Enhancement of Secondary Science teacher's professional knowledge in learning Pedagogical Content Knowledge through Involvement in the Professional Learning Community

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ABSTRACT

The qualitative research study explored Bangladeshi secondary science teacher's experiences working in a professional learning community (PLC) in terms of enhancing professional knowledge in learning pedagogical content knowledge (PCK). The research questions that guided this study are: (1) What are the learning experiences of the secondary science teachers regarding their involvement in a Professional Learning Community (PLC) as a means of professional learning for enhancing their Pedagogical Content Knowledge (PCK)? (2) How do Secondary Science teachers apply their learning from Professional Learning Communities (PLC) to their teaching plans and practices through the Content Representation (CoRe) framework? (3) How do secondary science teachers use the knowledge gained from participation in a professional learning community (PLC) to design and implement effective teaching strategies in their classrooms? The study is based on a constructivist approach to learning, which views knowledge construction as a socially mediated process. Therefore, teachers' experiences were collected as qualitative data through analyzing teachers' lesson plans and self-reflective journals. As a result, the findings showed teacher's enhanced professional knowledge working in a PLC in sizing up the topic, identifying the importance of the topic, exploring self-content knowledge relevant to the topic, knowing what learners might think, identifying contextual factors choosing the topic and examples, selecting more appropriate teaching-learning and assessment strategies. The findings of this study are expected to provide insights into how PLCs can be utilized to enhance secondary science teacher's PCK knowledge. This study is significant as it contributes to the literature on professional development for science teachers and offers practical recommendations for improving science teacher's professional knowledge in learning PCK.

Keywords: *Secondary science teachers, Professional learning community (PLC), Pedagogical content knowledge (PCK), Content Representation (CoRe) framework, Effective teaching strategies, Professional development.*

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Introduction:

Pedagogical Content Knowledge (PCK) evolves as a dynamic concept declining the line among teachers, students, and subject matter. Choosing a teaching-learning strategy wisely considering learners, classroom climate, and more importantly subject matter is all PCK cares about (Shulman, 1986). Hence, PCK is more 'applied' knowledge and understanding of a teacher which improves teaching-learning practice and improves students' learning (Grossman *et al.*, 2009; Baumert & Kunter, 2013). Research has shown that developing PCK is essential and crucial for enhancing teachers' professional knowledge (Magnusson et al., 1999). The similar literature also identified factors such as the teacher's own experience as a learner and, the teacher's subjective and pedagogical knowledge which play together as a complex idea of Pedagogical Content Knowledge (PCK). Therefore, developing Pedagogical Content Knowledge (PCK) is challenging as Grossman et al. (2009) address teacher's lack of content knowledge, lack of pedagogical knowledge, and deficiency in resources as the most common ones responsible for not being able to benefit from PCK. To facilitate the sharing of ideas, experiences, and resources to make teaching more effective, the Professional Learning Community can play a pivotal role (Akhter & Kamal, 2018). DuFour and Eaker (1998) believe that such collaborative opportunities within PLCs enable teachers to practice PCK through feedback from PLC members. Among the other practices, lesson study is identified as a significant one by Baumert and Kunter (2013). In a lesson study within a PLC, the teacher gets the opportunity to develop a plan and share the plan within the PLC on a specific lesson integrating both his/her subject knowledge and pedagogical knowledge. Later the teacher implemented the revised plan in front of the PLC members and finally revised the plan once again based on the discussion and the feedback from PLC members. This qualitative study aims to explore how lesson study within PLC informs and improves secondary science teachers' professional knowledge in learning Pedagogical Content Knowledge (PCK).

Research Problem with Justification:

Addressing pedagogical content knowledge as teachers' necessary professional knowledge, several researchers advocate that it is necessary to enhance teachers' professional knowledge to ensure effective teaching. Dufour and Eaker (1998) believe that participating in PLCs can enhance secondary teachers' PCK. Moreover, research has shown that teachers' professional knowledge in PCK is highly supportive in enhancing students' academic achievement (Kunter et al., 2013 Vescio et al., 2008). Penuel et al. (2007) identify increased confidence, motivation, and job satisfaction among science teachers who are involved in PLC. However, many secondary science teachers still abstain from participating in PLC due to a lack of time management, incentives, and other school administrations' support (Loucks-Horsley et al., 2010).

Recent studies have continued to underscore the significance of PCK and the effectiveness of PLCs in enhancing it. For instance, a study by Vossen et al. (2020) demonstrated a positive

correlation between PLC participation and improved PCK among secondary science teachers. Furthermore, a study by Armwood (2023) highlighted the critical role of collaborative professional development, including PLCs, in supporting teachers' ongoing professional growth. These recent findings reaffirm the relevance and timeliness of the proposed study in addressing the identified research gap.

In the Bangladeshi context, several studies have increasingly addressed the challenges and opportunities surrounding Professional Learning Communities (PLCs) and Pedagogical Content Knowledge (PCK) development. Rahman (2012) conducted a comprehensive examination of the impact of PLC participation on PCK enhancement among science teachers in Bangladesh, highlighting the positive outcomes associated with collaborative professional development initiatives. Similarly, Rahman (2011) emphasized the critical role of PLCs in improving teachers' instructional practices, particularly in the context of science education in Bangladesh through constructive discussions and workshops in PLCs. Their study revealed that active engagement in PLC activities positively influenced teachers' confidence and effectiveness in delivering science content.

Furthermore, Al-Faruki and Rahman (2022) explored the barriers to effective PLC implementation in Bangladeshi college-level education, shedding light on factors such as time constraints and administrative support, which resonate with the challenges identified in the present study. The research underscored the need for tailored strategies to address these specific contextual constraints. Moreover, a study by Shiddike and Rahman (2019) examined the relationship between teachers' participation in PLCs and their job professional development, emphasizing the positive impact of collaborative learning communities on teachers' overall professional well-being. Another research by Mim, Rahman, and Jahanara (2017) explored secondary science teachers' pedagogical content knowledge on the "Genetics" topic from the Content Representation (CoRe) perspective and found that teachers prefer to use traditional lecture methods to teach the mentioned topic inside the classroom.

However, no research has introduced the lesson study strategy to see secondary science teachers' learning experiences in enhancing pedagogical content knowledge through a Professional Learning Community. Therefore, a lesson study plan has been adopted to explore secondary science teachers' self-development experiences involving teachers' participation in the PLC. Researchers of this study believe that the findings would inform other secondary teachers and motivate them to be involved in PLCs more to improve their professional knowledge and practices. In addition, teachers' experiences will encourage the school authorities, and policymakers to take initiatives to involve the school teachers more in PLC.

Purpose and Research Questions:

The purpose of this qualitative study is to explore and understand how the professional

knowledge of secondary science teachers in pedagogical content knowledge (PCK) can be enhanced through teachers' involvement in a Professional Learning Community (PLC). While examining the perns and experiences of secondary science teachers regarding their involvement in a PLC, the study further aims to identify the factors responsible for facilitating and hindering professional development.

Research questions:

1. What are the learning experiences of the secondary science teachers regarding their involvement in a Professional Learning Community (PLC) as a means of professional learning for enhancing their Pedagogical Content Knowledge (PCK)?

2. How do Secondary Science teachers apply their learning from Professional Learning Communities (PLC) to their teaching plans and practices through Content Representation (CoRe) framework?

3. How do secondary science teachers use the knowledge gained from participation in a professional learning community (PLC) to design and implement effective teaching strategies in their classrooms?

Theoretical Framework:

To explore the areas in which educators improve pedagogical content knowledge (PCK) through working in a professional learning community (PLC), a conceptual framework has been developed by combining Lewis and Tsuchida's (1998) Lesson Study (Plan-Do-See) framework and Loughran et al.'s (2006) Content Representation (CoRe) concept developed from the 6 crucial areas of pedagogical content knowledge (PCK) framework of Shulman (1987). Both frameworks have been briefly described below-

Lesson Study (Plan-Do-See) Framework:

Lewis and Tsuchida (1998) developed this framework considering pedagogical development as a collaborative approach. The main idea involves a cyclic progression of planning, conducting or implementing, observing, and reviewing lessons. All these activities are divided into three domains- Plan, Do, and See.

Plan-Phase:

Planning the lesson is what teachers have to perform in the first stage. The only amazing fact about this stage is teachers have the option to improve their plans through interaction with the other teacher in a team, formally known as the 'professional learning community (PLC)'.

Do-Phase:

Teachers have to implement the individual plans in front of the other teachers in the PLC and fellow teachers provide constructive feedback on the observed class.

See-Phase:

Based on the class taken, teachers discuss again which part goes well, which part could be better, and many more. This stage informs future lesson planning.

Pedagogical Content Knowledge (PCK) Framework by Shulman (1987):

PCK is a dynamic concept encompassing 6 main ideas of Shulman (1987) as follows-

   a. **Content Knowledge (CK):** Shulman (1987) addresses teachers' knowledge about subject matter relating to the subject the teacher teaches.

   b. **Pedagogical Knowledge (PK):** Teachers' knowledge and understanding of teaching-learning processes.

   c. **Pedagogical Content Knowledge (PCK):** This includes knowledge of the student's prior knowledge, misconceptions, and learning styles, as well as knowledge of how to sequence and structure the content.

   d. **Curricular Knowledge (CuK):** Refers to the teacher's knowledge of the curriculum, including knowledge of the standards, goals, and objectives of the curriculum.

   e. **Knowledge of Learners (KoL):** Refers to the teacher's knowledge of the learners, including knowledge of their background, experiences, interests, and abilities.

   f. **Knowledge about Educational Contexts (KEC):** Refers to the teacher's knowledge of the broader social and cultural contexts in which education takes place, including knowledge of the school culture, community culture, and societal culture.

Loughran et al. (2006) represent Shulman's (1987) ideas of pedagogical content knowledge (PCK) through eight (8) questions, popularly known as the Content Representation (CoRe) Framework. The eight questions and their intentions have been briefly discussed in the chart-

Table: 8 Questions of Content Representation (CoRe) Framework and Their Conceptual Underpinning (Loughran, Berry & Mulhall, 2006).

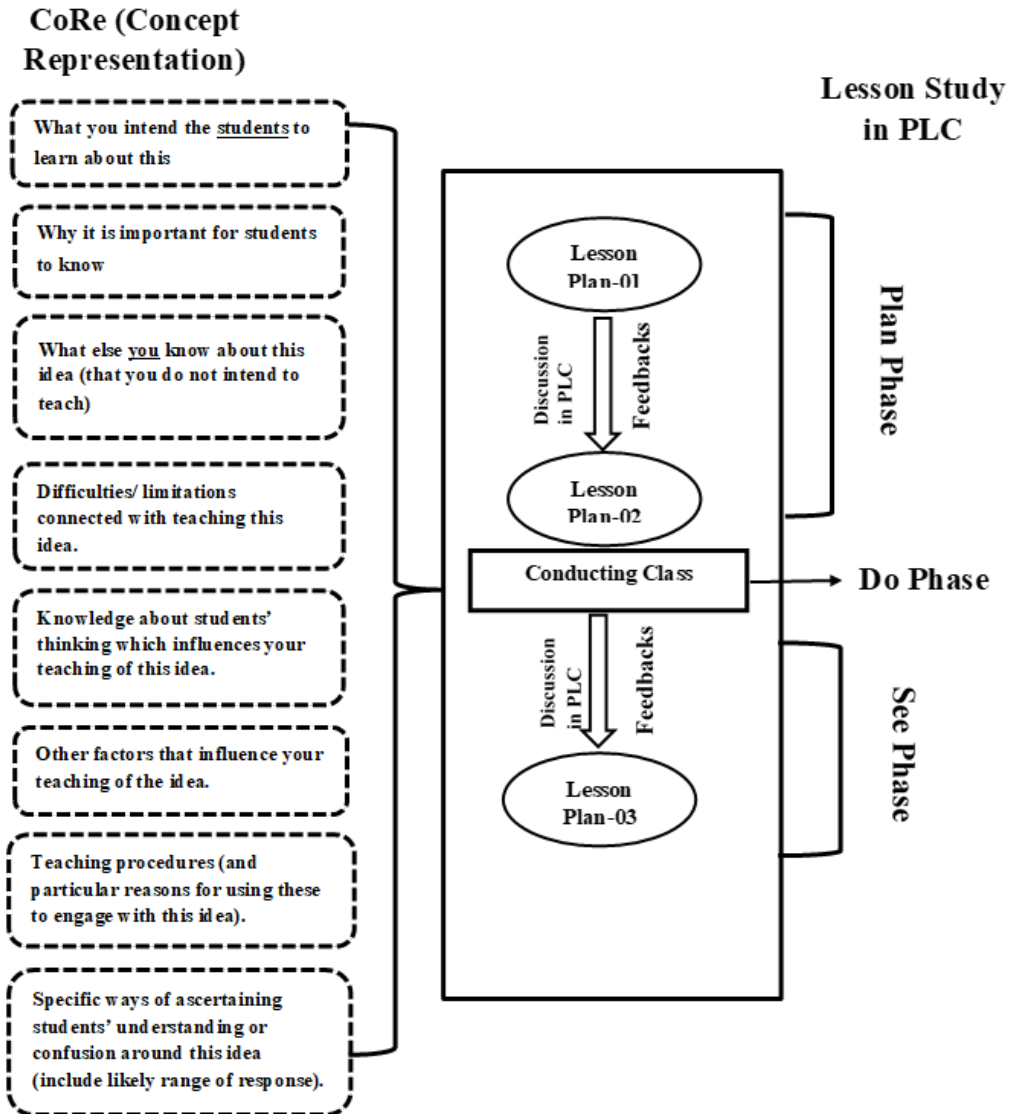| Your Level for which this CoRe is designed	Conceptual Underpinning
What you intend the students to learn about this idea.	- *'Unpacking' the big idea.* - *Being specific about what a particular group of students should be able to learn.* - *Being specific about what the students are capable of achieving.*

Why it is important for students to know this.	- *Relating concepts to learners' everyday lives to create meaningful ways of encouraging students to grasp the essence of the idea/concept.* - *Also relating the concepts to other curricular aims.*
What else <u>you</u> know about this idea (that you do not intend students to know yet).	- *Being not oversimplified.* - *Or maintaining content's complexity in order to enhance understanding.* - *Detracting unnecessary confusion.*

Difficulties/ limitations connected with teaching this idea.	- *Potential difficulties-*
	  › *Primary misconceptions*
	  › *Limitations of using analogies.*

Knowledge about students' thinking which influences your teaching of this idea.	- *Considering students' commonly held ideas about the topic* (understanding students' misconceptions). - *Considering the level of manner* (including level of interest) *in which students 'usually respond'.*
Other factors that influence your teaching of the idea.	- *Unpacking teachers' contextual knowledge about students as well as their general pedagogical knowledge.*
Teaching procedures (and particular reasons for using these to engage with this idea).	- *Teachers' familiarity with wide range of 'teaching procedures'.*
Specific ways of ascertaining students' understanding or confusion around this idea (include likely range of response).	- *To explore how teahcers' approach to monitor students' understanding and progress* (both formally and informally) *constantly.*

Conceptual Framework

Based on the concepts delivered by Shulman (1987), Loughran et al. (2006) developed a Content Representation (CoRe) framework encompassing eight questions for educators to check pedagogical content knowledge (PCK). Prioritizing the eight questions referred to by Loughran et al. (2006) and considering the three steps of the Lesson Study framework by Lewis and Tsuchida (1998), the conceptual framework of this study is as follows-

Figure 01: Conceptual Framework of the Study

CoRe (Concept Representation)

- What you intend the students to learn about this
- Why it is important for students to know
- What else you know about this idea (that you do not intend to teach)
- Difficulties/ limitations connected with teaching this idea.
- Knowledge about students' thinking which influences your teaching of this idea.
- Other factors that influence your teaching of the idea.
- Teaching procedures (and particular reasons for using these to engage with this idea).
- Specific ways of ascertaining students' understanding or confusion around this idea (include likely range of response).

Lesson Study in PLC

Lesson Plan-01

Discussion in PLC → Lesson Plan-02 ← Feedbacks

Plan Phase

Conducting Class → Do Phase

Discussion in PLC → Lesson Plan-03 ← Feedbacks

See Phase

Methodology:
Study Design:

This research employs an interpretive phenomenological qualitative approach to investigate the impact of Professional Learning Communities (PLCs) on the development of Pedagogical Content Knowledge (PCK) among Secondary Science Teachers, utilizing the Plan-Do-See (lesson study) framework. This methodology, as outlined by Alase (2017), is well-suited for this study as it allows for a comprehensive exploration of how PLCs influence PCK. The approach aligns with constructivist epistemology, recognizing knowledge as constructed through individual experiences and interactions (Creswell & Creswell, 2017). By delving into the subjective meaning-making process of participants, this methodology provides a platform for uncovering the contextual and underlying factors shaping the mentioned phenomenon which eventually get the audiences to gain a comprehensive and nuanced understanding of the pivotal phenomenon concerning the impact of PLCs on the improvement of PCK (Creswell, 2009).

Participants:

Science teachers who teach at the secondary level were selected through purposive sampling. In addition, teachers who were 'available' and wanted to participate 'voluntarily' participated in this study (Creswell, 2011). Finally, 8 secondary science teachers participated where 4 teachers were female (50%) and 4 teachers were male (50%). Teachers were advised to develop 3 lesson plans each (initial one, one after the first discussion, and the final one after the second discussion and simulation). Each step of the lesson study occurred in PLC and informs the constructive development of the next lesson plan.

Tools

1. Lesson Plans (LP);
3. Teachers' Self Reflections (SR).

Data Collection and Analysis:

Participants participated in a day-long session on 25th February 2023. In this session, they developed an initial lesson plan they wanted to implement (Plan Phase). Then discuss in a group consisting of other science teachers who gave verdicts to each other. Based on feedback from other teachers of the PLC, teachers developed a second lesson plan (Plan Phase). Teachers then conduct classes based on lesson plan 2 in a simulation manner (Do-Phase). Evaluating the class taken, the teachers in the PLC again discussed with each other and therefore developed a third lesson plan each based on the feedbacks given by the PLC members (See-Phase). In the end, teachers wrote self-reflection parts, and reflective journals, which, according to (Phelps, 2005), are very significant sources of data for narrative research.

8 teachers were coded as (T-1 to T-8) randomly to ensure privacy and anonymity and similarly, the reflective parts were coded as (SR-1 to SR-8). For lesson plans, each teacher had to develop three consecutive lesson plans. Therefore, the lesson plans were coded as (LP-1.1, 1.2, 1.3, 2.1, 2.2, ……8.1, 8.2, and LP-8.3).

For data analysis, thematic analysis was chosen to gather similar information under major ideas or themes (Creswell, 2011) through deductive strategy. After collecting data, the data was categorized manually using color coding considering the eight pre-defined themes relevant to the conceptual framework of the study in a deductive way (Proudfoot, 2023). For developing interpretation from the collected data, the below-mentioned procedural steps of Creswell (2011) were maintained-

Figure-02: Procedural Steps of Data Collection and Data Analysis of this Study

Ethical Consideration:

To let the participants participate voluntarily, convenience sampling was used (Bell & Walters, 2014). Participants were provided with detailed information about the study, including its purpose, potential risks, and their right to withdraw at any stage without consequence. Written informed consent was obtained from all participants. To safeguard the anonymity of participants, each individual was assigned a unique code, and all data was stored securely. Additionally, to further ensure confidentiality, any potentially identifying information was carefully redacted or anonymized in the final report or any related publications. This protocol was strictly followed throughout the research process to uphold the rights and well-being of the participants.

Findings and Discussions:
Summary of the Findings:

This qualitative study aimed to explore teachers' experiences of enhancing their professional knowledge in learning pedagogical content knowledge through involvement in a professional learning community. The findings under eight pre-defined themes were drawn from the eight questions of Loughran, Berry, and Mulhall (2006) representing the six key areas of pedagogical content knowledge by Shulman (1987). The summary of the findings under the themes has been sketched below-

Themes	Teachers' Experiences Working in PLC
Selection of Appropriate Topic	Working in PLC helped teachers to select/decrease content size appropriately considering class duration and class size.
Relating the Topic to Learners' Real-Life Situations/Contexts	Feedback from the PLC members helped teachers to relate their intended topic to students' real-life contexts.
Teacher's Content Knowledge	Feedback and discussions in PLC increased teachers' consciousness of identifying topics relevant to the topic intended to teach.
Determining Limitations/ Difficulties of Teaching the Topic	Feedback and discussions in the PLC help the teachers to identify class duration, class size, and technological constraints as possible constraints of teaching the intended topic. Therefore, teachers admitted to being more feasible about their topics.
Teachers' Knowledge about the Learners	Discussions and feedbacks from the PLC members inform the teachers more about 'how to', 'when to', and 'to what extent' teachers should determine learners' prior knowledge on the topics.
Identifying Other Factors Regarding Choosing the Topic	Teachers believed that working in a PLC enhanced their understanding of contextual considerations of choosing the specific topic intended.
Selection of Appropriate Teaching Learning Strategy	Teachers believe that working in a PLC helped them to modify the intended teaching-learning strategy or to further select appropriate teaching-learning strategies.
Assessing Students' Understanding/ Assessment for Learning	Discussions and feedback from the PLC members helped the teachers to be more practical about assessing the learners' understanding throughout the class.

Findings:

The predefined eight themes carefully sketched from the eight questions of Loughran et al. (2006) representing the six key areas of pedagogical content knowledge by Shulman (1987) are- Selection of Appropriate Topic (Sizing up the Topic), Identifying the Importance of the Topic (Relating the Topic to Learners' Real Life Situations), Teacher's Content Knowledge, Determination of the Limitations/ Difficulties of Teaching the Topic, Teachers' Knowledge about the Learners, Identifying Other Factors Regarding Choosing the Topic, Selection of Appropriate Teaching Learning Strategy, and Assessing Students' Understanding/Assessment for Learning. Here, findings under these aforementioned themes have been discussed briefly-

Selection of Appropriate Topic/Sizing up the Topic

Most of the teachers experienced an improvement in choosing the appropriate intended topic

size in the 2nd phase. All the changes involve decreasing the topic size and being more feasible in choosing a short amount of content considering the typical class size and class duration.

For instance, T-3 decided to shift focus to only teaching the characteristics of vertebrates rather than exploring the characteristics of all classes of vertebrates (e.g., Pieces, Amphibia, Reptilia, Aves, Mammalia, etc.). The approach is to provide a general idea before jumping into more specific concepts (classes of vertebrates). T-4 decreased the intended topic from teaching the whole urinary system (including the urethra, kidney, urinary bladder, etc.) to the concept, structure, and function of nephrons. T-8 also planned to decrease the topic to only teach the energy conversion process between two kinds of energy rather than addressing all types of energy in the same class.

Therefore, all the teachers who changed the size of the intended content mainly focus on decreasing the amount of the content. After implementing the 2nd lesson plan during simulation, no teacher had to change their focus of intended contents in their 3rd lesson plan. T-4 wrote in his/her self-reflection positively about working in PLC as follows,

> *"Working in my PLC, my vision of choosing a feasible topic enlarged.……..*
> *I also gained confidence in questioning peers (colleagues) ….I have decided*
> *to implement the idea of choosing to teach only nephron instead of the whole*
> *urinary system and adjusted with my lesson plans for the topic" (SR-4).*

In conclusion, most teachers experienced improvements in choosing their intended topic size during the second phase. By focusing on specific, feasible, and relevant topics, teachers can better engage their students and improve their learning outcomes

Identifying Importance of the Topic

Teachers admitted that working in a PLC helps them to choose appropriate real-life contextual examples to address the intended topic. A teacher who decided to address more real-life connections with the topics in the 3rd phase said,

> *"My fellow members (from PLC) want me to introduce the emergence need*
> *of the 4th industrial revolution and global job market during teaching*
> *programming so that students' interests grow to grasp the abstract idea of*
> *programming language" (SR-05).*

The teachers who planned to change this part in their 2nd phase mainly focused on questioning the learners and providing opportunities for the learners to question the topic. One of the teachers' (T-6) quote is worth mentioning,

> *"I want to start my physics class on the topic 'power' by asking questions*
> *where they use this concept in daily life and why. At the same time, I will also*
> *allow them to question me to explore the importance of learning the topic and*
> *its implications."*

The findings suggest that teachers who work in a professional learning community (PLC) can choose appropriate real-life contextual examples to address the intended topic more effectively. By working collaboratively, teachers can share ideas and experiences to create a more meaningful learning experience for their students.

Teachers' Content Knowledge

Teachers believed that feedback and discussions in PLC increased teachers' consciousness of identifying topics relevant to the topic intended to teach. A teacher (T-4) who believed that other members of PLC helped him/her to identify relevant other topics apart from the relevant topic could clearly define the relevant contents on the 2nd lesson plan (LP-4.2) that weren't intended to be taught. In the self-reflection, the teacher (T-4) wrote,

> *"At first, I chose to teach the whole urinary system and decided the contents such as digestive systems, circulatory system, and reproductive systems of the human body as additional contents I know besides the content intended……After discussing with fellow teachers in PLC, I decided to teach only 'nephron' and identified 'urethra', and 'urinary bladder' as potential contents which are relevant but wouldn't be addressed during the class" (SR-4).*

An ICT teacher decided to teach programming of the addition of two simple numbers and identified the addition of three simple numbers as relevant content that wouldn't be addressed. However, feedback from PLC encouraged him/her to give the addition of three simple numbers as a student activity and the previous one (addition of two simple numbers) for demonstration. Therefore, the teacher identified programming for adding complex numbers as the content that the teacher knows apart from the intended content but would rather not address in the same class (LP-5.2). The teacher believes that such planning would increase *'ownership of learning programming'* among the learners (SR-5).

Overall, the findings of the current study suggest that feedback and discussion in PLCs can be an effective way to increase teacher consciousness of relevant topics and improve their planning and decision-making. By collaborating with colleagues and engaging in reflective practice, teachers can develop a deeper understanding of the content they are teaching and identify more effective strategies for engaging students in meaningful learning experiences.

Determining Limitations/ Difficulties of Teaching the Topic

Feedback and discussions in the PLC help the teachers to identify class duration, class size, and technological constraints as possible constraints of teaching the intended topic. One of the teachers (T-1) who decided to teach diffusion through demonstration admitted that, feedback from PLC members helped him/her to consider classroom size for the demonstration. Therefore, he/she decided to involve students in groups to experiment with themselves in the classroom. The teacher wrote,

> *"Demonstrating the diffusion of gases would be difficult if the class contains more than 20 students. After the simulation class, PLC members raised questions like it be appropriate for a class with more than forty students to demonstrate this reaction? Another question was raised on whether the white bubbles of Ammonia gas can be seen clearly from the back seat. Therefore, I have decided to engage learners doing this activity in groups…. letting the whole class do the experiments may need more than the usual class duration and extra equipment facilities" (SR-1).*

Teacher (T-3) first decided to teach all the classes of vertebrates. Later, after one successful discussion in PLC, the teacher identified class duration as a possible constraint and decided to address only the general characteristics of vertebrates in a single class.

Teacher (T-5), who wanted to teach programming of adding two simple numbers identified lack of access to technologies as a major constraint through the feedback from the PLC. The teacher wrote in his/her self-reflection part,

> *"In my first lesson plan, I decided to teach programming in the computer lab. However, after getting feedback from my PLC members, I have accepted the fact that we generally don't have enough computers for each student. Therefore, I have decided to use one computer for at least 2-3 students…..working in PLC helped me to identify such constraint" (SR-5).*

Overall, the findings suggest that PLCs can play an important role in helping teachers identify potential constraints related to class size, duration, and technological resources, and develop strategies to address them. This highlights the importance of creating a collaborative culture among teachers and providing opportunities for professional development through PLCs to enhance teaching and learning practices in schools.

Teachers' Knowledge about the Learners' Thinking:
Discussions and feedbacks from the PLC members inform the teachers more about 'how to', 'when to', and 'to what extent' teachers should determine learners' prior knowledge on the topics. The teacher demonstrated the diffusion of two gases (T-01) to provide the learners with a concrete example of identifying which gas diffused first. The teacher wrote,

> *"Feedback from the other members of the PLC guided me to add scientific explanation after demonstration…….my PLC colleagues believe that students may not be able to explain why Ammonia gas diffused first. Therefore, I need to link the idea of mass and how it determines diffusion. Hence, I have added an explanation from my side" (SR-1).*

After the simulation session, the teacher also considers determining the learners' prior knowledge of the mass of a compound before going into an explanation in his/her 3rd lesson plan.

Teachers also explored students' lack of prior knowledge in specific content considering their experiences. One of the teachers wrote, *"Students' lack of prior knowledge and understanding about acceleration due to gravity may cause problems to teach them the difference and relation between gravitation and gravity" (T-6).* As the teachers could identify knowledge about students through their prior experiences, they decided not to change or add any plan regarding this concept after the first and second discussions.

In summary, the findings highlight the value of PLCs in supporting teachers' instructional decision-making based on students' prior knowledge. Teachers can use feedback from colleagues to inform their instructional practices and scaffold instruction based on students' prior knowledge. However, it is important to consider both students' prior knowledge and instructional goals when making decisions about changing or adding plans.

Identifying Other Factors Regarding Choosing the Topic
The findings suggest that teachers' participation in professional learning communities (PLCs) can enhance their understanding of contextual considerations when choosing specific topics to teach. Specifically, teachers reported that working in a PLC allowed them to gain insights into limited technological access and lack of resources, which they may encounter in their classrooms. Additionally, teachers also received feedback on choosing appropriate examples that are relevant to the learners' real-life contexts.

One of the teachers (T-1) who intended to demonstrate the diffusion of gases later admitted that he/she chose such due to a lack of resources. He/she wrote,

> *"...after sharing my plan to demonstrate, my fellow PLC members suggested engaging students in doing the activity themselves……knowing the constraints of adequate resource unavailability, my PLC members wanted me to arrange at least 2/3 materials to engage students into a group to observe the diffusion of gasses" (SR-01).*

Another teacher who planned to conduct an ICT class wanted to conduct a class in the computer lab. However, ensuring equal access to devices and the internet for every student was suggested to be difficult by other PLC members. Therefore, the teacher decided to demonstrate the programming through multimedia and later planned to engage students in groups, and in case there were not adequate computers/devices, the teacher was advised to maintain lab activities in different slots upon the suggestions of the PLC members.

Teachers also benefitted from PLC members' feedback to choose more contextual examples

relating to learners' real-life oriented contexts. One of the teachers (T-3) admitted that while teaching the characteristics of chordates, PLC members advised to let the learners explore the examples of chordates and non-chordates familiar and available around their environments rather than learning about non-familiar examples written in the textbook.

In conclusion, the findings suggest that participating in a PLC can help teachers enhance their understanding of contextual considerations when choosing specific topics to teach. By receiving feedback from other teachers, PLC members can help each other to address challenges such as limited resources and technological access. Additionally, the feedback can also help teachers to choose relevant examples that are meaningful and relevant to their students. These findings are consistent with other research on the benefits of PLCs, which suggests that they can lead to improved instruction and student outcomes.

Selection of Appropriate Teaching-Learning Strategy

Teachers believe that working in a PLC helped them to modify the intended teaching-learning strategy or to further select appropriate teaching-learning strategies. Teachers mainly showed a tendency to choose inquiry-based teaching-learning strategies after two potential discussions within the PLC. The strategies mentioned to be taken by the teachers are POE (Prediction, Observation, and Explanation) and 5E (Engage, Explore, Explain, Elaborate, and Evaluate). After the simulation, many teachers decided to include concept mapping and brainstorming during the implementation of inquiry-based classes in the future.

Teacher (T-01), who decided to demonstrate diffusion of gases, later changed his/her upon the feedback from the PLC to undertake the POE method of teaching-learning. Before the demonstration, PLC's feedback directed him/her to let the learners predict first, and then after observation, the teacher planned to explain processes scientifically to the arguments of the learners' prediction. Therefore, in his/her second lesson plan before the simulation, the teacher changed the methodology from only demonstration to POE inquiry.

> One of the teachers who introduced concept mapping during simulation class which was not planned previously wrote, *"When I have asked students what do you think about programming, three concepts came forth- computer, problem solving, and networking. Therefore, I had to develop a conceptual map of programming as solving problems through computer and developing networks" (T-5).*

Overall, the findings of the study suggest that working in a PLC can positively impact teachers' teaching-learning strategies, leading to the adoption of new strategies and the modification of existing ones. This can ultimately result in improved student learning outcomes.

Assessment for Learning:
Discussions and feedback from the PLC members helped the teachers to be more practical

about assessing the learners' understanding throughout the class. In the initial phase, most of the teachers planned to check learners' understanding through question-answers. After two potential and feedback from PLC, teachers decided to introduce hands-on activity, group discussions, individual work, and further homework.

The teacher (T-5) who decided to let the learners draw a flow chart for adding three numbers through programming couldn't implement the plan during the simulation due to the short class duration. Therefore, chose to provide this activity as homework/assignment in groups.

The teacher who intended to teach the characteristics of chordates planned to provide one picture of a chordate to each group and let the learners explore the characteristics themselves. Therefore, the teacher will get a chance to monitor group activity and finally assess their learning.

Overall, the findings suggest that discussions and feedback from PLC members can help teachers to be more practical about assessing learners' understanding throughout the class. The use of varied assessment methods, such as hands-on activities, group discussions, and individual work, can promote students' motivation, engagement, and learning outcomes. However, more support and guidance may be needed for teachers to adopt more diverse assessment methods.

Discussions

The debate is organized around the research questions (RQs), which will enable readers to interact critically with various literary works and gain an understanding of the findings.

Research Question 1: *What are the learning experiences of the secondary science teachers regarding their involvement in a Professional Learning Community (PLC) as a means of professional learning for enhancing their Pedagogical Content Knowledge (PCK)?*

The results show that instructors who participated in the Professional Learning Community (PLC) saw a positive change in their professional development journey. This is consistent with other studies showing that the goal of effective professional development for teachers should be to enhance their topic knowledge and make connections between it and their instructional strategies (Garet et al., 2001). One notable observation was the teacher's ability to tailor the topic's size to suit their students' needs (T-3). This adaptive approach reflects the importance of aligning teaching with student interests and abilities, consistent with research advocating for personalized instruction (Darling-Hammond & Bransford, 2005). Furthermore, the affirmative assessments of the advantages of PLC cooperation (T-4) coincide with research results highlighting the function of PLCs in assisting teacher growth and learning (Vescio et al., 2008).

Research Question 2: *How do Secondary Science teachers apply their learning from Professional Learning Communities (PLC) to their teaching plans and practices through Content Representation (CoRe) framework?*

Teachers acknowledged that participation in PLCs aided them in selecting real-life contextual examples, aligning with research promoting the use of real-world contexts in teaching (Darling-Hammond & Bransford, 2005). The teacher's decision to introduce concepts related to the 4th industrial revolution and the global job market (T-02) exemplifies how teachers can make their teaching more relevant and engaging by drawing connections to students' future careers, in line with effective teaching practices (Darling-Hammond & Bransford, 2005). This underlines the significance of integrating real-world applications into instruction to enhance student engagement and learning.

Research Question 3: *How do secondary science teachers use the knowledge gained from participation in a professional learning community (PLC) to design and implement effective teaching strategies in their classrooms?*

The findings suggest that participation in PLCs enhances teacher consciousness in identifying relevant teaching topics. Collaborative discussions and feedback within PLCs facilitate the sharing of knowledge, resources, and expertise, ultimately contributing to the identification of pertinent topics and the development of more effective teaching strategies (DuFour, 2004; Hord, 1997). Additionally, research has found that feedback and discussion in PLCs can improve teacher planning and decision-making, leading to increased confidence in implementing effective instructional strategies (Vescio et al., 2008).

In line with current research on successful teaching strategies and collaborative professional development, these conversations highlight the crucial role that PLCs play in influencing teachers' professional development. The study's conclusions highlight the benefits of PLC involvement for instructors' pedagogical material understanding, instructional techniques, and general efficacy as educators.

Implications

The findings of this study have significant implications for the enhancement of secondary science teachers' professional knowledge. The study suggests that involving science teachers in a professional learning community (PLC) can be an effective strategy for improving their pedagogical content knowledge (PCK). This implies that schools and educational institutions can organize PLCs as a professional development initiative for science teachers.

The study also highlights the importance of collaboration and communication within the PLC. Teachers who participated in the PLC reported that they learned from their peers and shared their experiences, which helped them to develop their PCK. Therefore, schools need to create a supportive and collaborative culture that encourages teachers to work together and share their knowledge.

The study didn't bring the factors that cause the enhancement of secondary science teachers'

professional knowledge while working in PLC. Therefore, further research is suggested in the aforementioned area.

Conclusions

In conclusion, this study has demonstrated that involving secondary science teachers in a professional learning community can be an effective strategy for enhancing their pedagogical content knowledge. The study highlights the importance of collaboration and communication within the PLC.

The findings of this study have implications for policy-makers, school administrators, and science teachers. Policymakers need to recognize the value of professional development initiatives and provide adequate resources to support them. School administrators should create a supportive and collaborative culture that encourages teachers to participate in professional learning communities. Finally, science teachers should be encouraged to participate in professional development initiatives to enhance their knowledge and improve their teaching practices.

Overall, this study contributes to the growing body of research on professional development and science education. It provides valuable insights into the effectiveness of professional learning communities in enhancing science teachers' pedagogical content knowledge and highlights the importance of collaboration and communication within the PLC.

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