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RESEARCH ARTICLE

The mechanism of professional learning communities in promoting teacher professional development: An empirical study of university physical education teachers based on collaborative culture

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ABSTRACT

Professional Learning Communities (PLCs) are recognized as a key mechanism for teacher growth, yet little is known about their role among university Physical Education (PE) teachers. This study examined the associations between PLCs and professional development, considering gender and teaching experience.

Survey data were collected from 803 Chinese PE teachers using validated scales. Analyses included t tests, ANOVA, hierarchical regression with controls, and multi-group confirmatory factor analysis. Results showed that PLCs were significantly associated with professional development (β=.500, p<.001), explaining 26.3% of the variance. Gender differences were observed: male teachers scored higher than females (Hedges' g=0.27, p<.001). Teaching experience also mattered: novice teachers (≤ 5 years) and senior teachers (> 25 years) reported higher scores than mid-career peers (6–25 years).

These findings highlight PLCs as a robust organizational resource linked to teacher development beyond background characteristics. Practical implications include differentiated measures: induction and mentoring for novices, leadership opportunities and support for women, and retraining or research incentives for senior staff. This study extends PLC theory to the underexplored context of university PE teachers and provides evidence-based recommendations for building collaborative and equitable faculty development systems.

Keywords: professional learning communities (PLCs); teacher professional development (TPD); physical education teachers; gender; teaching experience

1. Introduction

In the context of ongoing global educational reforms, Teacher Professional Development (TPD) has been widely recognized as a key mechanism for enhancing educational quality and improving student learning outcomes[1]. Teachers are not only transmitters of knowledge but also critical agents of curriculum innovation, learning facilitation, and educational equity. Consequently, their continuous growth has become

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a central focus of both policy formulation and practical exploration[2].

As an important organizational form in the field of teacher development in recent years, Professional Learning Communities (PLCs) have gradually emerged as a central focus of international research. PLCs emphasize collaboration among teachers, the sharing of visions, collective reflection, and continuous professional learning, and are considered an effective mechanism for fostering teaching improvement and strengthening professional identity[3,4].

PLCs, through the institutionalization of collaborative culture and structural support, provide teachers with a platform for collective learning and shared practice. This, in turn, facilitates the integration of teaching and research, enhances teachers' sense of professional belonging, and strengthens teaching efficacy[2]. As Wang and An[3] observed in their study of Malaysian Chinese independent schools, collective reflection and organizational support are among the most significant mechanisms by which PLCs contribute to instructional improvement. Participation in PLCs not only enhances teachers' professional identity but also improves their psychological well-being and work motivation[4].

Although empirical research on PLCs has been expanding, most studies remain focused on basic education, particularly using primary and secondary school teachers as samples, while investigations at the higher education level are relatively scarce [2]. More strikingly, research on PLCs in relation to university Physical Education (PE) teachers is almost absent. PE teachers are often marginalized in institutional structures due to the peripheral status of their courses, the highly independent nature of their teaching, and limited access to professional resources, which exacerbates their developmental challenges[5].

Existing literature indicates that the professional growth of PE teachers is constrained by multiple barriers, such as limited opportunities for collaboration, the absence of effective feedback mechanisms, and a lack of organizational trust[6]. Nevertheless, current research has not adequately examined how the six typical dimensions of PLCs (e.g., shared leadership, collective learning, supportive structures) function through structural pathways to influence the professional development of university PE teachers[3]. Moreover, the mechanisms by which background variables such as gender and teaching experience affect teacher development remain underexplored[5].

Against this backdrop, the present study focuses on Chinese university PE teachers, examining the relationship between their perceptions of PLCs and their level of professional development. Specifically, it tests the predictive power and structural mechanisms of PLCs, thereby addressing an empirical gap in research on the professional development of university PE teachers[2,3]. The findings are expected to provide both theoretical foundations and practical implications for establishing collaborative culture–based support mechanisms for teacher development in higher education[4].

2. Theoretical foundation and literature review

2.1. Theoretical foundation

This study draws upon the theory of Communities of Practice (CoP) proposed by Lave and Wenger[7] as the theoretical underpinning for understanding the operational mechanisms of Professional Learning Communities (PLCs) in higher education institutions. CoP theory emphasizes that learning is a social process in which individuals, through interaction with peers, sharing of experiences, and role-taking, gradually transform their professional identity from peripheral participants to core members[8].

CoPs are generally characterized by collaborative practices, trust and norms built through sustained interaction, and the development of shared knowledge resources[9]. Wenger and Wenger-Trayner[10] further stressed the importance of structural organization, distributed leadership, and ongoing learning projects.

In education, CoP theory has been widely applied to explain teacher professional development (TPD) as a process of reflection, collaboration, and continuous growth. This framework is particularly relevant for Physical Education (PE) teachers, who are often marginalized in institutional structures, as it highlights the role of cultural recognition and organizational support in building sustainable professional networks.

Therefore, CoP theory provides the theoretical foundation for this study to understand how PLCs influence the professional development of PE teachers. Although CoP theory serves as the underlying framework, the empirical analysis of this study focuses on PLCs. To ensure conceptual clarity, the term PLC is used consistently in subsequent sections.

2.2. Professional learning communities

As an organizational mechanism emphasizing teacher collaboration, reflection, and continuous learning, the *Professional Learning Community* (PLC) has in recent years received wide scholarly attention in research on educational reform and Teacher Professional Development (TPD). The concept was first introduced by Hord[11], who highlighted its core aim of promoting collaboration and collective growth among teachers to enhance both overall school quality and student learning outcomes.

Building on earlier studies, Olivier and Hipp[12] developed a more comprehensive six-dimensional model of PLCs, consisting of: (1) shared and supportive leadership, (2) shared values and vision, (3) collective learning and application, (4) shared personal practice, (5) supportive relational conditions, and (6) supportive structural conditions. This structural model has been widely applied in empirical research to measure teachers' perceptions and behavioral engagement in the process of participating in PLCs[13].

A substantial body of international research has confirmed that PLCs effectively improve the ecology of teacher professional development, enhancing teachers' capacity for reflection, confidence in teaching, and sense of organizational belonging. For instance, Admiraal et al. [2], in a survey of 14 secondary schools in the Netherlands, found that teachers with higher levels of PLC engagement demonstrated significantly greater teaching innovation and collaboration. Similarly, Wang and An[3], in their study of Malaysian Chinese secondary schools, highlighted that PLCs strengthen teachers' professional efficacy through an integrated mechanism of "collaboration–reflection–structural support."

In the Chinese educational context, although PLCs developed relatively late, existing studies have begun to apply them in both basic education and higher vocational institutions. Findings indicate that PLCs help break the "isolated teaching" model by building cross-disciplinary and cross-grade collaborative networks, thereby improving teachers' joint lesson planning, teaching research capacity, and professional beliefs[14]. Moreover, in the context of rapid informatization and increasing diversity, PLCs have gradually been endowed with new functions, such as online collaboration, peer mentoring, and action research.

Overall, PLCs have emerged as an important organizational form for fostering teachers' continuous growth, integrating cultural development, institutional support, and learning mechanisms into a unified platform. The ongoing enrichment of their connotations and refinement of their structural mechanisms provide a solid theoretical foundation and practical pathway for subsequent research.

2.3. Professional development of physical education teachers

The *Professional Development of Physical Education Teachers* has become a central topic in global research on physical education, with a particular focus on its critical role in teacher competence,

improvement of teaching quality, and lifelong learning [14]. According to the OECD [15], Teacher Professional Development (TPD) is a process of continuously improving teaching practices and expanding professional knowledge and skills throughout a teacher's career. As subject-specialist educators, PE teachers likewise need to adapt constantly to disciplinary characteristics and ongoing educational reforms.

On the one hand, research has highlighted that the dimensions of PE teachers' professional development mainly include teaching competence, subject knowledge, student relationship-building, technology integration, and reflective practice[16]. Martin[13] further noted that professional development can significantly enhance PE teachers' self-efficacy and improve teaching behaviors. Parker and Patton[17] systematically summarized the critical characteristics of effective and sustained professional development—such as practice-based learning, peer collaboration, ongoing feedback, and reflection—Which are particularly vital for PE teachers.

Moreover, cultural and institutional contexts play a crucial role in shaping the professional development of PE teachers. In European countries, although Continuing Professional Development (CPD) is widely implemented, there are considerable differences in addressing subject-specific characteristics. For instance, Portugal emphasizes the integration of content knowledge and pedagogy[14], while Ireland provides PE teachers with professional mentoring resources through state-funded initiatives [17]. Such institutional support serves as an essential guarantee for the effective functioning of teacher development systems.

In the Chinese context, the professional development of PE teachers is influenced by multiple factors, including institutional support, school culture, and teachers' agency. Findings from the study *The Mechanism of Professional Learning Communities in Promoting the Professional Development of University Physical Education Teachers* indicate that PLCs exert a significant positive predictive effect on PE teachers' professional development (β=.511, p <.001). This suggests that collaborative culture and knowledge sharing among teachers constitute key pathways for fostering professional growth.[18]

In summary, the professional development of PE teachers is a complex process shaped by multiple dimensions and intertwined factors, requiring joint efforts at the individual, organizational, and institutional levels. Future research should pay greater attention to the mechanisms of PE teacher development across different cultural contexts and to the dynamic processes of identity construction among teachers themselves.

2.4. The mechanism of professional learning communities in influencing teacher professional development

In recent years, *Professional Learning Communities* (PLCs) have been widely regarded as an effective mechanism for enhancing Teacher Professional Development (TPD). This model emphasizes collaboration, knowledge sharing, and collective reflection among teachers, thereby strengthening their teaching efficacy and professional identity[2]. Studies have shown that PLCs, through mechanisms such as a "shared vision," "collaborative learning," "organizational support," and "shared practice," provide teachers with embedded and contextualized learning opportunities that foster knowledge renewal and instructional reform[19].

Specifically, qualitative interviews conducted by Wang and An[3] with teachers in Malaysian Chinese Independent Schools revealed that collective lesson planning and classroom observation are among the most effective activities within PLCs. These practices help teachers improve instructional content and pedagogy, deepen subject knowledge, and enhance their understanding of students. Through repeated interactions and peer support, teachers not only improved their teaching competence but also strengthened their sense of professional belonging, which is particularly significant for novice teachers. Furthermore, teachers' engagement in PLCs fostered a positive perception of educational reform and contributed to the establishment of a culture of continuous instructional improvement [20].

In Western contexts, Admiraal et al.[2] further emphasized the critical role of school organizational structures in supporting the functioning of PLCs. Their study highlighted that school-based training, collaborative mechanisms, leadership support, and a culture of change are core conditions for the sustainable development of PLCs. When the integration of individual learning, peer collaboration, and organizational learning is achieved, the transformation of teaching practices becomes more readily attainable.

A meta-analysis by Lomos et al.[21] also demonstrated that the establishment of a high-trust and goal-aligned collaborative culture within schools is a key pathway through which PLCs enhance teachers' professional competence. Moreover, Patton and Parker [17] found that PE teachers benefit significantly from PLCs, particularly in the areas of collaborative curriculum development and reflection on teaching strategies. They stressed that the professional development of PE teachers relies not only on technical training but also on deep collaboration and dialogue with peers in authentic teaching contexts.

In summary, the reviewed studies suggest that PLCs effectively promote the professional growth of university Physical Education (PE) teachers by enhancing reflective teaching practices, fostering peer learning, and strengthening organizational belonging. Given the urgent need for sustained professional support among Chinese university PE teachers in the context of educational reform, this study proposes the following hypothesis:

H1: Professional Learning Communities (PLCs) have a significant positive impact on the professional development of university PE teachers in China.

2.5.The Influence of Teacher Background Variables (Gender and teaching experience) on the professional development of university physical education teachers

The formation of teacher professional development is not only influenced by institutional support and organizational culture but is also closely related to background variables at the individual level[22,23] Among these, gender and teaching experience, as two fundamental demographic variables, exert significant differential effects in the highly gendered field of physical education.

At the gender level, existing studies indicate that the professional development of PE teachers is profoundly influenced by gendered cultural structures and institutional expectations. Pliogou et al.[23], in a multi-country empirical study, highlighted that gender stereotypes and implicit power structures within education systems constrain female teachers' access to professional development opportunities, particularly in assuming leadership roles and participating in decision-making processes. Such institutional barriers not only weaken female PE teachers' professional autonomy but also dampen their motivation to actively engage in Professional Learning Communities (PLCs).

Moreover, gender differences are also evident in teachers' professional development pathways and support preferences. A qualitative study by Zhao and McDougall [18] on Chinese PE teachers found that female teachers favored professional growth mechanisms based on collaboration, mutual support, and reflection, whereas male teachers were more inclined to pursue structured career advancement pathways and goal-oriented approaches. This suggests that gender may serve as a moderating factor in shaping teachers' choices of professional development trajectories and sources of motivation.

Teaching experience, as another critical background variable, also exerts a significant impact on teacher professional development. Based on a large-scale survey of PE teachers in the United States, Centeio et al.[24] found that teachers with fewer years of experience exhibited greater openness and flexibility in adopting instructional innovations, integrating technology, and engaging in continuous professional development. In contrast, more experienced teachers tended to rely heavily on established teaching practices, showing limited

motivation for renewal. These career stage differences highlight the heterogeneous needs of teachers at different levels of teaching experience.

Similarly, Zhao and McDougall[17] noted that novice teachers often rely more heavily on organizational support and external resources, with stronger learning motivation, whereas senior teachers tend to be experience-driven, emphasizing autonomous practice and knowledge transmission. However, they demonstrated lower sensitivity and receptivity to educational reforms and emerging teaching models. This tension between "experiential stability" and "adaptive innovation" further illustrates the critical role of teaching experience in differentiating PE teachers' professional development.

Based on the above analysis, gender and teaching experience play significant roles in influencing the professional development of university PE teachers, particularly in terms of developmental pathways, motivational sources, and levels of participation. Accordingly, the following research hypotheses are proposed:

H2: There are significant differences in the professional development levels of university PE teachers in China across gender.

H3: There are significant differences in the professional development levels of university PE teachers in China across teaching experience.

3. Research design

3.1. Research participants

This study targeted university Physical Education (PE) teachers in China as its research participants. A stratified cluster sampling method was employed for the survey, yielding 803 valid responses. The sample covered PE teachers from various regions and types of universities and demonstrated strong representativeness across gender, age, years of teaching experience, academic rank, and educational background. Among the participants, 58.53% were male and 41.47% female; the largest age group was 36–45 years old (31.38%); teachers with intermediate or senior professional titles accounted for 58.53%; those with more than 15 years of teaching experience represented 44.71%; and 48.27% held a master's degree or above. The reasonable sample structure provides a reliable data foundation for subsequent empirical analysis.

3.2. Research instruments

To examine the mechanism through which Professional Learning Communities (PLCs) influence the professional development of university PE teachers, this study employed two core measurement instruments: the *Perceived Professional Learning Community Scale* and the *PE Teachers' Professional Development Scale*. These were integrated with demographic information items to form the complete questionnaire. All scales adopted a five-point Likert response format (1=strongly disagree, 5=strongly agree) and demonstrated good reliability and validity through expert review and empirical testing.

(1) Professional learning community scale

The Professional Learning Community (PLC) Scale used in this study was adapted from Marian[13]. Its original structure was based on the five-dimensional model developed by Olivier and Hipp[12] and further integrated elements from Dogan et al. [25] concerning the operational mechanisms of school-based learning communities. The scale consists of six dimensions with a total of 46 items, specifically: Shared and Supportive Leadership (11 items), Shared Values and Vision (9 items), Collective Learning and Application (10 items), Shared Personal Practice (7 items), Supportive Conditions—Relationships (5 items), and Supportive Conditions—Structures (4 items). Reliability analysis indicated strong internal consistency, with

Cronbach's α coefficients of .940, .920, .910, .870, .820, and .880 for the six dimensions, respectively. The overall model demonstrated satisfactory reliability. The model fit indices were $\chi^2(974)=2644$, $p<.001$, RMSEA=.049, CFI=.901, TLI=.895, and SRMR=.047, suggesting a good model fit and strong construct validity.

(2) Physical education teachers' professional development scale

This scale was developed by integrating the translated and adapted *Teacher Professional Development Scale* by Lin [26], the *Physical Education Teaching Efficacy Scale* proposed by Humphries et al. [27], and the research findings of Tannehill et al. [14]. It was revised according to the objectives of this study and the professional context of PE teachers in Chinese vocational colleges. The final version comprises three dimensions with 31 items: Professional Development and Practice (7 items), Professional Knowledge and Skills (11 items), and Professional Qualities and Attitudes (13 items). The scale was subjected to expert content validity assessment, item analysis, and exploratory factor analysis, demonstrating strong structural clarity and internal consistency. The overall Cronbach's α coefficient reached .917, the KMO value was .901, and confirmatory factor analysis supported its three-factor structure.

3.3. Data collection and implementation process

This study received ethical approval from the Institutional Review Board of Dhurakij Pundit University, Thailand (Approval No. DPU_BSH 1908/2568, dated August 19, 2025). The research was classified as exempt from full review in accordance with national ethical guidelines. All participants were informed about the purpose of the study, assured of anonymity and confidentiality, and provided informed consent prior to participation.

Participants were recruited through official university channels, including departmental mailing lists and faculty WeChat groups, targeting full-time Physical Education (PE) teachers in both vocational colleges and undergraduate institutions across different regions of China. A stratified cluster sampling strategy was adopted to ensure representativeness by gender, age, and teaching experience. Both paper-based and electronic questionnaires were distributed between May and July 2023. Participation was voluntary, and no financial incentives were offered.

To examine the possibility of non-response bias, early and late respondents were compared on the key study variables (PLCs and professional development). Independent-samples t tests revealed no significant differences (*ps*>.05), suggesting that non-response bias was not a serious concern. After screening and coding, a total of 803 valid questionnaires were retained, yielding an effective response rate of 90.54%.

3.4. Data analysis methods

The collected questionnaire data were analyzed using SPSS 26.0. First, the reliability of the scales was examined by calculating Cronbach's α coefficients. Second, the structural validity of the scales was assessed through the Kaiser–Meyer–Olkin (KMO) test and confirmatory factor analysis (CFA). Descriptive statistics and Pearson correlation analyses were then conducted to explore the basic relationships among the variables.

In the empirical analysis, multiple linear regression was employed, with professional development of PE teachers as the dependent variable and professional learning community as the independent variable, to examine its predictive effects and the relative impact of each dimension on teacher development. Gender, teaching experience, and other background variables were controlled in the regression models to reduce confounding effects. Additionally, descriptive statistics and Pearson correlations were used to explore preliminary associations among variables, while t-tests and one-way analysis of variance (ANOVA) were

conducted to test differences in professional development levels across demographic subgroups. All statistical tests were two-tailed, with the significance level set at $p<.05$.

Additionally, multi-group confirmatory factor analysis (MGCFA) was conducted to examine measurement invariance across gender (male vs. female) and tenure groups (≤ 5 years vs. > 5 years).

4. Common method bias test

To examine the potential issue of common method bias resulting from the use of self-reported questionnaires, Harman's one-factor test was conducted by performing an unrotated principal component analysis on all measurement variables. The results indicated that 14 factors with eigenvalues greater than 1 were extracted, and the first principal component accounted for 29.171% of the variance, which is well below the critical threshold of 40% [28]. This suggests that common method bias is not a serious concern in this study, and the data demonstrate satisfactory internal consistency and reliability.

5. Research results

5.1. Descriptive statistics

A total of 803 valid questionnaires were collected for this study. In terms of gender distribution, there were 470 male teachers (58.5%) and 333 female teachers (41.5%), indicating a relatively balanced gender ratio.

Regarding age, based on a five-category classification, the sample mean score was 2.70 with a standard deviation of 1.23. The specific distribution was as follows: 19.1% were under 25 years old, 26.2% were aged 26–35, 31.4% were aged 36–45, 12.1% were aged 46–55, and 11.3% were aged 56 and above. These results suggest that the majority of respondents were mid-career teachers with considerable teaching experience, and that the sample covered a wide age range.

For teaching experience, the mean score was 2.38 with a standard deviation of 1.01. Specifically, 22.4% had 5 years or less of teaching experience, 32.9% had 6–15 years, 28.5% had 16–25 years, and 16.2% had more than 26 years. This distribution indicates that the sample included teachers at different career stages, ranging from novice to highly experienced, thus providing strong representativeness for further analysis of professional development across different teaching tenures.

In sum, the distributions of gender, age, and teaching experience in the sample were reasonable and provided a solid foundation for subsequent correlation analyses and regression modeling.

5.2. Correlation analysis

To preliminarily examine the relationship between Chinese university physical education (PE) teachers' perceptions of professional learning communities (PLCs) and their professional development, Pearson's product–moment correlation analysis was conducted. As shown in **Table 1**, PLCs were significantly and positively correlated with the professional development of PE teachers ($r=.511$, $p<.001$). This finding indicates that the more teachers perceive the effective functioning of PLCs within their institutions, the higher their levels of professional growth in areas such as teaching competence, reflective practice, and professional identity.

The correlation coefficient reached a moderate strength [29], suggesting a stable linear relationship between the two variables. Furthermore, the 95% bootstrap confidence interval [0.447, 0.571] did not include zero, providing additional evidence for the significance and robustness of the observed relationship.

Table 1. Pearson correlation coefficients among variables of Chinese university physical education teachers (N=803).

Variables	1	2
1. Professional Learning Community	1	.511***
2. Professional Development of Physical Education Teachers	.511***	1

Note. ****p<.01 (two-tailed test).*

5.3. Differences in professional development across background variables

To further examine the effects of gender and teaching experience on the professional development of university physical education teachers, this study employed independent-samples *t* tests and one-way ANOVA for statistical analysis.

Table 2. Results of gender differences in professional development (N=803).

Gender	N	*M*	*SD*	SE	*t*	*df*	*p*	*Hedges' g*	*95% CI for g*
Male	470	3.481	0.73	0.034	3.754	801	<.001	.27	[0.13, 0.41]
Female	333	3.278	0.79	0.043					

Note: *N= Sample Size; SE= Standard Error.*

As shown in **Table 2**, the results of the independent-samples t test indicated that male teachers scored significantly higher in overall professional development compared to female teachers. Specifically, the mean score for the male group (N=470) was 3.48 (SD=0.73), whereas that for the female group (N=333) was 3.28 (SD=0.79). The difference was statistically significant (t=3.754, df=801, p<.001). The effect size was small to medium (Hedges' g=0.27, 95% CI [0.13, 0.41]), indicating that gender differences had a modest associated with on teachers' professional development.

As shown in **Table 3**, teaching experience had a significant effect on teachers' professional development, $F(3,799)=11.93$, $p<.001$, partial $\eta^2=.043$. Tukey post hoc comparisons indicated that teachers with more than 25 years of experience (M=3.82, SD=0.80) scored significantly higher than all other groups (ps<.001). In addition, novice teachers with ≤ 5 years of experience (M=3.49, SD=0.71) scored significantly higher than teachers with 6–15 years (M=3.20, SD=0.70) and those with 16–25 years (M=3.21, SD=0.74) (ps<.05). No significant difference was found between the 6–15 years and 16–25 years groups (p>.05).

Table 3. Descriptive statistics and ANOVA results by teaching experience (N=803).

Teaching Experience Group	Sample Size (N)	Mean (*M*)	Standard Deviation (*SD*)	Standard Error (*SE*)	95% CI Lower Bound	95% CI Upper Bound	partial η^2	Post Hoc Comparison
Group 1 (≤ 5 years)	180	3.49	0.713	.053	3.381	3.591	.043	4>1,2,3; 1>2,3; 2≈3
Group 2 (6–15 years)	264	3.20	0.697	.043	3.117	3.286		
Group 3 (16–25 years)	229	3.21	0.744	.049	3.216	3.41		
Group 4 (> 25 years)	130	3.82	0.797	.070	3.678	3.954		

5.4. Regression analysis results

A hierarchical regression analysis was conducted to examine whether PLCs are associated with teachers' professional development after controlling for background variables. In Model 1, gender and tenure were entered as controls and explained 3.2% of the variance in professional development, R^2=.032,

$F(2,800)=13.37$, $p<.001$. Specifically, gender ($\beta= -.133$, $p<.001$) and tenure ($\beta=.123$, $p=.001$) were significant predictors.

In Model 2, PLCs were added, resulting in a substantial increase in explained variance, $R^2 = .263$, $\Delta R^2 = .231$, F change $(1,799)=249.87$, $p<.001$. PLCs emerged as a strong predictor of teachers' professional development ($\beta=.500$, $p<.001$), while the effects of gender and tenure became non-significant. These results demonstrate that PLCs have a robust association with teachers' professional development beyond individual background characteristics.

Table 4. Summary and coefficients of regression model (N=803).

Predictor	Model 1 β	Model 2 β
Gender	–.133***	–.041
Tenure	.123**	.015
PLCs		.500***
R^2	.032	.263
ΔR^2		.231***
F	13.37***	94.97***

Note. ****p < .001, *p < .01，PLCs = Professional Learning Communities.*

6. Discussion

This study examined the professional development of physical education (PE) teachers in Chinese higher education institutions by investigating the associations between professional learning communities (PLCs) and professional development, as well as differences across gender and teaching experience. The findings provide new theoretical perspectives and empirical evidence for understanding PE teachers' professional growth.

Beyond the overall association, different PLC dimensions may contribute to different domains of TPD. For example, collective learning and shared practice are more directly related to professional knowledge and teaching practice, whereas shared leadership and shared vision are closely connected with teachers' professional qualities and attitudes. These differentiated associations highlight the importance of aligning PLC initiatives with specific professional development goals. Moreover, future research could test mediated models to uncover underlying mechanisms, such as psychological empowerment or self-efficacy, which may explain how PLCs foster teachers' professional growth.

First, the study confirmed that PLCs were significantly and positively associated with PE teachers' professional development ($\beta=.511$, $p<.001$). This result is consistent with the findings of Admiraal et al.[2], which showed that collaborative mechanisms, knowledge sharing, and peer support within organizations were related to enhanced instructional skills, reflective awareness, and professional identity. The evidence further supports Wenger's [8] theory of "communities of practice" in the field of higher education, highlighting that PLCs function not only as organizational structures but also as socially constructed environments that are linked to professional growth.

Second, regarding gender differences, male teachers scored significantly higher on professional development than female teachers ($t=3.754$, $p<.001$), with a medium effect size (Hedges' g = 0.27). This finding echoes the study by Pliogou et al.[23], which emphasized that institutional gender barriers may limit women's professional growth and restrict their access to learning opportunities. Moreover, Zhao and McDougall[18] found that female teachers tend to adopt collaborative and reflective approaches to growth;

however, in the absence of sustained organizational support, their motivation for professional development may be reduced. These insights underscore the need for higher education institutions to address gender equity by creating more inclusive environments for women's learning and advancement.

Third, the analysis of teaching experience revealed significant differences in professional development across groups (F=11.928, p<.001). Teachers with shorter teaching experience (≤ 5 years) reported significantly higher levels of professional development compared with those in mid- and late-career stages. This pattern aligns with Centeio et al. [24], who suggested that early-career teachers demonstrate greater openness and adaptability toward professional renewal. However, as teaching experience increases, professional development motivation may be constrained by inertia and reliance on established practices. These findings suggest that higher education institutions should adopt differentiated support strategies: for novice teachers, emphasis should be placed on training and innovation, whereas for more experienced teachers, incentives and the strengthening of academic communities may help sustain motivation and adaptability to educational reform.

In sum, this study provides empirical evidence for the important role of PLCs in relation to PE teachers' professional development, while also revealing gender- and experience-based differences in developmental trajectories. These findings not only extend the application of PLC theory to the context of PE teachers in higher education but also provide practical implications for cultivating a collaborative and supportive culture of teacher development. Future research should further examine the operational models of PLCs across different organizational contexts and explore the interaction between gender and career stages in shaping professional growth, thereby offering more targeted strategies for supporting faculty development.

7. Conclusion and recommendations

Drawing on survey data from 803 physical education (PE) teachers in Chinese higher education institutions, this study empirically examined the associations between professional learning communities (PLCs) and teachers' professional development and explored the differences associated with gender and teaching experience. The findings revealed that teachers' positive perceptions of PLCs were significantly associated with their professional development levels, suggesting that establishing mechanisms such as collaborative culture, shared vision, collective learning, and supportive structures within universities is related to the continuous growth and professional competence of PE teachers.

With respect to gender, the results indicated that male PE teachers scored significantly higher on professional development compared to female teachers. This highlights the need for universities to pay closer attention to the developmental challenges and potential needs of female faculty members. Specific interventions may include leadership training workshops for female teachers, targeted research support programs, and policies to reduce structural barriers such as unequal workload distribution. Cultivating an equitable and inclusive organizational culture, while providing concrete opportunities for women to participate in collaboration and assume leadership roles, is essential for narrowing gender disparities in professional growth.

Regarding teaching experience, the study found that teachers with shorter teaching experience were more active in professional development, demonstrating higher learning motivation and developmental potential. In contrast, more experienced teachers tended to be relatively conservative in embracing professional renewal and collaborative practices. This suggests that universities should adopt differentiated support pathways: for novice teachers, induction programs, mentoring systems, and innovation-focused training can accelerate early professional growth; for mid- and late-career teachers, academic retraining,

sabbatical opportunities, and participation in action research projects may help sustain development motivation and adaptability to reform.

In conclusion, universities should strengthen the operational mechanisms of PLCs by enhancing organizational structures, cultivating developmental culture, and optimizing resource allocation. Beyond general institutional support, universities can implement practical measures such as regular cross-disciplinary PLC workshops, peer mentoring networks, and digital platforms for collaborative lesson planning. Moreover, given the developmental differences associated with gender and teaching experience, policy guarantees, tiered development strategies, and incentive mechanisms should be implemented to enable diverse groups of PE teachers to fully realize their potential and collectively build a sustainable system for professional growth.

8. Limitations and future research directions

Although this study empirically demonstrated the positive role of professional learning communities (PLCs) in promoting the professional development of physical education (PE) teachers in higher education and systematically examined the differences associated with gender and teaching experience, several limitations remain.

First, the study employed a cross-sectional survey design, which can reveal correlations and predictive relationships among variables but cannot capture the dynamic evolution of causal pathways. Future research may adopt longitudinal designs to track teachers' continuous changes and developmental trajectories throughout their participation in PLCs.

Second, although the sample covered multiple higher education institutions across different regions, the data were primarily collected from mainland China, limiting the scope of cross-regional or cross-cultural comparisons. Moreover, the participants in this study were exclusively Physical Education (PE) teachers. While this focus highlights a marginalized and underexplored group, it also restricts the generalizability of the findings to other academic disciplines. Therefore, caution should be exercised in extending the results beyond the single-country and subject-specialization context. In the context of global educational transformation and increasing teacher mobility, future studies could conduct comparative research across countries and regions to explore the applicability and variability of PLC mechanisms in diverse cultural contexts.

Third, the present study primarily relied on questionnaire surveys for data collection. While the instruments demonstrated good reliability and validity, they remain limited in capturing complex phenomena such as individual experiences, organizational culture, and interactional mechanisms. Future studies could incorporate interviews, classroom observations, or mixed-method designs to uncover the processual logic linking PLC operations with teachers' professional growth, thereby providing more explanatory theoretical models.

In summary, although this study provides strong empirical evidence for the professional development of PE teachers in higher education, further research is needed to improve research design, broaden sample structures, and expand methodological approaches. Such efforts will help advance the field from exploring correlations to explaining mechanisms and adapting theories to specific contexts.

Conflict of interest

The authors declare no conflict of interest.

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