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Teacher Development Model to Facilitate Science Teaching through the Concept of Professional Learning Community

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Abstract

This research aimed to develop and evaluate a teacher development model that enhances science learning management based on professional learning community principles. In the initial phase, input was obtained from five experts in science learning management. This model was further refined with insights from experts in curriculum design, assessment, and evaluation. The model's impact was tested with 16 science teachers from eight schools under the Roi Et Municipality during the second semester of the academic year 2022. The research tools included the teacher development model, a quality assessment metric for science learning, and a teacher satisfaction survey. Data were analyzed using basic statistical methods, with the Wilcoxon Signed Rank Test for hypothesis validation. The results identified four key strategies: Learning Management Design, Learning Activity Organization, Use of Learning Media and Resources, and Learning Measurement and Evaluation. The model comprises six primary components: origin, objectives, principles, structure, content, and teaching process. The quality of science teaching improved over two phases, with a significant difference in quality scores at a 0.05 level. The model received positive feedback, with a satisfaction score averaging 4.52.

Keywords: Teacher development, professional learning community, science eduation, collaborative learning, pedagogical improvement

Introduction

Science teachers, under the mandate of the National Education Act of 1999, shoulder the crucial responsibility of ensuring science instruction not only imparts knowledge but also instills a passion for scientific exploration among students. This duty aligns with the objectives set forth in the Basic Education Core Curriculum of 2008 (revised in 2017), which emphasizes a student-centered approach to learning. Within this framework, students are expected to actively discover knowledge, intertwining theoretical learning with hands-on processes like observations, surveys, and experiments (Office of the Basic Education Commission, 2017, p. 3). In essence, the curriculum seeks to marry knowledge acquisition with practical application. Consequently, science teachers play a pivotal role in sculpting an educational environment that fosters these twin pillars of modern scientific education (Kuptavatin, 2009).

International science knowledge test results underscore developmental needs in the quality of science instruction in Thailand. There are multifaceted challenges impeding effective science instruction in the country's basic education system. A primary concern is the shortage of specialized science teachers, a shortfall particularly pronounced in expanded opportunity schools. Many of these institutions rely on non-science majors for instruction, compromising depth and proficiency in the subject matter. Additionally, even in primary schools, there's a pressing lack of teachers specialized in science, compelling educators from other disciplines to fill this gap. This, in turn, can dilute the quality of instruction, with some teachers stretched thin across multiple subjects and grade levels. Delving deeper, many science educators struggle to seamlessly integrate substantive knowledge with pedagogical techniques. The prevalent paradigm for teacher development tends to prioritize quantity over quality and often fails to address the genuine needs of science teachers. Consequently, many educators are ill-equipped to unlock their students' full learning potential in the realm of science (Kijkuakul, 2014).

To truly enhance the capabilities of science teachers in managing learning, the development process must address the real-world challenges faced by individual schools. Every school is uniquely positioned, with its specific set of issues relating to teacher quantity, the challenges of non-specialized instructors, and instructional management. Addressing these issues demands a collaborative approach, bringing together schools, administrators, and educators to identify problems and co-create sustainable solutions. The Professional Learning Community (PLC) framework presents a strategic avenue for this development. PLC facilitates change by learning from community members' practices through knowledge sharing and reflective evaluation. It encourages educators to exchange experiences, embrace holistic learning methodologies, forge multifaceted relationships, and

bolster teamwork to improve learning management. Such collaborative engagements lead to enhanced teaching quality, promoting a culture of continual self-improvement and dedication. Importantly, a school-based PLC ensures teachers are invested in collectively-set educational objectives. As Panich (2012) and Wongyai & Patphol (2019) suggest, teachers within a PLC are more inclined to refine their teaching strategies to suit student needs, exemplifying the shift from traditional training to collective learning highlighted by Montree Yamkasikorn (2017). Such active learning from hands-on experiences, combined with the freedom to discern effective solutions, underscores PLC's pivotal role in promoting collaborative learning, innovation, problem-solving, and the identification of best practices tailored to each school's unique circumstances.

Given the pivotal role of science teachers in fostering students' scientific learning, it is imperative to continually develop their capabilities in a sustainable manner. Such developmental endeavors should stem from genuine collaboration among teachers, administrators, and stakeholders, reflecting the real-world challenges that science educators confront daily. With this in mind, the researchers seek to introduce a teacher development model based on the Professional Learning Community framework. This proposed model aims to offer a structured pathway for educational institutions to bolster the proficiency of their science educators, ensuring a superior quality of science instruction and, consequently, enhancing student outcomes.

Methods

Research Design and Focus

The study targeted experts in science education and science teachers from Roi Et Municipal schools. Initially, the research engaged 5 experts in science education. This was followed by the involvement of an additional 5 experts with specializations in curriculum, teaching methods, assessment, and evaluation. In the subsequent phase, 16 science teachers from 8 different schools within the Roi Et Municipal for the academic year 2022 were incorporated. The core independent variable in this study was the model designed to develop teachers and enhance science learning using the concept of a professional learning community. The dependent variable, on the other hand, aimed to gauge the effectiveness of this model. While formulating this model, content was centered on various facets of science learning management, encompassing the design of efficient learning management strategies, the organization of suitable learning activities, the adept use of diverse media and learning resources, and the implementation of precise methods to measure and evaluate learning outcomes.

Procedures

During the initial phase of the research project aimed at enhancing the quality of science teaching, a comprehensive review was conducted, analyzing various documents and previous studies focused on both the enhancement of teacher roles in science and the principles underpinning professional learning communities. Five experts in science learning management were actively involved, offering insights based on their experiential knowledge and professional backgrounds. This phase was characterized by the meticulous design of semi-structured interviews. After a rigorous literature review, tailored interview questions were developed to address the challenges faced by science educators and to explore potential strategies for enhancing the quality of science teaching. For the creation and validation of the research tool, principles, ideas, and theories related to science education management were studied extensively. A draft of the semi-structured interview, encompassing open-ended questions, was fashioned, ensuring its alignment with the study's objectives. This draft underwent validation by presenting it to a panel of five experts to ascertain its content validity, with the Index of Item-Objective Congruence (IOC) ranging between 0.80-1.00. Feedback from these experts prompted revisions to enhance the interview's accuracy and relevance. Subsequent data analysis involved decoding expert interviews using content analysis, culminating in the formulation of a comprehensive teacher development model that integrated the principles of a professional learning community.

The second research phase pivoted towards the development of a specialized model tailored for teacher enhancement, with the aim of nurturing more effective science learning management through the lens of professional learning communities. This phase saw the involvement of five specialists, their expertise spanning across science learning management, curriculum instruction, and evaluation techniques. Delving deep into theories and concepts pertinent to teacher development and science education management, data from the first phase was synthesized into a conceptual framework. This underpinned the design of the draft model for teacher development, echoing the values and principles of professional learning communities. This model, intricately designed, encapsulated foundational principles, objectives, structural components, content, and instructional methodologies. A preliminary manual, serving as an operational guide for the model's deployment, was crafted, with an overarching goal to enhance the domain of science education by leveraging the tenets of professional learning communities. To round off this phase, tools such as the teacher development model, an operational manual echoing its principles, and a feedback form were employed to rigorously evaluate the model's alignment and efficacy in tandem with professional learning community concepts.

Tool Design, Validation, and Evaluation

In the process of establishing the model, a thorough research phase was pivotal. This involved comprehensive analysis of concepts and theories relevant to the creation of the model. Using the data from the first phase as foundational information, key components of the model such as its background, objectives, principles, structure, content, teaching methods, and evaluation were delineated. This established foundation facilitated the synthesis of a draft teacher enhancement model. Drawing upon methods of model development, data collection, and information from the first phase, a clear framework was crafted for the model. To ensure alignment with educational best practices, this draft model was subjected to scrutiny by a panel of five distinguished experts spanning domains of science education, science learning management, and academic learning. Their feedback resulted in targeted refinements to the model.

Alongside the teacher development model, an operational manual was conceptualized to offer clear guidelines for its application. After exhaustive study of relevant principles, theories, and concepts, the manual was organized into two sections: the first elucidating the teacher development model and its aim to promote science learning via professional learning community concepts, and the second delineating specific guidelines for model implementation. To ensure its robustness, the manual was examined by five experts in fields of science teaching, science education, and curriculum and instruction. Aiming for the IOC between 0.80 and 1.00, feedback from these experts led to further refinement of the manual.

The final step entailed evaluating the model's appropriateness in amplifying science education via the lens of professional learning communities. Using a plethora of concepts, theories, and principles as a backdrop, a detailed assessment tool was formulated. Designed specifically for the enhancement of the teacher development model in science education, this tool zeroed in on its fundamental elements, applications, and tangible outcomes. Adopting a stringent evaluation criteria, the tool was segmented into four distinct standards: utility, feasibility, propriety, and accuracy. The tool was then presented to a panel of five experts to ascertain content validity and gauge the IOC. Feedback from these professionals steered the final refinements to ensure the tool's academic rigor and effectiveness.

Instruments

During the course of this research, several key instruments were utilized to meet our objectives. Firstly, the teacher development model was introduced, designed to enhance the quality of science education by integrating the principles of professional learning communities. This was followed by the creation of the assessment tool for science education

management quality, which was developed to rigorously assess and evaluate the standards of science education management. Lastly, the satisfaction assessment questionnaire was implemented. This tool, tailored for teachers, was constructed to measure satisfaction and gather feedback regarding the teacher development model, which emphasizes the promotion of science education through the framework of professional learning communities.

Developing and Ensuring Quality of Tools

In the second phase of the research, a model was designed to enhance science learning through professional learning communities. This phase entailed significant groundwork, beginning with the study of principles, theories, and concepts related to science learning management. This encompassed areas such as instructional design, methodologies, media utilization, resource deployment, outcome assessment, and the establishment of professional learning communities.

From this foundational research, a quality assessment tool for science learning management was constructed. This tool aligned with the research objectives and adopted a 3-level rating scale. The categorization, determined by percentages, was as follows: scores of 75% and above were considered "excellent"; scores between 51% and 74% were deemed "adequate"; and scores ranging from 0% to 50% were classified as "needs improvement." To ensure its validity, the tool was presented to five specialists, known for their expertise in areas like science teaching, science education, evaluation, curriculum, and instruction. These experts validated its content and analyzed its IOC, which sought values between 0.80 and 1.00. Based on their invaluable feedback, appropriate refinements were made to the assessment tool.

Parallelly, attention was directed towards understanding teacher satisfaction concerning the newly developed model. The foundation for this exploration was set by understanding the principles, theories, and concepts that dictate the assessment of teacher satisfaction. A keen focus was maintained on the development model promoting science learning through professional learning community concepts. With this understanding, an assessment tool was crafted, intending to measure teacher satisfaction. This tool employed a 5-level rating scale, with scores between 4.51 and 5.00 indicating "highly satisfied", 3.51 to 4.50 showing "satisfied to a high extent", 2.51 to 3.50 as "moderately satisfied", 1.51 to 2.50 being "satisfied to a low extent", and scores between 1.00 and 1.50 reflecting "least satisfied." Like its predecessor, this assessment was also presented to a group of experts for validation. Their insights facilitated the final refinement of the tool, ensuring its accuracy and relevance.

Data Analysis

In this study, data analysis encompassed both quantitative and qualitative approaches. Quantitative analysis involved evaluating the quality of science learning management following the implementation of a teacher development model aimed at enhancing science education through professional learning communities. This evaluation considerd viewpoints from administrators, experts, and self-assessments across two rounds, utilizing the Wilcoxon Signed Rank Test for statistical assessment. Additionally, the study examined teacher satisfaction data regarding the same development model, utilizing the target group's perspectives. Mean and standard deviation calculations were compared against established criteria. On the qualitative side, content analysis was employed to scrutinize observed science learning management and teachers' reflections on learning outcomes, culminating in a structured presentation of findings.

Results

Phase 1

A content analysis of relevant research documents highlighted four main development directions for enhancing the quality of science teaching and learning management: instructional design, learning activity organization, utilization of media and learning resources, and assessment and learning outcome evaluation. Detailed elaborations of these directions are presented in Table 1.

Table 1. The development directions for enhancing the quality of science teaching and learning management

Guidelines	Behavioral Indicators based on Guidelines
Designing Learning Management	1. Define learning objectives that align with the curriculum. 2. Establish learning objectives that encompass Knowledge, Process, and Application (K-P-A). 3. Specify learning objectives that align with the content of learning and relevant knowledge. 4. Define learning content that aligns with learning standards and performance indicators. 5. Design learning activities consistent with learning objectives. 6. Design diverse learning activities. 7. Design hands-on learning activities. 8. Design learning activities that match learners' contexts. 9. Design activities that promote self-discovery for learners. 10. Design activities that promote self-discovery for learners.

Guidelines	Behavioral Indicators based on Guidelines
	11. Develop a comprehensive learning plan according to academic principles. 12. Create a detailed and sequential learning plan.
Organizing Learning Activity	1. Organize diverse learning activities. 2. Plan hands-on learning activities. 3. Arrange learning activities that allow learners to contribute to the topic of interest for learning. 4. Create activities that emphasize promoting students' thinking skills. 5. Design activities that encourage learners to formulate observations. 6. Develop activities that promote exploration and knowledge search for learners. 7. Implement activities that encourage learners to explain acquired knowledge from research. 8. Structure activities that promote learners to assess knowledge gained from activities. 9. Implement learning activities that enhance scientific process skills. 10. Utilize appropriate teaching methods for subject areas and content. 11. Provide opportunities for students to engage in collaborative activities. 12. Pose questions that stimulate critical thinking.
Utilizing Media and Learning Resources	1. Choose diverse instructional materials/resources. 2. Select instructional materials/resources suitable for the content. 3. Choose instructional materials/resources appropriate for the learners' age. 4. Opt for instructional materials/resources that stimulate learning. 5. Select instructional materials/resources suitable for the learners' context. 6. Involve learners in using the instructional materials/resources.
Assessing and Evaluating Learning Outcome	1. Design assessment tools aligned with learning objectives. 2. Design assessment tools aligned with content and activities. 3. Design diverse assessment tools. 4. Define clear and appropriate criteria. 5. Provide opportunities for learner participation in assessing learning. 6. Offer feedback and suggestions for improvement to learners.

Phase 2

A teacher development model was established, emphasizing the promotion of science learning management through a professional learning community approach. The model incorporates components such as origin, significance, objectives, principles, structural framework, content integration, instructional process, and assessment strategy. Within the instructional process, five stages were identified: Preparation and Planning, Collaborative Learning, Collaborative Practice, Learning Management Practice, and Reflection and Application.

Phase 3

The efficacy of the teacher development model was evaluated by assessing the teaching practices of 16 science teachers over two rounds. The outcomes of this evaluation can be found in Table 2.

Table 2. The results of the assessment of the quality of science learning management practices among 16 science teachers in phases 1 and 2

Evaluation Criteria	n	Phase 1	Results	Phase 2	Results
Designing Learning Management	16	59.90	adequate	80.73	excellent
Organizing Learning Activity	16	56.60	adequate	81.94	excellent
Utilizing Media and Learning Resources	16	66.67	adequate	82.29	excellent
Assessing and Evaluating Learning Outcome	16	59.72	adequate	82.64	excellent

The study on the effectiveness of the teacher development model to enhance science learning management using the professional learning community concept found that the quality of science learning management by teachers is at a good level. The teacher development process was conducted in two phases, revealing an improvement in the quality of science learning management by teachers in the second phase compared to the first phase. This suggests that teachers have shown higher levels of development.

The results of comparing the average scores of the quality of science learning management by teachers in the overall context between phase 1 and phase 2 after implementing the teacher development model to enhance science learning management using the professional learning community concept are shown in Table 3.

Table 3. Comparison of average scores for science learning management quality between phases 1 and 2 post-implementation of the teacher development model

The quality of science learning management	n	Mean	S.D.	Z	p
Phase 1	16	1.78	0.16	3.24	.001**
Phase 2	16	2.45	0.11		

** There are statistically significant findings at the .05 significance level.

From Table 3, a comparison of the mean scores for the quality of science learning management by science teachers, before and after the implementation of the teacher development framework, reveals a significant improvement. The adoption of the framework, grounded in the professional learning community approach, led to notable enhancements in science learning management quality from phase 1 to phase 2.

Results from the implementation of teacher development according to the framework aimed at enhancing science learning management based on the professional learning community approach indicate the following outcomes.

Phase 1

1. Areas of Excellence

- Curriculum Design: Teachers were able to align learning objectives with the content of the curriculum. Activity designs promoted collaborative student engagement. Lesson plans addressed all essential components.
- Activity Organization: Emphasis was placed on student-centered activities that fostered cooperative learning. Group activities were well-structured, positively reinforcing, and age-appropriate.
- Use of Resources: Teachers appropriately selected resources that matched the content and students' age. Resources were accurate and presented step by step.
- Assessment: Teachers design measurement tools and assessment strategies aligned with learning objectives. Students were briefed before evaluations, and teachers used assessment results for student development.

2. Areas for Improvement

- Curriculum Design: The specification of learning objectives did not comprehensively cover process skills and desirable attributes. The determination of learning content did not adequately address the assessment criteria, often relying heavily on textbooks from various publishers. The design of learning activities was still lacking in diversity.

- Activity Organization: It was advisable to arrange activities that enhanced the process of inquiry and allowed students to derive knowledge from their own activities. Furthermore, providing opportunities for students to define topics or subjects of their own interest was crucial. The design of activities should have focused on fostering scientific process skills and providing students with opportunities to practice them.
- Use of Resources: Opportunities were provided for students to participate in using media and for diversity to be present.
- Assessment: The design of measurement tools and assessment should have had well-defined and clear criteria, incorporated interval measurements, and provided feedback to students.

Phase 2

1. Areas of Excellence

- Curriculum Design: Teachers were able to set learning objectives comprehensively across all domains (knowledge, skills, and attitudes). They aligned the content with the learning standards and indicators, designd learning activities that engaged students in practical tasks that correspond with the learning objectives, and created detailed lesson plans with all components.
- Activity Organization: Teachers organized activities that enhanced the process of inquiry, allowing students to independently summarize knowledge gained from the activities and providing opportunities for students to identify topics or subjects of interest. They were able to formulate age-appropriate questions, stimulating students' thinking and encouraging them to practice generating questions based on the lesson.
- Use of Resources: Teachers were able to select and use appropriate and interesting media and learning resources, allowing students to actively participate in using the media.
- Assessment: Teachers successfully designed measurement and evaluation tools that were both aligned and appropriate, with clearly defined criteria.

2. Areas for Improvement

- Curriculum Design: Plans were written that did not reflect the TPACK model. Learning activities were designed focusing on practice through the process of seeking and researching knowledge, and scientific procedural skills were enhanced.

- Activity Organization: Activities were organized to reinforce scientific procedural skills, allowing students to practice and convey meaningful information. Students were also able to express their opinions based on the data.
- Assessment: The results from measurements and evaluations were used to provide feedback to students, enabling them to adjust, improve, and develop their own learning.

From the qualitative study on the quality of science learning management, through observation, note-taking, and informal interviews with the target group, the researchers analyzed the content and concluded interesting points reflecting the results of teacher development according to the teacher development model to enhance science learning management using the professional learning community concept as follows:

> "Teachers' learning activities are very interesting. They teach using the PBL method, which involves collaborative planning and designing. They receive feedback from fellow teachers and administrators and then adjust before actual teaching. In the classroom, students engage in activities, create projects, present their work, and there is a boost in students' motivation." (Teacher 10, Reflection)

> "I want to try this approach in schools. I want our students to be expressive, not afraid to answer questions." (Teacher 7, Reflection)
> "At first, I didn't understand PLC. There were policies to implement it, but I wasn't convinced because I didn't see results or any changes. It seemed like regular meetings. But today, having learned and seen the workflow and teaching management here, I'm very surprised. The atmosphere is conducive to learning, and I will adapt the new things I've learned to my school." (Teacher 12, Reflection)

> "This activity trains in a format that involves teachers. It integrates knowledge in science learning management through practical training, helping teachers understand and see how to apply it in schools. This boosts confidence in teaching, affirming that we can do it." (Teacher 1, Reflection)

> "Learning about the methods of science learning management from exemplary teachers, I saw the classroom, the role of the

teacher, the learning behaviors of students, and this helped me reflect on my own teaching: what I originally did and how I can adjust, improve, and develop myself." (Teacher 3, Reflection)"

"Participating in this practical training activity with involvement made me understand the approach to science learning management and the process of PLC. This will enable me to provide accurate suggestions to teachers." (Teacher 15, Reflection)

"I feel that attending the training is about gaining knowledge and trying out what was taught at school. I see continuity; it's not just training and then it's over, but it's actually put into real practice. I know the answers and see the direction for improvement." (Teacher 11, Reflection)

"To be frank, I used to lack confidence in teaching, especially the difficult topics. I was afraid to miscommunicate with the students. But designing lessons with fellow teachers and getting feedback on areas that need improvement has increased my confidence. It might not be perfect, but there is a direction for improvement and development." (Teacher 4, Reflection)

Table 4. Satisfaction findings for the science management model via professional learning communities

Evaluation item	Mean	S.D.	Interpretation
1. Teachers are proficient in managing science learning, including designing learning management, organizing learning activities, using media and learning resources, and assessing and evaluating learning outcomes.	4.56	0.51	highly satisfied
2. The content of the development covers aspects of designing learning management, organizing learning activities, using media and learning resources, and assessing and evaluating learning outcomes.	4.44	0.51	satisfied to a high extent
3. The content can be applied to organize quality science learning.	4.31	0.48	satisfied to a high extent
4. The process of conducting activities is consistent with the context of the institution/school.	4.38	0.50	satisfied to a high extent
5. The teacher development process involves teachers, administrators, and experts working together in a manner that has a good relationship and mutually supports and promotes each other.	4.50	0.52	satisfied to a high extent

Evaluation item	Mean	S.D.	Interpretation
6. The teacher development process in the preparatory phase promotes teachers to form teams, collaboratively analyze situations or problems, and set goals together for the development of the quality of science learning management.	4.56	0.51	highly satisfied
8. Learning from good models inspires teachers, instills confidence, and highlights the importance of developing science learning management based on a professional learning community.	4.63	0.50	highly satisfied
9. The collaborative learning phase through participatory training and learning science management from good model teachers helps generate ideas for quality science teaching management.	4.63	0.50	highly satisfied
10. In the collaborative practice phase, teachers collaboratively analyze problems and design science teaching activities together.	4.44	0.51	satisfied to a high extent
11. In the operational learning management phase, teachers receive classroom observations and exchange knowledge with each other.	4.44	0.51	satisfied to a high extent
12. In the reflection and application phase, it helps teachers to review and reflect on their own learning management. There is an exchange of knowledge among each other, leading to the improvement and development of quality science learning management.	4.63	0.50	highly satisfied
13. The measurement and evaluation of the quality of science learning management from actual practice can be genuinely applied in the classroom.	4.44	0.51	satisfied to a high extent
14. The assessment and evaluation open opportunities for teachers to participate in measuring and evaluating their own learning management.	4.69	0.48	highly satisfied
15. Feedback from the evaluation of the teacher's learning management allows the teacher to make improvements and develop their own learning management.	4.56	0.51	highly satisfied
Average	4.51	0.50	highly satisfied

From Table 4, it was found that the teachers' satisfaction with the model of teacher development to promote science learning using the concept of a professional learning community overall was at the highest level, with an average total score of 4.52. When considering the details, the top three areas where teachers were most satisfied were:

1. The measurement and evaluation process which allows teachers to participate in assessing and evaluating their own learning management. This received the highest satisfaction level with an average score of 4.69.
2. Learning from a good model inspires teachers, instills confidence, and makes them recognize the importance of improving science teaching based on the professional learning community foundation. The satisfaction here was also at the highest level, with an average score of 4.63.
3. The collaborative learning phase involving participative training and learning about science teaching from a good role model helps generate ideas for quality science teaching. This too had a satisfaction level at the highest, with an average score of 4.63.

Discussion

The development of teacher professional growth models to promote science learning using the concept of a professional learning community revealed the following findings. There are four main strategies to enhance the quality of science learning: designing learning experiences, organizing learning activities, the use of educational media and resources, and assessment and evaluation of learning outcomes. The teacher professional growth model, which utilizes the concept of a professional learning community, consists of six components: the origin and importance of the model, its objectives, foundational principles, structure, content, and instructional steps. These instructional steps are further divided into five stages: preparatory actions, collaborative learning, joint practical training, managing the learning process, and reflection and application.

This approach stems from an extensive review and synthesis of key concepts related to the components of the professional learning community. The model has been developed based on literature review, expert interviews, and a synthesis of the community's characteristics. It incorporates six essential elements: shared vision creation, collaborative empowerment, friendly community, cooperation to enhance student learning, openness to feedback, and reflective practices. All six elements are vital and interrelated, reinforcing the objective of establishing a thriving professional learning community in educational institutions, especially regarding the quality of learners (Khotthaphan, 2020).

Furthermore, this model aligns with the teacher competency standards set by the Teacher Council Office (2019), which stipulate that learning management, media/resource selection, and assessment should be part of a teacher's core knowledge and abilities. This is consistent with Office of the Basic Education Commission (2010), which states that curriculum

management and learning management are part of a teacher's essential competencies, encompassing five indicators: curriculum development, knowledge and skills in designing learning, learner-centric learning management, utilization and development of innovative technological media for learning, and assessment and evaluation of learning outcomes.

Drawing on the previously discussed paradigms in Thai educational reforms, two seminal pieces of research have played instrumental roles in shaping the 21st-century pedagogical landscape in Thailand. A study by Wangmee and Naiyapat in 2017 delved deep into the competencies of Thai educators. This study revealed that among the 7 core competencies for basic education instructors, two stand out: the focus on student-centered learning approaches and the aptitude to assess and evaluate with sensitivity to diverse individual needs.

In a similar vein, research by Khotthaphan (2020) took a closer look at strengthening science education for primary level educators. This research elucidated an advanced teacher development model anchored in the ethos of professional learning communities. A noteworthy outcome was the identification of indicators for quality science instruction. These comprised of 15 sub-indicators spread across four dimensions: 4 relating to instructional design, 6 associated with learning activity organization, 2 concerning the use of educational media and resources, and 3 dedicated to assessment and evaluation of learning outcomes. Moreover, the research proposed a comprehensive 6-component framework for the said teacher development model, incorporating the rationale, principles, objectives, content structure, a 6-step methodology termed "PLCCCA", and strategies for assessment and evaluation.

The study on the effectiveness of the teacher development model to enhance science learning using the concept of a professional learning community found that the quality of science learning management by teachers was at a good level. After two rounds of teacher development, there were improvements in the quality of science learning management between the first and second rounds. Several reasons can support the effectiveness of the teacher development model to enhance science learning using the concept of a professional learning community, as follows:

Professional learning communities create a culture of collaborative learning under positive interactions, and knowledge exchange among peers, which ultimately leads to knowledge that can be applied in future opportunities. This aligns with the ideas of Mazano (2003) and Pongthip Theparee (2014), suggesting that the culture of collaboration within schools and the professional approach among teachers can enhance student outcomes and foster deep active learning (Khotthaphan, 2020).

The development aligns with the real practice of teachers, which stems from problems teachers encounter during instruction. When teachers tackle these problems in real settings under the professional learning community concept, there's collaboration among school members throughout the process, leading to the alleviation of student-related issues. This provides teachers with a practical perspective on the professional learning community process.

Expert guidance helps teachers find pathways to enhance learning management and professional development. This aligns with Lowriendee (2013) stating that mentoring and guidance are vital processes in teacher professional development.

Participation in a teachers' professional learning community resulted in significant changes in how teachers work together, the development of a collaborative work culture, and the creation of effective learning activities. These changes boosted the teachers' motivation and helped them overcome challenges in teaching. Five evident components of this change were curriculum, teaching methods, learning, the role of the teacher, and the subject to be taught.

After joining the professional community, teachers experienced three types of change in their beliefs and practices:

1. A change in practice without altering their original beliefs.
2. A change in beliefs without changing their practices.
3. A simultaneous change in both beliefs and practices.

These transformations benefited the improvement of lessons and student learning. A study by Khotthaphan (2020) found that teachers' science teaching quality was rated as "good", and over three cycles, there was a statistically significant improvement. Teachers were highly satisfied with this model of professional development, possibly because the school served as the base for their development, which was cost-effective and directly applicable to their students.

Wongyai & Patphol (2019) stated that effective professional development must come from within, as it forms the foundation for sustainable progress and happiness. This aligns with research by Singsan (2011), which found that teachers were highly satisfied with a development model based within schools.

Conclusion

This study underscores the profound importance and effectiveness of the teacher professional growth model centered on the ethos of professional learning communities in the context of science education. Four strategies, namely designing learning experiences, organizing activities, employing educational media/resources, and evaluating learning outcomes, emerged as

pivotal to enhancing the quality of science learning. The model was bolstered by its alignment with Thai education reforms and encapsulated the core competencies expected of educators. Notably, it effectively bridged the essential aspects of pedagogical development and authentic classroom challenges.

The success of this approach was observed in the notable improvements in the quality of science learning management after its implementation. The core of its effectiveness lay in fostering a culture of collaboration, deriving insights from real-life teaching challenges, and benefiting from expert guidance. Moreover, the professional learning community approach heralded shifts in teachers' practices and beliefs, ultimately culminating in improved lesson quality and enhanced student outcomes.

It's evident that grassroots, school-based professional development not only offers practical, cost-effective solutions but also resonates deeply with teachers, leading to sustainable progress. The overarching takeaway is that the fusion of professional learning community principles with teacher development can be a formidable catalyst for elevating the quality of science education, promoting both teacher satisfaction and enhanced student learning.

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Conflicts of interest

The authors of this paper certify that they have NO affiliations with or involvement in any organization or entity with any financial or non-financial interest (such as honoraria; educational grants; membership, employment; affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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