International Journal of Evaluation and Research in Education (IJERE)
Vol. 14, No. 6, December 2025, pp. 4498~4508
ISSN: 2252-8822, DOI: 10.11591/ijere.v14i6.33511

The components and indicators of professional learning community: the guidelines for educational quality improvement

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Article Info

Article history:

Received Nov 4, 2024
Revised Jul 21, 2025
Accepted Sep 30, 2025

Keywords:

Collective learning and application
Professional learning community
Shared and supportive leadership
Shared personal practice
Shared values and vision
Supportive conditions–relationships
Supportive conditions–structures

ABSTRACT

A professional learning community (PLC) is a group of educational personnel who come together to exchange knowledge, develop, and collaboratively solve problems related to improving instructional practices and school issues. The common goal is to develop students' competencies. PLCs have the potential to transform the quality of educational results significantly. Consequently, studying the components and indicators of a PLC and conducting confirmatory factor analysis (CFA) of PLC models can help schools understand the key factors and practices that contribute to PLC success. This knowledge can be applied to develop a strong PLC within the school. The study of components and indicators of the PLC is exploratory research. The samples consisted of 1,080 administrators and heads of the subject group from 120 schools under the Secondary Educational Service Area Office, randomized by multi-stage random sampling. The research tool was a 4-level rating scale questionnaire. Research findings indicate that the CFA of PLCs aligns with empirical evidence. All components in the PLC model have significant factor loadings ranging from 0.916 to 0.945 at the 0.01 level ($p<0.01$). When ranked from highest to lowest, these components are: i) supportive conditions–structures; ii) shared values and vision; iii) collective learning and application; iv) Shared and supportive leadership; v) supportive conditions–relationships; and vi) shared personal practice. All of these are essential components of a PLC and serve as an important mechanism for educational personnel to work together to improve the quality of schools.

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1. INTRODUCTION

Thailand has undertaken an educational reform to improve the quality of education in accordance with the objectives of the National Education Plan 2017-2036 and the government's educational policies, which aim to develop Thai society into a learning community [1]. To effectively transform Thai society into a learning community, modern educational institutions must create and utilize knowledge, as well as facilitate the exchange of learning among school administrators, teachers, educational staff, and other stakeholders. This should foster a collaborative learning culture, where everyone works together to improve their performance and that of the organization, to strengthen academic and professional capabilities, which are key factors for the success of student-centered educational management [2], [3]. Research and studies have shown that the concept of professional learning communities (PLCs) can lead to improvements in educational

outcomes [4], [5]. In many successful countries, the culture of teaching has shifted from working alone to collaborative team-based work. As a result, the concept of PLCs has been widely implemented in many countries [6].

Currently, PLCs are considered essential for all educational institutions and play a crucial role in contributing to the development of schools and improving teachers' teaching activities to make them more effective. The key benefits of having a PLC include: i) enhancing teachers' knowledge and skills by providing opportunities for them to exchange knowledge with each other, which leads to continuous self-development; ii) improving teaching methods, as teachers can apply the knowledge gained from collaborative learning to tailor their teaching to better suit individual students' needs; iii) increasing students' academic achievement, as teachers with enhanced knowledge and skills will lead to improved student learning and higher academic performance; and iv) creating a culture of learning, as PLCs help foster an environment conducive to learning in schools, ensuring that everyone participates in the development of the school, including teachers' teaching capabilities, the learning environment, and the key competencies of students [7]–[9].

The Office of the Basic Education Commission has established PLC as a key strategy and practice for developing teachers to enhance the quality of education nationwide, starting in 2017. Teachers are required to participate in PLC activities as part of their application for or promotion of professional status. Additionally, this has been incorporated into the internal quality assurance standards for schools, specifically in the second area of administrative processes (indicator 2.4: developing teachers and staff to achieve professional expertise). Schools are required to promote, support, and develop teachers and staff to become professionally proficient and to establish PLCs to improve both their work and the learning of students [10]. Considering the background and importance of the problem, the researcher studied the components and indicators of PLCs and analyzed the model of the confirming factors of PLC in secondary schools.

This study extends the existing framework of PLC, which has been developed mainly in Western contexts. In the Thai educational setting, PLCs must be understood within the framework of the collectivist culture, where collaboration and shared values play a significant role. The study also incorporates the concept of learning organizations [11], examining whether PLCs in Thailand can be seen as a key component of developing a learning organization in schools to help educational institutions understand the main factors affecting the success of PLCs. This can be used as a guideline for developing their PLC. It will affect the educational development of the school in the future by serving as a guideline for developing their PLC.

Conceptualizing PLC involves understanding diverse definitions and perspectives across different cultural and educational contexts. The field of education is continually shaped by evolving paradigms, and at the forefront of this transformative journey are PLCs. These communities, as defined by various scholars, embody a collective and purposeful effort among professional educators to cultivate a dynamic culture of learning. Hipp and Huffman as cited in Belay and Melesse [12] elucidate this essence, emphasizing the collaborative commitment to fostering an environment conducive to learning for both students and adults. Building upon this foundational definition, DuFour and Eaker as cited in Antinluoma *et al*. [13] provides a nuanced perspective by portraying PLCs as more than mere gatherings; they are transformative entities that emerge from staff members with a shared goal of collaboration, eventually becoming integral components of school culture over time. Stoll and Louis as cited in Alexopoulos and Dimas [14] contribute a multifaceted view, framing PLCs as environments where teachers engage in collaborative reflection on practices, meticulously examine evidence linking practices to student outcomes, and instigate changes to elevate teaching and learning within specific classrooms. In summary, a PLC refers to continuous learning exchange among school administrators, teachers, and educational personnel to develop better learning methods and prioritize the potential of students. The ongoing process in which school administrators, teachers, and educational personnel collaborate involves questioning and action research. They believe that the most crucial thing in student learning development lies in collaborative teamwork among all stakeholders in the school, with a shared vision, mission, values, and goals [15]–[17].

Uvhagen *et al*. [11] describe the implementation of learning organization theory in social services as a process where leaders and practitioners collaborate to develop the organization using key strategies like collaboration for knowledge sharing, continuous learning, adaptability to change, shared vision to align the team towards common goals, and leadership support to drive transformation. The use of these strategies helps create an environment that fosters continuous improvement and innovation within the organization. The concept of PLC has been extensively researched in Western educational contexts [13], [18]. However, in applying PLC within the Thai educational context, it is necessary to extend these theories by considering the collectivist culture, which emphasizes community-driven collaboration and shared values. Additionally, incorporating Uvhagen *et al*. [11] framework of learning organizations adds another layer to the understanding of how PLCs function within schools and fosters continuous improvement. In Thailand, participating in PLC activities is mandated as part of the criteria for teacher promotion according to the Ministry of Education's policies. This requirement forces all teachers to participate in PLC activities aimed at

enhancing their teaching skills. A concern that arises is that policy pressures may lead to the formal implementation of PLCs, potentially undermining the genuine involvement of the members. Structural support, such as allocating time, resources, and proper management, can help mitigate these limitations and encourage more effective PLC enactment [18]. This research on PLCs in Thailand can be compared with studies from Western and Asian countries to assess the significance of different PLC components across cultures.

The core components of PLC are essential elements that promote collaboration among teachers and administrators to improve school quality. PLCs represent a dynamic approach to educational development [19], with scholars offering diverse perspectives on their foundational components. This literature review delves into the rich discourse surrounding the compositions of PLCs as defined by key researchers. Previous research [18] delineates five integral components of PLCs:

- Supportive and shared leadership: leadership does not depend on school administrators, and PLC aims to encourage all members to be leaders through visual exchange. Administrators should be supporters and learning leaders, so they must be open-minded and acknowledge teachers' academic leadership roles to help teachers feel respected and proud to perform to their full potential.
- Collective creativity: learning collectively can transform the working culture with different ideas into collaborative learning, and most importantly, applying the knowledge gained from collaborative learning to develop learners with consistency.
- Shared values and vision: administrators and teachers must jointly define visions and goals so that they have the same direction and goals in action. The main goal is to improve the learning of learners.
- Supportive conditions emphasize providing an environment to promote and support the learning community, such as providing an atmosphere for teachers in the school to meet and exchange learning regularly, and establishing structures or rules that facilitate the exchange of learning.
- Shared personal practice involves sharing teaching techniques with fellow teachers, providing the atmosphere for learning exchange, and creating familiarity among school teachers.

Another research [13] expands the understanding of PLCs with six distinct components:

- Vision and goals: everyone need to gather up and share their vision and goals for mutual success.
- Shared learning cultures: teachers' learning is based on work that must be done together in every activity, including thinking, understanding, deciding, setting guidelines, evaluating results, and taking responsibility together.
- Exploration of best practices: the system for storing knowledge and applying knowledge must be practiced inside and outside the community.
- Learning by practicing emphasizes learning to develop their teaching profession in terms of knowledge, teaching skills, and attitudes by practicing.
- Persistent development: stresses the learning process for solving problems and developing the community collaboratively and constantly. In addition, there must be knowledge sharing between communities.
- Learner achievement: setting goals for student learning collectively is mainly focused on teachers having the belief that all students can learn, and being aware of their obligations towards students' learning and quality.

Several studies [12], [20] also contribute further insights by detailing six dimensions of PLC components observed during school visits and confirmed by research:

- Shared values and vision: involves supporting shared values and norms among personnel, focusing on students' learning, having high expectations, and sharing a vision for teaching and student learning.
- Collective learning and application: encourages information sharing, seeking new knowledge, skills, and strategies, everyone working together for planning and problem-solving, and improving to create learning opportunities.
- Shared and supportive leadership: executives promote and support leadership among personnel. Sharing power, duty, responsibility, and decisions reflects commitment and responsibility.
- Shared personal practice: emphasizes observation among colleagues for the exchange of knowledge, skills, encouragement, accepting suggestions, sharing the results of practice, mentoring, and counseling between personnel.
- Supportive conditions – relationships: focuses on having a good relationship with others with trust and respect. Acceptance, praise, taking risks, and mutual attempts are needed for changes.
- Supportive conditions – structures: executives support resources (time, money, materials, and humans), facilities, and effective communication systems.

Furthermore, several theories [13], [18], [20] on PLCs present complementary views but also some differences. Previous research [18] emphasizes supportive leadership and shared values, focusing on collaboration and creating a supportive environment for teachers. On the other hand, other research [13] highlights collective responsibility and learning by doing, emphasizing measurable student outcomes and accountability. Olivier and Hipp as cited in Christensen *et al*. [20] integrate both perspectives, focusing on

shared leadership and collective learning, while also addressing the importance of supportive conditions like relationships and structures. In terms of cultural application, Western countries tend to prioritize individual professional development and accountability, which aligns with DuFour's model. In contrast, Asian countries emphasize team-based problem-solving, shared values, and collaboration, aligning more with Hord's model. These differences reflect the underlying cultural values of individualism in the West and collectivism in Asia. These theoretical perspectives are not necessarily in conflict but rather complement each other.

In collectivist cultures such as Thailand, Hord's emphasis on shared values and vision may hold greater importance, as collaboration is prioritized. However, integrating DuFour's focus on accountability and learning by doing can ensure that PLCs also remain goal-oriented, driving measurable improvements in educational practices. In the components of a PLC, the researcher synthesized the ideas of several researchers [12], [13], [18], [20]. It can be summarized that a PLC consists of six components: i) shared and supportive leadership; ii) shared values and vision; iii) collective learning and application; iv) shared personal practice; v) supportive conditions – relationships; and vi) supportive conditions – structures, as shown in Figure 1.

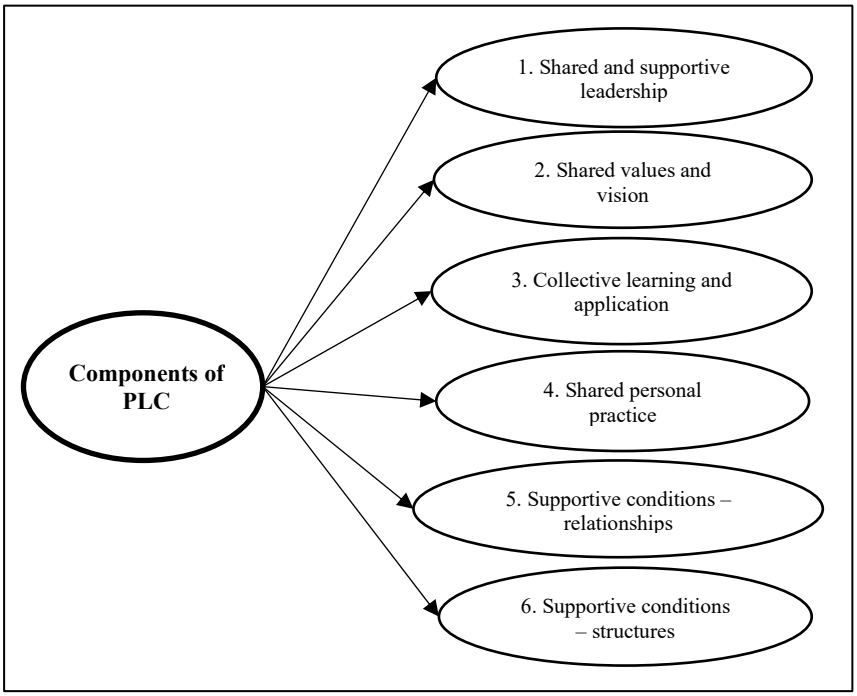

Figure 1. The conceptual framework of the components of the PLC

2. METHOD

The study of the components and indicators of PLC is exploratory research. The population consists of personnel from schools under the Secondary Education Area Office, Office of the Basic Education Commission, Ministry of Education, totaling 2,369 schools, with 106,967 people. The samples consisted of 1,080 administrators and heads of the subject group from 120 schools under the Secondary Educational Service Area Office, randomized by multi-stage random sampling. The multi-stage random sampling process used in this study began with the random selection of 60 Secondary Educational Service Areas (SESAs) out of a total of 62 nationwide. After that, three schools were randomly selected from each SESA, categorized by school size: large, medium, and small. In the second stage, the administrators and heads of subject groups from the selected schools were chosen to be the respondents to the survey. This process ensured that the sample was diverse and well-representative of the population being studied. The research instrument was a 4-level rating scale questionnaire with 54 items.

2.1. Defining the operational definition of research variables

A PLC refers to the coming together, pooling of resources, and collaboration of members in a mutually supportive relationship. It involves a shared vision, foundational principles, attitudes, values, and common goals. It entails teamwork, exchange of learning, teacher leadership, organizational structures, a conducive atmosphere, and environmental factors aimed at learning and professional development to

enhance individual quality. The primary focus is on students' success and well-being, achieved through collaborative work within a PLC [12], [13], [18], [20]. This community comprises six essential components.

The first component is shared and supportive leadership, refers to being co-leaders within the organization by distributing power in the workplace. It involves empowering members to become leaders themselves, driving the organization towards becoming a PLC. There is a working atmosphere that promotes voluntary expression, encouraging all members to become leaders and fully demonstrate their potential to facilitate mutual learning exchanges. The second component is shared values and vision, entails having a shared vision, foundational principles, attitudes, values, and common goals among organization members. This includes envisioning success, having plans as guidelines, organizational perceptions, decision-making attitudes, and collaborative work strategies to achieve the organization's set goals. The third component is collective learning, and application, means harnessing the power of all members in the organization to work together. It involves processes that enable the group to develop intelligence and abilities in its work, opening opportunities, and supporting members' participation, thoughts, actions, benefits, tracking, and shared responsibility for the organization's operations. All teachers are dedicated to promoting student learning by using diverse teaching techniques and strategies that link to student learning processes for their holistic development.

The fourth component is shared personal practice, means that members of the organization can teach openly and provide opportunities for colleagues to express opinions and provide feedback. There are discussions related to teaching practices, organizational equity, and justice within the school. It promotes and supports learning exchanges in terms of knowledge, practices, and experiences in work and the spirit of being a teacher, consistently and continuously translating these results into regular and continuous practices. The fifth component is supportive conditions – relationships, refers to all members being interconnected both professionally and personally. They are professional friends who complement each other. The organization aims for everyone to be happy at work and living together, emphasizing an open culture. Everyone can freely express their opinions, creating a sense of security, trust, and mutual respect. There are mutual support and cooperation among members to work selflessly for the profession and maintain a positive attitude towards education and students. The sixth component is supportive conditions – structures, means organizational structures that support the emergence and sustainability of a PLC. This involves transforming organizational culture from a bureaucratic to a friendly academic model. Organizational structures are designed to streamline work processes and reduce gaps between administrators and between teachers themselves.

2.2. Development of the questionnaire

The questionnaire about PLC for schools under the district education office was developed using a 4-level rating scale. It included 6 components, 24 indicators, and 54 questions. The draft questionnaire was reviewed by academic advisors to check the accuracy of the content and the appropriateness of the language. Suggestions from the advisors were used to revise and improve the questionnaire. Then, the content validity was checked by five experts in measurement, evaluation, research, and PLCs. the index of item–objective congruence (IOC) was calculated, and only questions with an IOC value of 0.50 or higher were kept, resulting in a total of 54 questions for the final version.

2.3. Validation of instrument

The revised questionnaire was tested on a sample group from 4 schools, with 9 participants from each school, including 1 administrator and 8 curriculum leaders, totaling 36 participants. The discriminant power index (r) ranges from 0.416 to 0.833, and the reliability coefficient (Cronbach's alpha) for individual items ranges from 0.970 to 0.980. The overall reliability coefficient is 0.980.

2.4. Data collection and data analysis

This completed questionnaire was used to collect data from a sample of 120 schools, consisting of 9 people per school, consisting of 1 administrator and 8 subject leaders, resulting in a total of 1,080 informants. Analysis of components and indicators of the PLC using confirmatory factor analysis (CFA) to examine the structural validity of the model using the Mplus program.

3. RESULTS AND DISCUSSION

The results of the second-order CFA on the structural validity of the PLC of the secondary educational service area office are shown in Table 1. As shown from the table, when considering the importance of each component in the model of the PLC of the secondary educational service area office, it was found that all components in the model of the PLC have significant statistical weights, ranging from 0.916 to 0.945 at the 0.01 level of significance ($p<0.01$). The component with the highest weight is supportive

conditions-structures, which is 0.945, followed by collective learning and application, with a covariance with a PLC of 89.30%. The next in descending order are shared values and vision, shared and supportive leadership, and supportive conditions-relationships, with weights of 0.937, 0.935, 0.921, and 0.918, respectively. They have covariances with the PLC of 87.90%, 87.40%, 84.80%, and 84.30%, respectively. The component with the least weight is shared personal practice, with a weight of 0.916 and a covariance with the PLC of 83.90%, as shown in Figures 2 and 3.

Table 1. Results of the second CFA of the PLC of the secondary educational service area office

PLC components	Factor loading			R-Square (R^2)
	β	SE	t-value	
1. Shared and supportive leadership (sl)	0.921*	0.011	87.314	0.848
2. Shared values and vision (sv)	0.937*	0.009	108.502	0.879
3. Collective learning and application (cl)	0.935*	0.005	180.317	0.874
4. Shared personal practice (sp)	0.916*	0.007	135.517	0.839
5. Supportive conditions–relationships (cr)	0.918*	0.007	139.822	0.843
6. Supportive conditions–structures (cs)	0.945*	0.006	152.862	0.893

$\chi 2$=88.095, df=85, P-value=0.3876, RMSEA=0.006, SRMR=0.010, CFI=1.000, TLI=1.000 Note. *p<0.01

Based on the review of documents and previous research on the components and indicators of PLCs, the CFA revealed that the PLC model was consistent with the empirical data, as indicated by the following fit index values: $\chi 2$=8.095, df=85, P-value=0.3876, root mean square error of approximation (RMSEA)=0.006, standardized root mean square residual (SRMR)=0.010, comparative fit index (CFI)=1.000, Tucker–Lewis index (TLI)=1.000. Since the components obtained from the study of documents and related research cover important factors affecting the creation and development of PLCs in all respects, it can be said that a PLC of an educational institution occurs when school administrators and teachers continuously exchange knowledge and learning to develop the quality of education that focuses on learners. The educational institution has continuously implemented activities based on the research results of all six components, which are consistent with the framework and approach of PLCs that are widely accepted [12], [13], [18], [20]; a PLC is a group of educational personnel who come together to work continuously with the main purpose of developing learning for both teachers and students. The practices are consistent with Antinluoma *et al.* [13], namely: i) working together consistently to solve problems and develop teaching and learning methods; ii) having a common goal focused on developing the academic achievement of all students; iii) all members of the PLC jointly analyze data and evidence to improve teaching methods to be more effective; iv) all members have a culture of learning and self-development; and v) the school uses evidence-based information to make decisions to solve problems and improve school practices.

In the study "components and indicators of the PLC: guidelines for educational quality improvement", it was found that there are six components: i) supportive conditions–structures; ii) shared values and vision; iii) collective learning and application, iv) shared and supportive leadership, v) supportive conditions–relationships, and vi) shared personal practice. Since the PLC is formed from the cooperation of school administrators, teachers, and educational personnel continuously exchanging learning for the development of improved learning methods and the potential of students, continuous processes where school administrators, teachers, and educational personnel work together involve questioning and practical research. People believe that the heart of student learning and development is the teamwork of everyone involved in the school, with shared visions, values, goals, and missions. This aligns with Antinluoma *et al.* [13], who stated that a PLC is a group of educational personnel who come together to work cooperatively as lifelong learners, aiming to develop the performance of all students in the school [21], [22].

The component "supportive conditions – structures" has the highest component weight of 0.945 and has a covariance with a PLC of 89.30%. This is because schools with good organizational structures will create the: i) an atmosphere conducive to learning, an open, warm, and safe atmosphere for all members to express their opinions, exchange knowledge, and jointly solve problems; ii) efficient resource allocation, which can allocate various resources such as time, budget, and equipment appropriately; iii) clear role and duty definition will help all members understand their roles and duties, making work smoother and more efficient; iv) creating continuity in work even when there are changes in school personnel; v) building confidence in members. When members see that the organization truly supports the PLC, they will feel encouraged and confident in their work; and vi) create clear work standards, which allow for tangible measurement and evaluation of work performance. Consistent with the research of other scholars [23]–[25]. A study was conducted on enabling school structures, collegial trust, and academic emphasis in PLCs. The study examined the role of enabling school structures, which was explored through the perspectives of teachers and administrators. The results found that high-enabling school structures, collegial trust, and academic emphasis

of the school affected the development of PLCs in schools [26]–[39]. The findings challenge the existing PLC framework by highlighting the importance of cultural and policy factors in Thailand's educational system. While PLC components such as shared leadership, values, and vision align with existing theories, this study extends the framework by integrating Uvhagen *et al.* [11] concept of learning organizations, which emphasizes continuous professional development within a collaborative school culture.

In Thailand, participating in PLC activities is mandated as part of the criteria for teacher promotion by the Ministry of Education. This policy puts pressure on all teachers to participate in PLC activities, which may influence how PLCs are implemented in terms of structure, such as allocating time for PLC meetings or providing support in terms of resources from the school. This structural support could include time allocation for teachers to collaborate in PLCs, provision of learning materials, training, or support from school leadership, all of which are essential for the success of PLCs. Additionally, state policies may influence the direction of PLC development, which could differ from the approach taken in other countries that do not have such a policy mandate. In Western countries such as the United States or the United Kingdom, the education system tends to emphasize individual professional development. The PLC components emphasized may include learning by doing or collective responsibility, which can be measured by individual performance and professional growth [5].

In East Asian countries such as Japan or South Korea, which have collectivist cultures, there is often a greater emphasis on shared values within PLCs. Teachers in these cultures tend to focus more on collective student learning and teamwork within the school. Support from school leaders and proper resource allocation are crucial in these settings. Structural supports in collectivist countries tend to reflect the creation of an environment that encourages teachers to collaborate within PLCs, and there is an emphasis on sharing resources and knowledge. This approach may help PLCs succeed more effectively [40], [41].

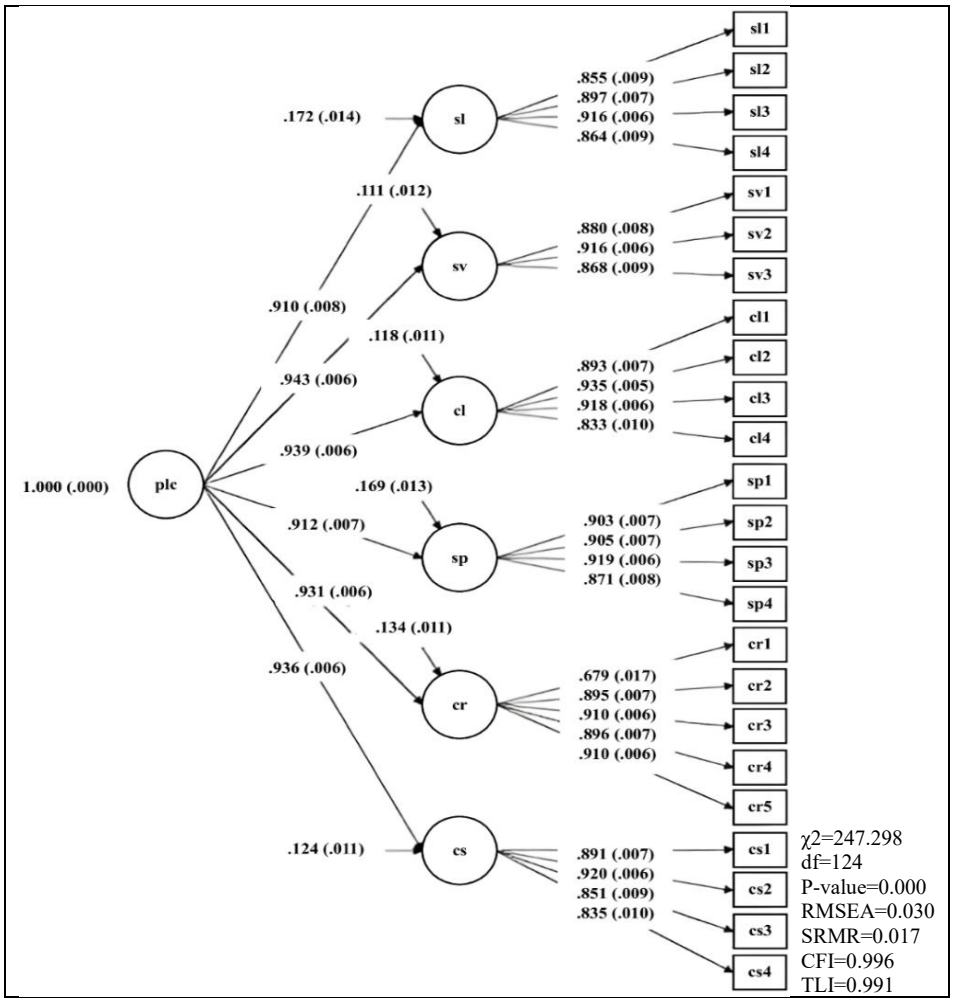

Figure 2. CFA model: components of the PLC of the secondary educational service area office (before)

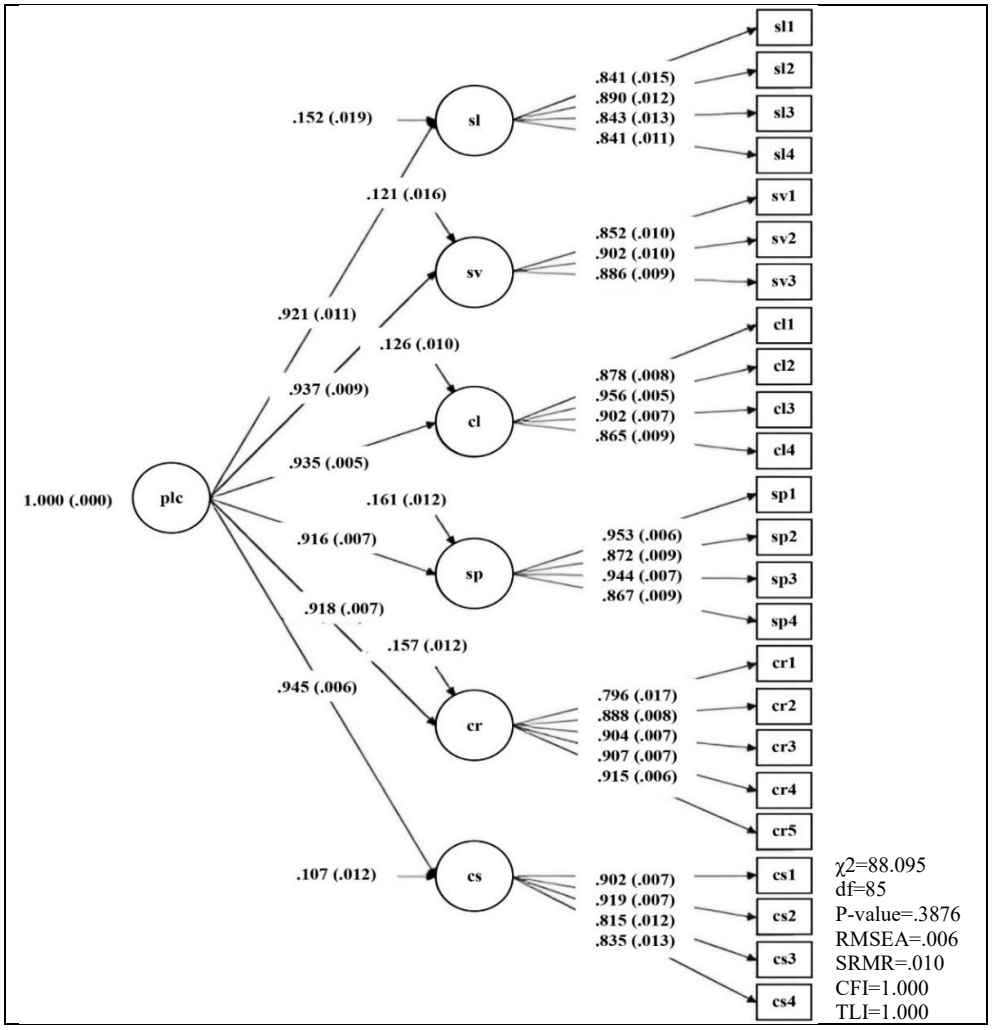

Figure 3. CFA model: components of the PLC of the secondary educational service area office (after)

4. CONCLUSION

The results revealed that all components of the PLC were statistically significant and positively correlated with one another. This finding suggests that the presence of one component promotes and strengthens the functioning of the others, leading to a more effective PLC. Among the components, supportive conditions–structures was identified as the most influential factor. This refers to the availability of resources, facilities, and support systems that create favorable conditions for developing a PLC—such as reducing communication gaps among personnel, providing budgetary support, and utilizing modern technology. These results highlight that external and structural factors play a crucial role in the creation and sustainability of PLCs. The next most important components, reflecting the organizational culture, included shared values and vision; collective learning and application; shared and supportive leadership; supportive conditions–relationships; and shared personal practice, respectively. All components demonstrated strong positive relationships with PLCs, with covariance values ranging from 83.90% to 89.30%. This indicates that these components collectively explain a substantial proportion of the PLC construct. Notably, supportive conditions–structures exhibited the highest covariance value, confirming that organizational structure and resource availability are critical factors in fostering and developing PLCs in schools.

Research indicates that building a strong PLC requires multiple interconnected components working in harmony. It involves not only sharing individual experiences but also cultivating an organizational culture that fosters collaborative learning and establishing appropriate structures that enable teachers to work together, develop professionally, and collaboratively solve school-related problems to maximize students' learning potential. The findings of this study can be applied in various ways. Teachers can use the results to refine their practices and become more effective members of PLCs. School administrators can apply the findings to formulate policies and design activities that strengthen PLCs. Parent organizations can also utilize

this information to oversee, support, and promote the development of PLCs within schools. For future research, more in-depth studies should be conducted to investigate how specific structural factors—such as resource allocation, teachers' collaborative time, and environments conducive to learning—affect the implementation and sustainability of PLC practices. Moreover, comparative analyses of PLCs across diverse educational contexts—urban and rural areas, public and private schools—would be valuable for identifying the most suitable organizational structures for different school settings. In conclusion, this study expands the understanding of PLCs in the Thai educational context by integrating cultural dimensions and the concept of learning organizations. By adapting the PLC framework to align with Thailand's collectivist cultural values, this research contributes to a deeper understanding of how PLCs can foster ongoing collaboration, professional growth, and, ultimately, sustainable educational improvement in schools.

ACKNOWLEDGMENTS

The author would like to thank all advisors for their support in publishing this research and all faculty members in the Department of Measurement and Evaluation, Khon Kaen University, Thailand.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

The study was conducted by the Declaration of Helsinki and approved by the Ethics Committee for Human Research of Khon Kean University (HE653301 on 4 March 2023) for studies involving humans.

DATA AVAILABILITY

The data that support the findings of this study are available from the first author [KK] and corresponding author [JT], upon reasonable request.

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