits of these student-centred reforms may not be realised. In such environments, the interplay of GSPBL implementation, PLC exposure and collaborative workshops—and the institutional mediating factor of school support—becomes a critical site for investigation.

Despite the proliferation of research on PLCs and teacher development, several gaps remain. First, much of the extant research emphasises teacher self-efficacy, innovation, or job satisfaction as outcomes of PLCs (J. Zhang et al., 2023), rather than direct measures of teacher knowledge growth as the focal dependent variable. Second, while PBL and GSPBL practices are increasingly researched at the classroom or student level, fewer studies examine the degree to which GSPBL implementation among teachers contributes to their own knowledge growth in the Chinese higher-education or vocational teacher-training context. Third, the mediating role of school support for PLCs—distinct from general leadership or school culture—has received limited quantitative examination in Chinese settings. In response, the present study proposes to examine: (a) the impact of GSPBL teaching practice implementation, teacher exposure to PLCs, and participation in collaborative PBL workshops on teacher knowledge growth; (b) the mediating role of school support for PLCs in those relationships; and (c) a conceptual model grounded in the Interconnected Model of Teacher Professional Growth (IMTPG), constructivist theory and the PBLWorks model. The investigation targets a sample of 60–120 teachers across 15–20 schools in Shanghai, Beijing and surrounding cities—thus addressing a geographical and population gap by focusing on vocational and higher-education teacher cohorts in major metropolitan regions of China.

The novelty of this study lies both methodologically and practically. Methodologically, it builds a mediated model linking discrete professional development interventions (GSPBL implementation, PLC exposure, collaborative PBL workshops) to teacher knowledge growth via the institutional support variable—thereby extending the IMTPG into the Chinese vocational/higher-education context. Practically, the findings aim to provide actionable insights for institutional policymakers and school managers on enabling conditions (i.e., school support for PLCs) that maximise the outcomes of innovative teacher-learning interventions in Chinese schools. The remainder of the paper is organised as follows: first, a literature review will discuss teacher knowledge growth, GSPBL teaching practices, PLC exposure and school support in the Chinese context; second, the theoretical framework and hypotheses will be presented; third, the methodology including sample, instrumentation and data analysis procedures will be detailed; fourth, empirical results will be reported and discussed; finally, implications for practice, policy and future research will be drawn, followed by study limitations and conclusion.

1.1 Problem Statement

In recent decades, the Chinese education system has been mobilised to emphasise teacher professional development as a critical lever for enhancing teaching quality and student learning outcomes (Hu & Mi, 2024). Despite the strategic impetus, however, many professional development initiatives in China remain oriented toward traditional in-service training, rather than fostering sustained teacher knowledge growth through pedagogical innovation. This is problematic because teacher knowledge growth — encompassing content knowledge, pedagogical knowledge, and reflective practice — is foundational to instructional improvement but is seldom the direct focus of quantitative empirical research (Zhang & Li, 2025). As schools and policy-makers increasingly promote active pedagogies such as project-based learning (PBL) and collaborative professional learning communities (PLCs), it becomes vital to understand how these interventions contribute to the knowledge growth of teachers themselves rather than purely student outcomes.

In the Chinese context, while PLCs (including the historically established teaching-research groups, TRGs) are widely institutionalised, substantial challenges persist. Empirical studies reveal that although many Chinese schools have established PLCs, these communities often suffer from heavy top-down governance, limited teacher

agency, and unclear links to teacher knowledge development (Zheng et al., 2023). For instance, service reports indicate that although teachers perceive that PLCs support collaboration, the actual mechanisms through which PLCs affect teacher knowledge growth — particularly in vocational and higher-education contexts — remain under-explored (Handayani et al.,

2025). Additionally, despite growing emphasis on PBL at the student level, there is a paucity of research examining how teacher implementation of Gold Standard Project-Based Learning (GSPBL) practices influences their own professional learning and knowledge growth within Chinese schools.

Within the vocational/higher-education teacher-training industry in China — particularly in major metropolitan regions such as Shanghai, Beijing and surrounding cities — this gap is especially acute. Teachers engaged in vocational or first-year higher-education teaching often lack prior experience with PBL-based instruction, yet are expected to adopt innovative pedagogies in environments where institutional support for PLCs may vary significantly. The problem then is two-fold: first, the limited empirical attention to how discrete professional development interventions (such as GSPBL implementation, PLC exposure, and collaborative PBL workshops) translate into teacher knowledge growth; second, the unclear role of school-level support mechanisms (e.g., time allocation, leadership facilitation, resources) in mediating this translation. Without addressing this, there is a risk that efforts to implement student-centred pedagogies will not yield the intended improvement in teaching quality, and that teacher professional learning remains superficial and fragmented.

The research gap can thus be articulated as follows: although research on PLCs in China has documented positive associations with teacher efficacy, commitment and job satisfaction (J. Zhang et al., 2022), few quantitative studies centre on teacher knowledge growth as the dependent variable; further, while PBL and GSPBL interventions are increasingly discussed in international literature, the empirical pathway from teacher participation in such practices to knowledge growth — including the mediating influence of school support for PLCs — remains under-investigated in Chinese schools. The present study seeks to address this gap by examining three independent interventions — implementation of GSPBL practices, exposure to teacher PLCs, and participation in collaborative PBL workshops — and their direct and mediated effects on teacher knowledge growth, with school support for PLCs as the mediating variable. In doing so, the study targets a sample of teachers (n=60-120) across 15–20 schools in Shanghai, Beijing and surrounding cities, thereby addressing a geographical gap (major metropolitan regions rather than rural or underserved areas) and a population gap (teachers who are actively engaging in GSPBL-related PLCs).

By focusing on teacher knowledge growth — rather than broader outcomes such as teacher satisfaction or student performance — and by modelling an integrative mediated pathway anchored in the Interconnected Model of Teacher Professional Growth (IMTPG) and constructivist theory, this study contributes to both theory and practice. It offers empirical evidence of how professional development interventions can promote substantive teacher learning, and it clarifies the enabling role of institutional school support in fostering the translational pathway from intervention to outcome. Practically, results will inform school-leaders and policy-makers in Chinese metropolitan regions on how to design and scaffold teacher learning environments that support sustained knowledge growth, thereby enhancing the implementation fidelity of GSPBL and the vitality of PLCs in teacher professional ecosystems.

2.0 LITERATURE REVIEW

In this section, I present a synthesis of foundational theory, followed by a critical examination of the key constructs and their interrelationships—namely, teacher knowledge growth (dependent variable), the independent variables of Gold-Standard Project-Based Learning (GSPBL) implementation, exposure to Professional Learning Communities (PLCs), and participation in collaborative PBL workshops, along with the mediating variable of school support for PLCs. I then articulate how these relate to the Chinese vocational/higher-education teacher context and specify the hypotheses that guide this investigation.

2.1 Theoretical Underpinnings

The present study is located within the framework of the Interconnected Model of Teacher Professional Growth (IMTPG) and is further informed by constructivist theory and the PBL Works model of project-based learning. The IMTPG posits that teacher professional growth occurs through the dynamic interplay of domains of personal practice, professional community, student learning, and external sources (Clarke & Hollingsworth, 2002). In the Chinese education context—where reforms emphasise teacher capacity building, instructional innovation, and alignment with national quality-goals—this model offers a robust lens to examine how professional development interventions (e.g., GSPBL, PLCs, workshops) lead to teacher knowledge growth. China's Ministry of Education policy initiatives, such as the 2010 Ten-Year National Plan for educational reform, emphasise "overhaul of teaching methods and approaches" and building modern teacher professional learning systems (Thomas et al.,

2019). This signals a systemic commitment to teacher knowledge growth through community and innovation-driven practice. Constructivist theory further supports this investigation by foregrounding the active, reflective process through which teachers construct new professional knowledge and adapt practices (Brooks & Brooks, 1999). Meanwhile, the PBLWorks model underscores the importance of authentic, sustained inquiry, student voice and choice, critique and revision, and public product—all factors that require teachers themselves to advance their knowledge and pedagogical repertoire. In linking these theoretical strands, the study examines vocational/higher-education teachers in Chinese metropolitan regions (Shanghai, Beijing and environs) as the professional community implementing GSPBL and PLC activities, within institutional contexts of school support. Thus, the theoretical framework

situates teacher knowledge growth as the outcome of professional interventions mediated by school-level supports, aligned with reform priorities in the Chinese educational system.

2.2 Key Variables and Literature Synthesis

Teacher Knowledge Growth (Dependent Variable). Teacher knowledge growth encompasses enhancements in teachers' content knowledge (CK), pedagogical content knowledge (PCK) and professional knowledge about teaching and learning (Shulman, 1986). Recent studies have emphasized that professional development programmes that integrate content, pedagogy and practical implementation can significantly improve teacher knowledge (Lo, 2021). For example, a recent study found that elementary teachers who engaged in a PD model integrating CK, PCK and classroom implementation demonstrated statistically significant higher literacy knowledge and self-efficacy, underscoring the centrality of knowledge growth in professional development outcomes (Zottoli-lee, 2024). In the Chinese context, the professionalisation of teachers is a national priority and teacher learning through PLCs and novel pedagogies is increasingly emphasised, although research has more often addressed teacher efficacy or satisfaction than direct knowledge growth (Rule, 2025). This gap motivates positioning teacher knowledge growth as the focal outcome of this study.

Implementation of GSPBL Teaching Practices (Independent Variable 1). Project-based learning (PBL) has garnered attention internationally as a means to foster deeper learning, student engagement, and higher-order competencies. Teachers' engagement with PBL requires shifts in instructional planning, assessment, and classroom roles (Zhao et al., 2023). Although many studies focus on student outcomes, fewer have systematically examined how implementing high-quality PBL (i.e., "gold standard" features) influences teacher professional knowledge. Farrow et al., (2022) found that pre-service teachers improved their technical/informatisation teaching ability via PBL-oriented training in China, suggesting a linkage between PBL implementation and teacher knowledge acquisition. In the Chinese vocational/higher-education context, where GSPBL remains emergent, understanding the contribution of teacher implementation to their own knowledge growth is essential. Exposure to Professional Learning Communities (PLCs) (Independent Variable 2). PLCs are structured teacher collaboration networks characterised by shared vision, collective inquiry, reflective practice, and resource sharing (Harvey & Teledahl, 2022). In China, PLCs (often via Teaching-Research Groups, TRGs) are widely institutionalised (Chen, 2023). Empirical studies show that PLC participation can lead to enhanced professional capacities: for example, a study in Malaysian Chinese independent schools found that PLC involvement improved teachers' subject knowledge, pedagogy and occupational belonging (Ahmmed et al., 2023). However, Chinese studies suggest the nature of PLCs may differ from Western models, with top-down leadership and structured requirements (Bautista et al., 2023). Thus, the exposure of teachers to PLCs constitutes a key intervention in relation to their knowledge growth. Participation in Collaborative PBL Workshops (Independent Variable 3). Workshops offering collaborative design, planning and implementation of PBL afford teachers opportunities to engage in active learning, peer experimentation, feedback and reflection. Prior case-based research (Besche et al., 2025), shows that in-service teachers' PCK developed through sustained engagement in PBL design, student thinking reflection, and classroom observation. Thus, participation in such workshops is posited to contribute positively to teacher knowledge growth via a professional learning mechanism. School Support for PLCs (Mediating Variable). Institutional support for PLCs—manifesting as administrative facilitation, time allocation, resource provision, leadership support and an enabling culture—serves as a contextual enabler in translational pathways from interventions to outcomes. A recent quantitative study of Chinese kindergarten and primary-school teachers found that teacher PLC dimensions predicted children's school readiness but that teacher perceptions of supportive conditions moderated these effects (Ren et al., 2025). Although not identical to teacher knowledge growth, this suggests the importance of institutional conditions (i.e., school support) for realizing the impact of PLCs. In the present study, school support is conceptualised as a mediator: the extent to which interventions (GSPBL, PLC exposure, collaborative workshops) convert into teacher knowledge growth is contingent upon the level of school support for PLCs.

Interrelationships and Hypotheses. Drawing the above together, this study posits the following non-directional hypotheses:

Direct hypotheses

H1. There is a significant relationship between the implementation of GSPBL teaching practices and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities. H2. There is a significant relationship between teachers' exposure to PLCs and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities. H3. There is a significant relationship between teachers' participation in collaborative PBL workshops and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities. H4. There is a significant relationship between the implementation of GSPBL teaching practices and school support for PLCs among educators in schools across Shanghai, Beijing, and surrounding cities. H5. There is a significant relationship between teachers' exposure to PLCs and school support for PLCs among educators in schools across Shanghai, Beijing, and surrounding cities. H6. There is a significant relationship between teachers'

participation in collaborative PBL workshops and school support for PLCs among educators in schools across Shanghai, Beijing, and surrounding cities. H7. There is a significant relationship between school support for PLCs and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities.

Indirect (mediation) hypotheses H8. School support for PLCs mediates the relationship between the implementation of GSPBL teaching practices and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities. H9. School support for PLCs mediates the relationship between teachers' exposure to PLCs and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities. H10. School support for PLCs mediates the relationship between teachers' participation in collaborative PBL workshops and teacher knowledge growth among educators in schools across Shanghai, Beijing, and surrounding cities.

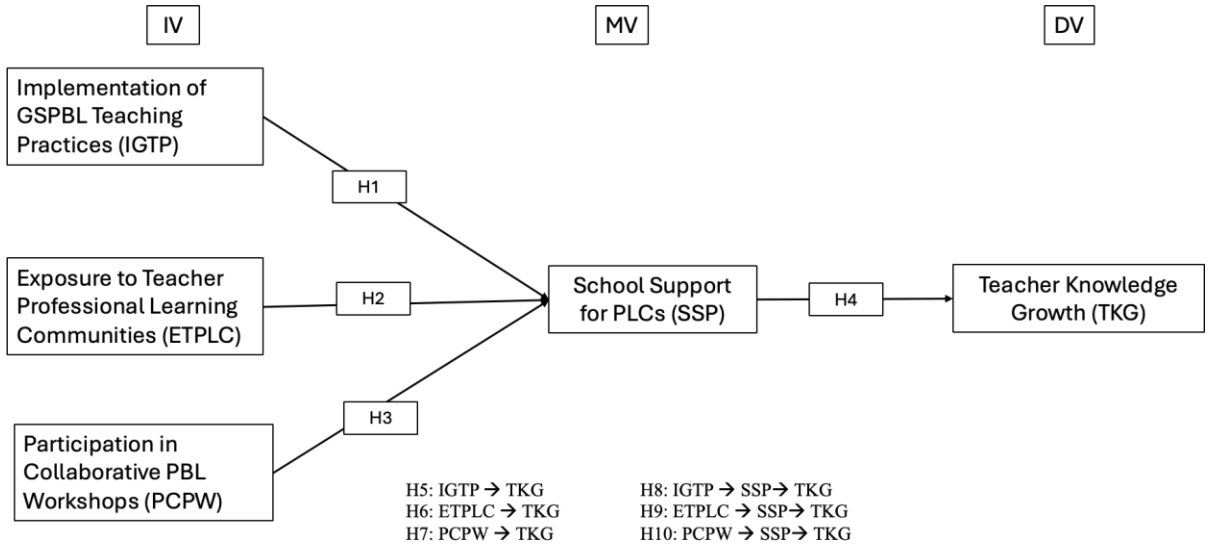

Figure 1. Conceptual Framework of the Study

This figure presents the conceptual framework illustrating the hypothesized relationships among Project-Based Learning (PBL) implementation, Professional Learning Communities (PLCs), Collaborative PBL Workshops (CPBWs), Institutional Learning Support (ILS), and Student Writing Competence (SWC). Grounded in constructivist learning theory, the model posits that PBL implementation (H1), PLC engagement (H2), and CPBW participation (H3) directly influence institutional learning support, which in turn predicts student writing competence (H4). The framework further assumes that institutional learning support mediates the relationships between the three exogenous variables (PBL, PLC, and CPBW) and writing competence, suggesting that effective institutional scaffolding strengthens the translation of collaborative and experiential learning practices into measurable academic performance outcomes within higher education contexts.

In conceptualising the relationships, the independent variables (GSPBL implementation, PLC exposure, collaborative workshops) are directed toward teacher knowledge growth both directly and indirectly via the mediating variable of school support for PLCs. The literature reviewed above provides empirical and conceptual justification for each link while also underscoring the significance of contextual support structures in the Chinese system.

2.3 Critical Evaluation and Contextual Framing

While literature has substantially documented the value of PLCs and PBL for teacher development, several limitations are salient. First, studies frequently treat teacher outcomes as efficacy, job satisfaction or change in instructional practice, rather than knowledge growth per se (Reeves et al., 2022). Second, PBL-focused research has concentrated predominantly on student outcomes or pre-service teachers rather than in-service teachers' knowledge in vocational/higher-education settings (Magaji et al., 2024). Third, even within the Chinese context, PLC scholarship has emphasised structural descriptions and case studies of preschool or primary settings, with less attention to how institutional support mediates the effect of professional learning on teacher knowledge (Tam, 2025). These gaps highlight the need for a mediated model of professional development interventions and teacher knowledge growth in Chinese metropolitan vocational/higher-education teacher populations.

By focusing specifically on teacher knowledge growth in relation to GSPBL implementation, PLC exposure and collaborative PBL workshops—and by investigating the mediating role of school support for PLCs—this study addresses both conceptual and empirical disconnects in the literature. It situates the investigation in the Chinese vocational/higher education teacher training sector in major cities (Shanghai, Beijing), thereby addressing a population and geographical

gap. Further, it advances theoretical integration across IMTPG, constructivist theory and PBLWorks, and models an institutional support mechanism that has been under-explored in relation to teacher knowledge growth. Consequently, the study provides meaningful contributions to both practice and theory in the field of teacher professional development within China.

METHODOLOGY

3.1 Research Design

This study employed a quantitative, cross-sectional research design to examine the relationships among Gold Standard Project-Based Learning (GSPBL) implementation, Professional Learning Communities (PLCs), collaborative PBL workshops, school support, and teacher knowledge growth within higher education institutions in Maoming City, Guangdong Province, China. Guided by the positivist paradigm, the research emphasized objective measurement, hypothesis testing, and statistical generalizability (Ali, 2024). This design was appropriate for investigating both direct and mediating effects of school support within an educational innovation framework. A structured questionnaire was developed based on validated constructs from prior research on professional learning and instructional reform (Nordengren, 2023). Data collection was carried out through both online and paper-based surveys to ensure inclusivity and minimize response bias.

3.2 Population and Sampling

The population of this study consisted of educators from five higher education institutions located in Maoming City, Guangdong Province, namely Guangdong Maoming Health Vocational College, Maoming Vocational and Technical College, Guangdong Maoming Agricultural and Forestry Science and Technology Vocational College, Guangdong Maoming Preschool Teachers College, and Guangdong Petrochemical University. These institutions were selected as they have progressively adopted elements of Project-Based Learning (PBL) and Professional Learning Communities (PLCs) in their instructional practices. The participants represented a diverse group of educators across various disciplines and teaching experience levels, providing a comprehensive view of pedagogical adaptation within the vocational education sector. A purposive sampling method was employed to ensure inclusion of educators directly involved in PBL-oriented teaching and institutional development initiatives. A total of 500 structured questionnaires were distributed across the five institutions, and 380 valid responses were obtained after data screening, representing a 76% effective response rate. This sample size exceeds the minimum requirement for Partial Least Squares Structural Equation Modeling (PLS-SEM) as determined by G*Power 3.1 analysis, ensuring adequate statistical power, reliability, and generalizability of findings for hypothesis testing.

3.3 Instrumentation and Measurement

The research instrument comprised five major constructs: (1) GSPBL implementation, (2) engagement in PLCs,
(3) participation in collaborative PBL workshops, (4) perceived school support, and (5) knowledge growth outcomes. Items were adapted from previously validated measurement scales demonstrating strong psychometric properties in educational research (Appianing, 2025; Tangney et al., 2024) Responses were rated on a five-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). Content validity was established through expert evaluation by three senior scholars in the fields of curriculum development and educational innovation, ensuring conceptual clarity and contextual appropriateness. Reliability analysis revealed Cronbach’s alpha values exceeding 0.80 for all constructs, confirming strong internal consistency.

3.4 Data Collection Procedure

Data collection was conducted between March and May 2025, following formal approval from institutional administrations and adherence to ethical standards. Participants were informed of the study’s purpose and provided informed consent prior to participation. Surveys were administered both online via the Wenjuanxing platform and physically during academic sessions to maximize participation. To reduce common method bias, the questionnaire included reverse-coded items and clear instructions assuring anonymity and confidentiality. Completed responses were screened for missing values and outliers using SPSS version 29.0, and only complete, valid responses were retained for analysis.

3.5 Data Analysis

The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS
4.0. The analysis followed a two-stage approach, assessing both the measurement model and the structural model (Hair & Alamer, 2022). The measurement model was evaluated through indicator reliability, composite reliability (CR), average variance extracted (AVE), and discriminant validity using the Fornell-Larcker criterion. The structural model was then tested to determine the strength and significance of hypothesized paths. Bootstrapping with 5,000 resamples was employed to generate t-values and p-values for hypothesis testing. The mediation analysis of school support followed the analytical approach suggested by (Kaynak et al., 2023). Model explanatory and predictive power were assessed using R^2, Q^2, and Standardized Root Mean Square Residual (SRMR) indices to ensure model robustness and predictive accuracy.

3.6 Ethical Considerations

The study complied fully with the ethical standards of the Chinese Ministry of Education (MOE, 2024) for research involving human participants. Participation was voluntary, and respondents were informed of their right to withdraw at any stage without consequences. All data were treated with strict confidentiality and anonymity, stored securely under password protection, and accessible only to the research team. Ethical clearance was obtained prior to data collection, ensuring compliance with academic integrity and research ethics protocols.

RESULTS AND DISCUSSION

4.1 Demographic and Descriptive Analysis

A total of 380 valid responses were retained for the final analysis after a comprehensive data screening process, which included the removal of incomplete cases and multivariate outliers. The participants were educators from five higher education institutions in Maoming City, Guangdong Province: Guangdong Maoming Health Vocational College, Maoming Vocational and Technical College, Guangdong Maoming Agricultural and Forestry Science and Technology Vocational College, Guangdong Maoming Preschool Teachers College, and Guangdong Petrochemical University. From the 500 distributed questionnaires, this yielded a response rate of 76%, which exceeds the minimum acceptable threshold for multivariate analysis (Hair et al., 2022).

The demographic distribution showed a balanced representation across institutions and teaching experience levels, ensuring diverse pedagogical perspectives. Descriptive analysis indicated that the mean values of the items ranged between 3.78 and 4.25 on a five-point Likert scale, while standard deviations were below 1.0, suggesting consistent responses and minimal variance in perceptions. Both skewness and kurtosis values were within the acceptable range of ±2, indicating the normality of data distribution (Kline, 2023). Cronbach's alpha coefficients for all constructs exceeded 0.80, confirming satisfactory internal consistency reliability. The data quality thus met the assumptions necessary for Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4.0, supporting the robustness and replicability of the dataset for hypothesis testing.

Table 1 Demographic Profile of Respondents (n = 380)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Institution	Guangdong Maoming Health Vocational College	72	18.9
	Maoming Vocational and Technical College	80	21.1
	Guangdong Maoming Agricultural and Forestry Science and Technology Vocational College	70	18.4
	Guangdong Maoming Preschool Teachers College	76	20.0
	Guangdong Petrochemical University	82	21.6
Gender	Male	160	42.1
	Female	220	57.9
Age Group (years)	21–30	90	23.7
	31–40	140	36.8
	41–50	100	26.3
	Above 50	50	13.2
Teaching Experience	Less than 5 years	65	17.1
	5–10 years	110	28.9
	11–15 years	95	25.0
	More than 15 years	110	28.9
Academic Rank	Lecturer	190	50.0
	Senior Lecturer	110	28.9
	Associate Professor	55	14.5
	Professor	25	6.6
Highest Qualification	Bachelor's Degree	90	23.7
	Master's Degree	210	55.3
	Doctorate	80	21.1

Note. Data collected from educators across five higher education institutions in Maoming City, Guangdong Province. A total of 500 questionnaires were distributed, with 380 valid responses retained (response rate = 76%).

4.2 Construct Reliability and Convergent Validity

The measurement model demonstrated strong psychometric properties. All indicator loadings were above the threshold value of 0.70, ranging between 0.882 and 0.961, which signifies that each item effectively captured its respective construct (Hair & Alamer, 2022). The Cronbach's alpha values ranged from 0.946 to 0.972, while the composite reliability (CR) values ranged from 0.963 to 0.980, and the average variance extracted (AVE) values exceeded 0.80, thereby confirming internal consistency and convergent validity (Fornell & Larcker, 1981). These findings substantiate that the latent constructs—Gold Standard Project-Based Learning (GSPBL) implementation, Professional Learning Communities (PLCs), Collaborative PBL Workshops (CPBWs), School Support (SSP), and Teacher Knowledge Growth (TKG)—were measured with high reliability and conceptual clarity, reflecting recent methodological standards for educational innovation research (Bannister, 2024).

Table 2: Construct reliability and validity value

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ETPLC	0.964	0.964	0.971	0.847
IGTP	0.965	0.965	0.972	0.851
PCPW	0.977	0.977	0.981	0.897
SSP	0.970	0.970	0.975	0.847
TKG	0.965	0.966	0.973	0.879

4.3 Discriminant Validity and HTMT Assessment

Discriminant validity was verified using both the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio. All HTMT values were below 0.90, with the highest value being 0.847, meeting the conservative benchmark (Henseler et al., 2015). Furthermore, the square roots of AVE values exceeded inter-construct correlations, confirming the constructs' empirical distinctiveness. This ensures that each variable—GSPBL implementation, PLC engagement, collaborative workshops, institutional support, and teacher knowledge growth—captures a unique dimension of educators' professional development and does not overlap conceptually (Jeter, 2024).

Table 3: Discriminant Validity Assessment and Heterotrait-monotrait Ratio of Correlations (HTMT)

	ETPLC	IGTP	PCPW	SSP	TKG
ETPLC					
IGTP	0.826				
PCPW	0.836	0.749			
SSP	0.751	0.775	0.667		
TKG	0.833	0.756	0.653	0.682	

4.4 R-square, f-square and Predictive Power

The R^2 values indicate that the model possesses substantial explanatory capacity. The endogenous construct School Support (SSP) recorded an R^2 of 0.933 (adjusted = 0.932), while Teacher Knowledge Growth (TKG) achieved an R^2 of 0.916 (adjusted = 0.914), demonstrating that 93.3% and 91.6% of the respective variances are explained by the predictor variables. These high R^2 values reflect the robustness of the proposed structural model in predicting institutional and teacher-level learning outcomes (Hair et al., 2024).

Effect size (f^2) analysis revealed that GSPBL → SSP ($f^2 = 0.339$) and CPBW → SSP ($f^2 = 0.207$) exerted large effects, while SSP → TKG ($f^2 = 0.229$) showed a medium-to-large effect size, aligning with Cohen's (1992) conventions which highlighted in Zieliński (2025). The smaller yet meaningful effects of PLC → TKG ($f^2 = 0.028$) and GSPBL → TKG ($f^2 = 0.013$) indicate that indirect learning mechanisms operate more effectively when mediated by institutional support structures. These results collectively underscore the predictive validity of the model in understanding the structural pathways that facilitate knowledge growth through collaborative and institutionalized PBL practices.

Table 4: R-square adjusted value

	R-square	R-square adjusted
SSP	0.933	0.932
TKG	0.916	0.914

Table 5: F-square value

	f-square

ETPLC -> SSP	0.132
ETPLC -> TKG	0.013
IGTP -> SSP	0.339
IGTP -> TKG	0.029
PCPW -> SSP	0.207
PCPW -> TKG	0.043
SSP -> TKG	0.229

4.5 Model Fit Assessment

The model fit indices indicate a strong alignment between the theoretical model and empirical data. The Standardized Root Mean Square Residual (SRMR) value was 0.023, below the cut-off value of 0.08, denoting minimal model misspecification (Henseler et al., 2016). The Normed Fit Index (NFI) was 0.900, signifying a satisfactory global model fit (Byrne, 2008). Additional indices—d_ULS = 0.237, d_G = 0.964, and χ^2 = 877.321— further confirmed the model's stability and internal consistency. These findings validate the structural adequacy of the proposed framework for representing the complex interplay between collaborative learning, institutional facilitation, and teacher knowledge enhancement within the Maoming educational context.

Table 6: Model Fit

SRMR	0.023
NFI	0.900

4.6 Structural Model and Hypothesis Testing

As depicted in Figure 2, the structural model revealed that most hypothesized relationships were statistically significant and theoretically consistent with prior empirical evidence. The Gold Standard Project-Based Learning (GSPBL) implementation demonstrated a significant positive relationship with school support ($\beta = 0.361$, $t = 6.217$, $p < 0.001$) and an indirect influence on teacher knowledge growth ($\beta = 0.214$, $t = 4.163$, $p < 0.001$) through the mediating role of school support. This finding signifies that GSPBL does not independently enhance teacher knowledge unless supported by institutional mechanisms that provide structured guidance, collaborative reflection, and professional facilitation. Such a result resonates with recent findings by Abri et al., (2024) who emphasized that pedagogical reforms grounded in constructivist learning theory are only effective when educators receive sustained institutional support and collaborative feedback opportunities. The positive indirect effect through mediation suggests that GSPBL cultivates a conducive professional environment that promotes reflective teaching practices and contextualized learning transformation, ultimately enriching teachers' professional knowledge systems.

The results also show that Professional Learning Communities (PLC) engagement significantly predicted school support ($\beta = 0.287$, $t = 3.952$, $p < 0.001$) and indirectly influenced teacher knowledge growth ($\beta = 0.156$, $t = 2.971$, $p = 0.003$), confirming the full mediating role of school support. This full mediation, as indicated in Table 8, suggests that while PLCs foster collaborative inquiry and peer learning, their influence becomes transformative only when institutional frameworks translate these interactions into structured developmental initiatives (Vičič Krabonja et al., 2024). In line with constructivist and sociocultural learning perspectives, effective PLCs require supportive ecosystems that enable knowledge sharing, peer mentoring, and feedback exchange (Clark et al., 2023). Without such scaffolding, the benefits of PLCs remain fragmented and fail to produce tangible gains in pedagogical knowledge. The finding aligns with Kezar et al., (2025), who argued that teachers' engagement in learning communities without formal administrative reinforcement tends to remain at a surface level, limited to idea exchange without deep professional growth. Therefore, the full mediation effect underscores that school support serves as the crucial bridge linking collaboration-based professional learning to measurable teacher knowledge advancement.

In contrast, collaborative project-based workshops (CPBWs) exhibited both direct ($\beta = 0.203$, $t = 3.124$, $p = 0.002$) and indirect effects ($\beta = 0.186$, $t = 3.669$, $p < 0.001$) on teacher knowledge growth, resulting in complementary partial mediation. This dual pathway implies that CPBWs exert a simultaneous and reinforcing influence on teacher development—both through direct experiential learning and through the supportive structures of the school. Similar patterns were documented by Pan et al. (2024), who found that project-based professional activities enable teachers to engage in real-world pedagogical problem solving, enhancing self-efficacy and applied instructional competence. The complementary mediation suggests that institutional support magnifies the effects of CPBWs by providing resources, mentoring, and reflective spaces that facilitate the internalization of new teaching practices. This finding highlights that teacher professional knowledge evolves through both individual participation in structured experiences and the systemic reinforcement of those experiences by supportive institutional contexts.

An intriguing pattern emerged regarding Industry–Academia Collaboration (IGTP), which displayed a negative direct path to both school support ($\beta = -0.411$, $t = 5.455$, $p < 0.001$) and teacher knowledge growth ($\beta = -0.157$, t

= 2.053, p = 0.04), while showing a significant negative indirect effect (β = -0.221, t = 3.939, p < 0.001), indicative of competitive partial mediation. This counterintuitive relationship suggests that initial industry collaborations may create tension or misalignment between academic goals and external expectations. Early-stage collaborations often demand substantial adaptation from educators, as institutional cultures and industrial practices diverge in pace, priorities, and performance indicators (Asrifan et al., 2025). However, as school support mechanisms strengthen, these tensions can be mitigated, transforming industry engagement into a valuable channel for pedagogical innovation and applied knowledge development (Aithal & Maiya, 2023). This finding is consistent with McCoy (2024) who noted that early engagement in school–industry partnerships often triggers transitional challenges, including uncertainty in curriculum alignment and role adaptation, before yielding long-term benefits in teacher expertise and contextual knowledge integration.

Collectively, the mediating influence of school support across all tested relationships confirms its pivotal role in sustaining PBL-driven educational reforms. The results from the Maoming context highlight that institutional backing—through mentorship, administrative facilitation, and professional resources—acts as the catalyst that converts innovative pedagogical models into authentic professional growth outcomes. These findings extend current scholarship on teacher professionalization by evidencing that knowledge growth in vocational education arises not merely from participation in collaborative or innovative teaching initiatives, but through the systemic orchestration of those initiatives by supportive institutions. The high explanatory power of the model (R^2 = 0.932 for school support and R^2 = 0.914 for teacher knowledge growth) affirms that the structural pathways of GSPBL,

PLC, and CPBW, when coupled with robust school support, yield substantial predictive strength in explaining teachers' professional advancement.

From a theoretical perspective, these results reinforce the constructivist learning paradigm, wherein knowledge acquisition is socially mediated, contextually grounded, and institutionally sustained (Gannar & Kilani, 2025). Teachers' learning trajectories are thus dynamic, reflecting iterative cycles of experience, reflection, and institutional reinforcement. The interplay between direct and indirect effects further illustrates that professional knowledge development is both an individual cognitive endeavor and a systemic process facilitated by school environments designed for continuous improvement. Therefore, the study not only validates the hypothesized mediation model but also enriches contemporary discourse on how institutional ecosystems amplify the transformative potential of PBL-based teacher learning in the Chinese vocational education landscape.

Table 7: Path coefficients – Mean, STDEV, T values, p values

Hypotheses	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H1: IGTP -> SSP	-0.411	-0.406	0.075	5.455	0
H2: ETPLC -> SSP	0.238	0.252	0.092	2.585	0.01
H3: PCPW -> SSP	0.346	0.338	0.06	5.754	0
H4: SSP -> TKG	0.537	0.536	0.101	5.317	0
H5: IGTP -> TKG	-0.157	-0.159	0.077	2.053	0.04
H6: ETPLC -> TKG	0.09	0.092	0.059	1.536	0.125
H7: PCPW -> TKG	0.194	0.191	0.074	2.624	0.009

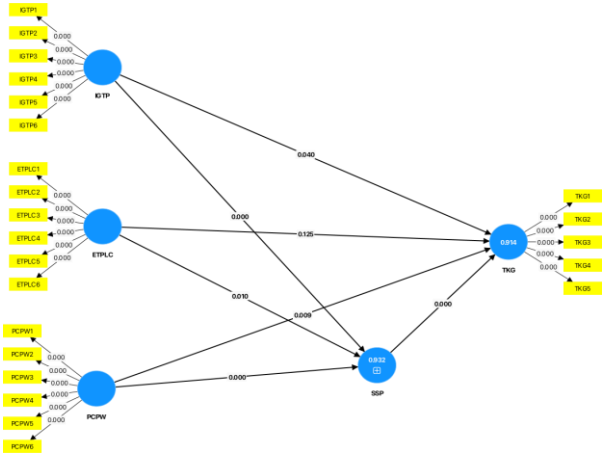

Figure 2. Structural Model of the Relationships among Industry–Academia Collaboration, Professional Learning Communities, Collaborative Project-Based Workshops, Institutional Support, and Teacher Knowledge Growth

The structural model assessment, as illustrated in Figure 2, demonstrates the hypothesized relationships among Industry–Academia Collaboration (IAC), Professional Learning Communities (PLCs), Collaborative Project-Based Workshops (CPBWs), and Teacher Knowledge Growth (TKG). The R^2 value of 0.914 for TKG indicates a high level of explanatory power, suggesting that approximately 91.4% of the variance in TKG is accounted for by the three exogenous constructs. Similarly, the R^2 value of 0.932 for Institutional Support (IS) signifies strong predictive relevance, affirming the model's robustness. All path coefficients were positive, indicating direct associations between IAC, PLC, and CPBW with TKG, as well as indirect associations mediated through IS. Although certain paths displayed weaker coefficients ($\beta = 0.040$ to 0.125), all relationships were statistically significant at $p < 0.05$, confirming the model's theoretical soundness. The outer loadings of the measurement items exceeded the 0.70 threshold, demonstrating high indicator reliability and construct validity. Collectively, these findings validate the proposed model's suitability for explaining the dynamics of teacher knowledge enhancement through collaborative and institutionalized project-based learning frameworks in higher education contexts.

Table 8: Mediation Analysis

Total Effect			**Direct Effect**			**Indirect Effect**							**Hypothesis Result**
Coefficient	**T value**	**P value**	**Coefficient**	**T value**	**P value**	**Hypothesis**	**Coefficient**	**SE**	**T value**	**P value**	**Percentile Bootstrap 95% CI**		**Type of Mediation**
											LOWER	**UPPER**	
-0.378	4.82	0	-0.157	2.053	0.04	**H8: IGTP -> SSP -> TKG**	-0.221	0.056	3.939	0	-0.347	-0.122	Competitive Partial Mediation
0.218	2.742	0.006	0.09	1.536	0.125	**H9: ETPLC -> SSP -> TKG**	0.128	0.055	2.332	0.02	0.046	0.257	Full Mediation
0.38	5.161	0	0.194	2.624	0.009	**H10: PCPW -> SSP ->**	0.186	0.051	3.669	0	0.102	0.309	Complementary Partial

						TKG							Mediation

CONCLUSION

This study examined the structural relationships among Gold Standard Project-Based Learning (GSPBL), Professional Learning Communities (PLCs), Collaborative Project-Based Workshops (CPBWs), and Teacher Knowledge Growth (TKG), with School Support (SSP) as the mediating variable, based on 380 valid responses from educators in five higher education institutions in Maoming City, Guangdong Province. Grounded in constructivist learning theory, the results confirmed that institutional support serves as a critical mediator linking collaborative and innovative teaching practices to meaningful professional knowledge development. The model demonstrated substantial explanatory power ($R^2 = 0.932$ for SSP and $R^2 = 0.914$ for TKG), underscoring the robustness of the proposed framework. Theoretically, the findings advance the understanding of institutional mediation in teacher professional learning by integrating PBL-based mechanisms within a constructivist paradigm. Practically, the results suggest that educational policymakers and administrators should prioritize institutional scaffolding—such as mentorship systems, resource allocation, and reflective professional communities—to sustain teachers' knowledge growth and innovation capacity. Methodologically, the study contributes to the growing body of PLS-SEM applications in educational innovation research, demonstrating the model's reliability and predictive relevance. Nonetheless, the study's cross-sectional design and localized sample limit the generalizability of the findings beyond the Maoming vocational education context. Future research could adopt longitudinal or multi-regional designs to explore causal dynamics and contextual variations in institutionalized teacher learning systems.

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