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## **A Model of Developing Professional Noticing Skills for Mathematics Student Teachers Based on Professional Learning Community**

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### **Abstract**

This research aimed to: 1) develop a model for enhancing the professional noticing skills of mathematics student teachers grounded in the concept of a professional learning community; and 2) cultivate the professional noticing skills of mathematics student teachers through the implementation of this developed model. The target group for this study comprised seven mathematics student teachers, seven mentor teachers, and three supervising lecturers. The research instruments employed included: 1) a test designed to measure professional noticing skills; 2) learning logs maintained by the pre-service teachers; and 3) an assessment form for evaluating professional noticing skills. Data analysis involved content analysis and descriptive statistics, specifically means, percentages, and standard deviations. This research investigated a professional learning community-based model to enhance mathematics student teachers' professional noticing skills. The model comprises five components: rationale, principles, objectives, development process (collaborative learning establishment and professional noticing skill development), and evaluation. The development involved PLC group formation, goal setting, sharing best practices, designing observation foci, exchanging suggestions, observation/teaching practice, and reflection. Expert evaluation showed high suitability ( $\bar{x} = 4.59$ ,  $SD = 0.56$ ). Mathematics student teachers' noticing skills improved from Level 2 (Limited) to Level 4 (Robust) through stages involving short video clips, longer video clips, observing mentor teachers, and conducting their own teaching.

**Keywords:** Professional Noticing Skills, Professional Learning Community, Pre-Service Teacher

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## 1. Introduction

Professional noticing skills are defined as competencies that support the development of teachers or pre-service teachers toward expert instructional practice (Mason, 2009; Sherin & Star, 2011; Jacobs et al., 2010). These skills help educators understand how students engage with content, reveal their cognitive processes, and determine how best to guide their learning (Goleman, 1985). Jacobs et al. (2010) conceptualize professional noticing as comprising three interrelated components: (1) attending to students' strategies, (2) interpreting students' mathematical understandings, and (3) deciding how to respond based on those understandings

An examination of international mathematics education research concerning professional noticing skills indicates that teachers possessing these skills are better equipped to design and implement instruction that effectively addresses the needs of struggling learners and promotes high-quality mathematics teaching practices (Doabler et al., 2014). Furthermore, proficient professional noticing skills may enable teachers to gain insights into students' learning strategies, including the identification of their misconceptions (Hill & Chin, 2018). Professional noticing is also recognized as a high-leverage practice that can foster expertise in novice teachers or pre-service teachers (Grossman et al., 2009). Pre-service teachers with well-developed professional noticing skills demonstrate a greater capacity to analyze and design effective learning experiences (Schack et al., 2013; Fisher et al., 2012). Furthermore, research indicates that variations in teachers' teaching experience often correlate with differences in their professional noticing skills. Specifically, teachers with more extensive teaching experience tend to exhibit more developed professional noticing skills compared to those with less experience (Jacobs et al., 2010; Alwast & Vorholter, 2021; Star & Strickland, 2008). Similarly, Yang et al. (2021) noted that novice teachers often provide justifications related to classroom management, student engagement, and collaborative learning, whereas experienced teachers are more likely to articulate reasoning that reflects students' learning processes, their cognitive perceptions, and analyses of student thinking. In the Thai context, there is a limited amount of research focusing on professional noticing skills, with existing studies primarily investigating the observation practices of in-service teachers and administrators (e.g., Pradubsook et al., 2017; Chayaban, 2021). Notably, current research lacks studies that explore observation from the perspective of pre-service teachers. Therefore, there is a need for research specifically aimed at developing the professional noticing skills of pre-service mathematics teachers. The perspective on professional noticing can be divided into two viewpoints. The first viewpoint states that professional noticing is a process of engaging with and making sense of events (e.g., Sherin, Jacobs, & Philipp, 2011; Miller et al., 2007; van Es, 2011). The second viewpoint states that professional noticing is a process of engaging with and interpreting events based on understanding, as well as considering teachers' instructional responses. (e.g., Luna, Russ & Colestock (2019); Jacobs et al. (2010)) Thus, the researcher chooses the second viewpoint and defines professional noticing skill refers to the ability of pre-service teachers to carefully observe students' learning behaviors. It consists of three components: (1) Attending Skills, (2) Interpreting Skills, and (3) Responding Skills.

Drawing upon the aforementioned conceptualizations, significance, and research concerning professional noticing skills, it is evident that these skills are crucial for the teaching profession. Neglecting to observe student learning may impede a teacher's ability to design and implement instruction that effectively addresses the diverse needs of all learners. Consequently, the development of effective pre-service teachers should involve fostering collaborative learning and learning from authentic experiences to independently solve problems effectively. The Professional Learning Community (PLC) approach should serve as a vital instrument in this developmental process. Establishing professional learning communities provides pre-service teachers with opportunities for collaborative learning, co-creation, joint problem-solving, and the collective identification of effective problem-solving practices (Yamkasikorn, 2017). The PLC model represents a valuable framework for cultivating pre-service teachers' professional noticing skills. It entails a process of fostering change and development through the collaborative efforts of individuals who come together to work and support one another. This involves reflecting on both individual and collective performance through processes of knowledge exchange, critical discussion, teamwork, and cooperation, alongside the active involvement of mentor teachers and supervising lecturers who focus on formative assessment to promote pre-service teacher growth (Rakwijitkul, 2017).

The researcher was therefore motivated to develop a model for enhancing the professional noticing skills of mathematics student teachers grounded in the professional learning community framework, and to subsequently cultivate these skills through the implementation of this developed model to serve as a critical guideline for developing the capabilities of prospective mathematics student teachers within teacher education institutions for their future professional practice.

## 2. Methodology

### 2.1. Research Methodology

This research is a mixed methods research using both quantitative and qualitative data to analyze and explain the research results.

### 2.2. Research Instruments

The instruments utilized for data collection in this study include:

1. The professional noticing skills assessment employed in this study was a subjective instrument utilized to evaluate mathematics student teachers' professional noticing skills both prior to and following the intervention. This assessment involved presenting mathematics student teachers with samples of student written work and requiring them to analyze these artifacts

through the lens of professional noticing skills. An illustrative test item asked mathematics student teacher to identify salient learning events or behaviors exhibited by a hypothetical student ("Boy A"), demonstrating their attending skills. Subsequently, they were prompted to articulate their understanding of the student's comprehension related to these observations (interpreting skills). Finally, they were asked to propose instructional strategies to address the identified learning behaviors, reflecting their responding skills. The instrument underwent rigorous validation, with a content validity assessment conducted by five experts yielding an Index of Item-Objective Congruence (IOC) ranging from 0.80 to 1.00. Furthermore, a pilot test was administered to a group of five individuals outside the target group to determine item difficulty and discrimination indices. The results indicated acceptable difficulty levels (0.24 – 0.70) and discrimination power (0.20 and above). Reliability analysis using Cronbach's alpha coefficient revealed a high level of internal consistency for the assessment, with a reliability coefficient ( $\alpha$ ) of 0.95.

2. The mathematics student teachers learning logs served as a record of their engagement in the research activities. This instrument comprised open-ended questions designed to elicit detailed reflections. Each pre-service teacher received a copy of the learning log and was instructed to document their experiences and insights throughout both Phase 1 (establishment of collaborative learning processes) and Phase 2 (development of professional noticing skills within the professional learning community framework). This required them to record information pertaining to all implemented activities. The learning log underwent content validation by five experts, yielding an Index of Item-Objective Congruence (IOC) ranging from 0.80 to 1.00, indicating a high degree of alignment with the research objectives.

3. The professional noticing skills evaluation form was designed as a behavioral assessment tool to evaluate the professional noticing skills of the mathematics pre-service teachers during Phase 2 of the research, within the professional learning community framework. Data collection involved the use of a checklist to record observed behaviors. Additionally, the researcher and supervising lecturers had the provision to include supplementary notes and observations within the evaluation form. The instrument underwent content validation by five experts, resulting in an Index of Item-Objective Congruence (IOC) ranging from 0.80 to 1.00, indicating a strong alignment with the intended constructs of professional noticing skills.

### 3. Sample and Data Collection

#### 3.1. Sample

The target groups used in this research were 7 mathematics student teachers, 7 mentor teachers, and 3 supervisor teachers, selected purposively.

#### 3.2. Data Collection

The researcher presented a preliminary draft of the model for developing professional noticing skills in mathematics student teachers, based on the professional learning community concept, to a panel of five experts for quality assurance. These experts were selected based on predefined criteria and included two specialists in mathematics education, two specialists in curriculum and instruction, and one specialist in educational measurement and evaluation. The feedback and recommendations provided by these experts were subsequently used to revise and refine the model, enhancing its comprehensiveness and rigor.

The researcher implemented the developed model and employed a three-phase data collection process. The first phase, conducted prior to the model's implementation, involved collecting data using the professional noticing skills assessment administered to the mathematics pre-service teachers. The second phase, which took place during the model's implementation, involved collecting data through the pre-service teacher learning logs, the professional noticing skills evaluation form, and semi-structured interviews conducted with the mathematics student teachers following each cycle of professional noticing skill development activities. The final phase, conducted after the completion of the professional observation skill development model, involved administering the professional noticing skills assessment to the mathematics student teachers once more.

The researcher checked the validity of the results obtained from the research instruments and then analyzed the results.

#### 3.3. Analyzing of Data

The data obtained from the professional noticing skills assessment, learning logs, and evaluation forms were subjected to both qualitative and quantitative analysis. For the qualitative analysis, content analysis techniques were employed to interpret the data. To ensure the trustworthiness of the qualitative findings, triangulation was applied, specifically method triangulation, which involved the use of multiple data collection instruments. For the quantitative analysis, descriptive statistics, including mean scores and standard deviations, were calculated to determine the level of professional noticing skills demonstrated by the mathematics pre-service teachers. The evaluation criteria for professional noticing skills were categorized into four distinct levels: Level 4 (Robust), Level 3 (Substantial), Level 2 (Limited), and Level 1 (Lack). An illustrative example of the evaluation criteria for the "Attending Skills" component of professional observation is presented in Table 1.

**Table 1. An Example of the Assessment Criteria for the Attention Skill of Professional Noticing Skills**

Level	Behavioral details of attention skills
<b>4 Robust</b>	Pre-service teachers can identify learners' learning events or behaviors as follows: .1 Specifically identify content, completely, and refer to relevant evidence. .2 Identify problem-solving strategies that are relevant to the problem situation and the method of obtaining the answer, completely, and refer to relevant evidence. .3 Identify learners' errors/wrong steps correctly, completely, and refer to relevant evidence. .4 Identify the reasons why learners are unable to solve problems correctly, completely, and refer to relevant evidence.
<b>3 Substantial</b>	Pre-service teachers can identify learners' learning events or behaviors as follows: .1 Specifically identify content, but not completely, and cite relevant evidence. .2 Identify problem-solving strategies related to the problem situation and the derive of the answer, but not completely, and cite relevant evidence. .3 Identify learners' errors/wrong steps, but not completely, and cite relevant evidence. .4 Identify the reasons why learners cannot solve problems, but not completely, and cite relevant evidence.
<b>2 Limited</b>	Pre-service teachers can identify learners' learning events or behaviors as follows: .1 Identify general topic content but do not cite evidence .2 Identify general problem-solving strategies but do not cite evidence .3 Identify general student errors/missteps but do not cite evidence .4 Identify general reasons why learners cannot solve problems but do not cite evidence
<b>1 Lack</b>	Pre-service teachers are unable to identify the following learning events or behaviors: .1 Not specifying the content or specifying the content incorrectly .2 Not specifying the problem-solving strategy or specifying the problem-solving strategy incorrectly .3 Not specifying the student's errors/wrong steps or -specifying incorrectly .4 Not specifying the reason why the student was unable to solve the problem or specifying incorrectly

#### 4. Results

##### 4.1. The Development of a Model for Developing Professional Noticing Skills of Mathematics Student Teachers Based on the Concept of Professional Learning Communities

The development of the model for enhancing professional noticing skills in mathematics student teachers, grounded in the professional learning community framework, resulted in five key components: 1) the rationale and significance of the model; 2) the guiding principles of the model; 3) the objectives of the model; 4) the developmental process of the model; and 5) the measurement and evaluation framework of the model. The developmental process was structured into two phases: Phase 1 focused on establishing collaborative learning processes, and Phase 2 centered on developing professional noticing skills within the professional learning community. Phase 2 comprised seven stages: 1) group formation; 2) goal setting; 3) sharing of best practices; 4) designing observation foci; 5) providing and exchanging suggestions; 6) enacting observation, teaching, and co-observation; and 7) reflection. This developmental process was implemented across eight cycles. Cycle 1 involved developing professional noticing skills through the analysis of short video clips of mathematics instruction. Cycles 2 and 3 focused on developing these skills through the analysis of longer video clips of mathematics instruction. Cycles 4 and 5 involved developing professional noticing skills through observing mentor teachers conducting mathematics lessons in the classroom. Finally, Cycles 6 through 8 focused on developing professional noticing skills through the pre-service teachers' own enactment of mathematics instruction in the classroom. This sequence is visually represented in Figure 1. From the developed model, it can be concluded that this model is derived from the theories of constructivism and social constructivism, which emphasize the active construction of knowledge and the importance of social interaction in learning.



**Figure 1. A Model of Developing Professional Noticing Skills for Mathematics Student Teachers Based on Professional Learning Community**

Furthermore, the results of the expert evaluation regarding the suitability of the developed model for enhancing professional noticing skills in mathematics student teachers, based on the professional learning community framework demonstrated an overall suitability rating at the highest level ( $\bar{x} = 4.59$ ,  $SD = 0.56$ ). Examining individual aspects of the model, the "Principles of the Model" were rated as having the highest level of suitability ( $\bar{x} = 4.67$ ,  $SD = 0.46$ ), followed closely by the "Developmental Process" ( $\bar{x} = 4.63$ ,  $SD = 0.61$ ) and the "Objectives" and "Measurement and Evaluation" components, both with a mean suitability rating of 4.60 ( $SD = 0.59$  and  $0.49$ , respectively). The aspect receiving the slightly lower, yet still high, rating was the "Rationale and Significance of the Model" ( $\bar{x} = 4.40$ ,  $SD = 0.58$ ). Experts provided a suggestion to further elaborate on the definitions of each component of professional noticing skills within this section.

**4.2. The Development of Professional Noticing Skills in Mathematics Student Teachers Through the Implementation of the Professional Learning Community-Based Model**

The findings regarding the impact of the developed model on the professional noticing skills of the mathematics student teachers are presented in Table 2.

**Table 2: Results of the Development of Professional Noticing Skills**

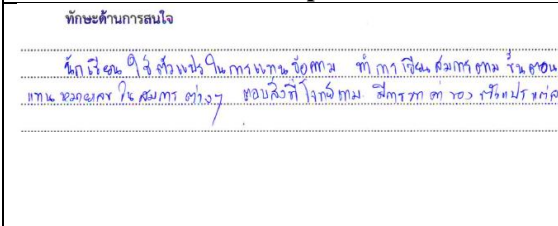
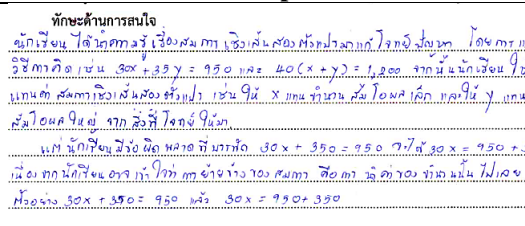
Professional Noticing Skills	Number of pre-service teachers classified by level and development cycle									
	Before	cycle 1	cycle 2	cycle 3	cycle 4	cycle 5	cycle 6	cycle 7	cycle 8	after
<b>Attending Skills</b>										
Level 4 Robust	0	0	1	1	4	4	7	7	7	7
Level 3 Substantial	1	1	2	2	3	3	0	0	0	0
Level 2 Limited	4	4	4	4	0	0	0	0	0	0
Level 1 Lack	2	2	0	0	0	0	0	0	0	0
<b>Interpreting Skills</b>										
Level 4 Robust	0	0	0	0	4	4	7	7	7	7
Level 3 Substantial	0	0	3	3	3	3	0	0	0	0
Level 2 Limited	5	5	4	4	0	0	0	0	0	0
Level 1 Lack	2	2	0	0	0	0	0	0	0	0
<b>Responding Skills</b>										

Level 4 Robust	0	0	0	0	3	3	7	7	7	7
Level 3 Substantial	0	0	2	2	4	4	0	0	0	0
Level 2 Limited	0	5	5	5	0	0	0	0	0	0
Level 1 Lack	7	2	0	0	0	0	0	0	0	0

Based on the data presented in Table 2, The pre-service teachers' professional noticing skills improved after the model's development process. Prior to joining the development process, their professional noticing skills were at Level 2 (Limited), similar to the results observed after participating through watching short instructional video clips. Subsequently, after the pre-service teachers developed their professional noticing skills through watching longer instructional video clips, their skills improved to Level 3 (Substantial). Following this, when they further developed their professional noticing skills by observing mentor teachers conduct real classroom lessons, their skills progressed to Level 4 (Robust). However, at that stage, some pre-service teachers still maintained their skills at Level 3 (Substantial). Later, after developing their professional noticing skills through conducting their own classroom teaching, most mathematics student teachers achieved Level 4 (Robust), consistent with the results professional noticing skills after participating in the model's development process.

4.3. The Developing Professional Noticing Skills in the Aspect of Attending Skill through the Implementation of the Professional Learning Community-Based Model

Table 3. Example of Attending Skills Response from Mathematics Student Teacher ID 2ST01

Before Model Implementation	After Model Implementation
<p>ทักษะด้านการสนใจ</p> 	<p>ทักษะด้านการสนใจ</p> 
<p>The student effectively utilized variables to represent textual information and systematically formulated equations, substituting numerical values within these equations .Furthermore, the student directly addressed the question posed in the problem and demonstrated the ability to solve for the value of each variable.</p>	<p>The student appropriately applied their knowledge of systems of linear equations with two variables to solve the word problem, as evidenced by the formulation of equations such as '30x 35 +y 950 =' and ')40x +y1200 + ('.The student correctly defined variables, stating 'Let x represent the number of small pomelos, and let y represent the number of large pomelos,' based on the information provided in the problem . However, a procedural error was observed in the transformation of the equation '30x 350 + y = 950' to '30x 350 + 950 =' .This suggests a potential misconception regarding the transposition of terms in an equation, where the student appears to have directly moved the numerical value of the coefficient without changing its sign .For instance, in the example '30x 350 +y 950 =' , the student incorrectly derived '30x 350 + 950 ='.</p>

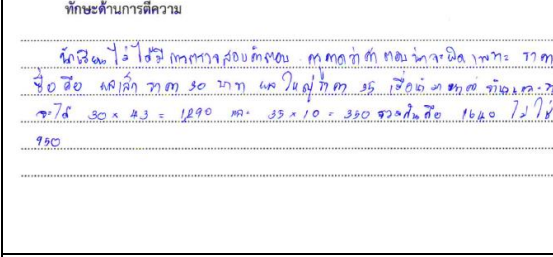
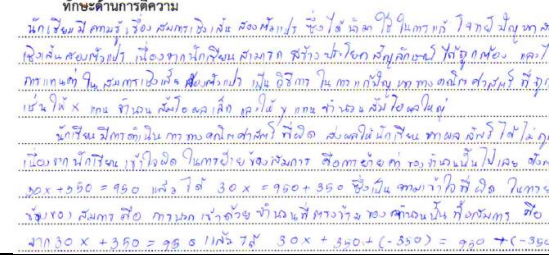
Analysis of table 3, which illustrates a response from the professional noticing skills assessment, reveals that prior to the implementation of the professional learning community-based model for developing professional noticing skills, mathematics student teacher's ID 2ST01 demonstrated "Attending Skills" at Level 2, classified as "Limited." This categorization is attributed to the fact that mathematics student teacher's ID 2ST01 could only identify general content topics and broad problem-solving strategies exhibited by the student, without providing specific evidence from the student's work to support these observations. Furthermore, the identification of student errors/incorrect steps and the reasons for the student's inability to solve the problem were also general in nature and lacked specific textual references or evidence from the student's work.

However, following the implementation of the professional learning community-based model for developing professional noticing skills, mathematics student teacher's ID 2ST01 demonstrated a significant improvement in "Attending Skills," reaching Level 4 (Robust). This advancement is evidenced by the mathematics student teacher's enhanced ability to identify student learning events or behaviors with the following characteristics: 1) specific and comprehensive identification of the mathematical content; 2) accurate and comprehensive identification of problem-solving strategies relevant to the problem context and the derivation of the solution; 3) precise and comprehensive identification of student errors and incorrect steps; and

4) accurate and comprehensive identification of the reasons underlying the student's inability to solve the problem, with consistent and relevant evidence cited from the student's work to support each of these observations.

4.4. The Developing Professional Noticing Skills in the Aspect of Interpreting Skills through the Implementation of the Professional Learning Community-Based Model

**Table 4: Example of Interpreting Skills Response from Mathematics Student Teacher ID 2ST01**

Before Model Implementation	After Model Implementation
<p>ทักษะด้านการตีความ</p> 	<p>ทักษะด้านการตีความ</p> 
<p>The student did not demonstrate any attempt to verify their solution .Based on the initial purchase prices provided in the problem )small pomelos at 30baht and large pomelos at 35baht(, and the student's calculated quantities 43)small and 10 large(, a post-hoc verification reveals a discrepancy .Multiplying the price per unit by the calculated quantity yields 30 :baht/small pomelo × 43small pomelos 1290 =baht, and 35 baht/large pomelo × 10large pomelos 350 = baht .The sum of these amounts = 350 + 1290) 1640baht (does not match the total cost of 950 baht stated in the problem .This suggests a potential error in the student's calculation or in their understanding of the relationships between the variables and the total cost.</p>	<p>The student demonstrates foundational knowledge of systems of linear equations with two variables, as evidenced by their correct translation of the word problem into symbolic representations and their appropriate use of the substitution method, a valid mathematical approach for solving such systems .For instance, they correctly defined variables as 'Let x represent the number of small pomelos, and let y represent the number of large pomelos.' However, the student's mathematical manipulation contains a significant procedural error that leads to an incorrect solution .This error stems from a misunderstanding of the principles of algebraic manipulation, specifically the transposition of terms in an equation .The student incorrectly transformed '30x 350 +y 950 =' into '30x 950 = 350 +', indicating a misconception that transposition involves simply moving the numerical value of a term across the equality sign without altering its operation .The correct procedure for isolating '30x' would involve adding the additive inverse of '350y' to both sides of the equation, as follows :'30x 350 +y -) + 350y(350-) + 950 = (y('.</p>

Analysis of table 4, which illustrates a response from the professional noticing skills assessment, reveals that prior to the implementation of the professional learning community-based model for developing professional noticing skills, mathematics student teacher’s ID 2ST01 demonstrated "Interpreting Skills" at Level 2, classified as "Limited." This categorization is attributed to the fact that mathematics student teachers ID2ST01 could provide some explanation of the student's understanding by analyzing their grasp of general mathematical concepts, definitions, properties, rules, theories, principles, or problem-solving strategies. However, the mathematics student teacher’s analysis lacked a deeper understanding of the specific errors or incorrect steps made by the student and did not adequately explore the underlying reasons why the student was unable to solve the problem effectively. Furthermore, the interpretation lacked specific references or evidence from the student's work to support the claims made.

However, following the implementation of the professional learning community-based model for developing professional noticing skills, mathematics student teacher’s ID 2ST01 demonstrated a significant improvement in "Interpreting Skills," reaching Level 4 (Robust). This advancement is demonstrated by the mathematics student teachers' improved ability to explain student understanding through comprehensive analysis of the following aspects: 1) accurate understanding of the mathematical content; 2) effective application of problem-solving strategies; 3) precise identification of errors and incorrect steps; and 4) clear reasoning for the student's inability to solve the problem, supported by consistent evidence from the student's work.

4.5. The Developing Professional Noticing Skills in the Aspect of Responding Skills through the Implementation of the Professional Learning Community-Based Model

**Table 5: Example of Interpreting Skills Response from Mathematics Student Teacher ID 2ST01**

Before Model Implementation	After Model Implementation
<p>ทักษะด้านการตอบสนอง</p> <p>ในโอกาส การสอน นักเรียน ได้มีการสอน ตาม คู่มือ ที่ให้ไว้</p> <p>ตาม ข้อ มูล ที่ได้ ให้ไว้ ไม่ค่อย ได้ ไร เลย</p>	<p>ทักษะด้านการตอบสนอง</p> <p>เมื่อ จาก การ ได้ รับ มี ความ ทึบ ที่ เกี่ยว กับ การ แก้ไข ปัญหา ที่ เกี่ยว กับ ระบบ สมการ เชิงเส้น สมการ หนึ่ง ตัว มี คำ ว่า</p> <p>ขอ ให้ แก้ สมการ หนึ่ง ตัว จาก ข้อ มูล ที่ ได้ รับ มา แล้ว ก็ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้</p> <p>เมื่อ จาก ข้อ มูล ที่ได้ ให้ไว้ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้</p> <p>การ ที่ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้</p> <p>เมื่อ จาก ข้อ มูล ที่ได้ ให้ไว้ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้</p> <p>การ ที่ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้ แล้ว ก็ ได้ แก้ สมการ ได้</p>
<p>To address the student's lack of verification and potential errors, I would explicitly instruct the student on the importance of checking their solutions. This would involve modeling strategies for verifying answers, such as substituting the obtained variable values back into the original equations or using alternative methods to solve the problem and comparing the results. Emphasizing the habit of self-correction and error detection would be a key instructional focus to minimize future mistakes in problem-solving.</p>	<p>Given the student's existing understanding of solving word problems involving systems of linear equations, the instructional approach should focus on providing more varied examples and guiding the student through the problem-solving process step-by-step, line by line. Introducing diverse examples and scenarios related to the application of substitution in systems of linear equations will be beneficial, with the teacher modeling the solution process while the student actively follows along. Emphasis should be placed on the accurate substitution of values into formulas and careful execution of calculations to reinforce correct procedures and lead to accurate answers. Addressing the student's procedural error, it is crucial to directly point out the specific step where the mistake occurred and explicitly teach the correct method. Since the student demonstrated an incorrect understanding of transposing terms in an equation, the intervention should clearly explain the correct algebraic manipulation, emphasizing the principle of adding the additive inverse of the term being moved to both sides of the equation to maintain equality.</p>

Analysis of Table 5, which illustrates a response from the professional noticing skills assessment, reveals that prior to the implementation of the professional learning community-based model for developing professional noticing skills, mathematics student teacher’s ID 2ST01 demonstrated "Responding Skills" at Level 2, classified as "Limited." This categorization is attributed to the fact that mathematics student teacher’s ID 2ST01 could make decisions regarding addressing student difficulties based on their general understanding of mathematical concepts, definitions, properties, rules, theories, principles, or problem-solving strategies. However, the proposed responses lacked specific strategies for correcting the student's identified errors or incorrect steps, did not address the underlying reasons for the student's inability to solve the problem, and did not offer concrete pedagogical approaches or instructional interventions.

However, following the implementation of the professional learning community-based model for developing professional noticing skills, mathematics student teacher’s ID 2ST01 demonstrated a significant improvement in "Responding Skills," reaching Level 4 (Robust). This advancement is evidenced by the mathematics student teachers 's enhanced ability to make sound instructional decisions using diverse and appropriate strategies, specifically in the following areas: 1) proposing pedagogical approaches for the content that are well-suited to the student's level of understanding; 2) suggesting instructional strategies for the student's mathematical problem-solving approaches that are appropriate for their level of understanding; 3) clearly identifying and addressing the student's specific errors and incorrect steps, followed by the presentation of relevant instructional strategies; and 4) clearly identifying and addressing the underlying reasons for the student's inability to solve the problem, accompanied by the presentation of appropriate instructional strategies, all while providing clear and detailed explanations for their proposed actions.

## 5. Discussion

This study developed a professional noticing skills enhancement model for mathematics student teachers, grounded in the concept of a professional learning community (PLC). The model comprises five core components: (1) Rationale and Significance, (2) Guiding Principles, (3) Objectives, (4) Developmental Process, and (5) Measurement and Evaluation. The developmental process unfolded in two main phases. Phase 1 established collaborative learning foundations, while Phase 2 focused on enhancing professional noticing skills through a structured seven-stage process: (1) PLC group formation, (2) goal setting, (3) sharing best practices, (4) designing observation foci, (5) exchanging suggestions, (6) observation and co-teaching, and (7) reflection. Expert evaluation of the model indicated high overall suitability ( $\bar{x} = 4.59$ ,  $SD = 0.56$ ), affirming its practical viability. The model's creation was informed by a synthesis of literature on mathematics education, learning theory, and PLC frameworks. Empirical data were collected through interviews with mathematics student teachers, mentor teachers, and academic supervisors, leading to iterative model refinements based on expert feedback and pilot testing.

This robust development process, encompassing the creation and quality assurance of the model, was informed by a comprehensive synthesis of relevant literature and research, both domestically and internationally. The initial stages involved an in-depth exploration of professional noticing skills, the philosophy of mathematics education, learning theories, and the principles of professional learning communities. Subsequently, interviews were conducted with mathematics student teachers, mentor teachers, and supervising lecturers to gather empirical data regarding the existing state of their professional noticing skills. This information was then analyzed and synthesized to inform the development of the model's core components. The preliminary model was presented to a panel of experts for evaluation of its suitability across various dimensions, and revisions were made based on their insightful feedback. Following expert validation, the model underwent pilot testing, and the resulting data were used for further refinement before full-scale implementation. A final evaluation of the model was conducted after its complete implementation. This systematic approach aligns with the research methodologies employed in studies such as Hajaturus (2024) developed a learning management model to enhance the competencies of mathematics pre-service teachers through a two-stage process: foundational data analysis and model creation, followed by the construction and development of the learning management model. Similarly, Sakpakornkan (2020) developed a learning activity model to foster active learning management competencies in mathematics pre-service teachers through a three-stage process: needs assessment, model development involving creation and pilot testing, and model evaluation. These phased development approaches demonstrate clarity of purpose, credibility, flexibility, and systematic structure, aligning with the theories of constructivism, social constructivism, professional development, and action research. This structured approach enables the collection of empirical data and systematic model refinement, resulting in models that are both effective and sustainable.

Results of the development of professional noticing skills. mathematics student teachers showed measurable improvements in their professional noticing skills throughout their engagement with the model. Initially assessed at Level 2 (Limited), their skills progressed to Level 3 (Substantial) after analyzing instructional video clips. Direct observation of mentor teachers led to further improvement, with most participants achieving Level 4 (Robust). After conducting their own classroom teaching, nearly all participants reached Level 4, demonstrating significant skill acquisition.

The PLC-based developmental framework proved effective in fostering this growth. In Phases 1–3, teachers analyzed curated video exemplars, enhancing their ability to interpret teacher actions and student responses. PLC has a significant impact on the development of professional noticing skills (PNS) among mathematics pre-service teachers. This impact is attributed to the PLC's emphasis on collaborative learning, reflective practice, practical application, awareness of professional roles, and ongoing self-assessment. These processes enable pre-service teachers to enhance their Attending Skills, Interpreting Skills, and Responding Skills, progressing from lower levels (Limited) to higher levels (Robust) in a meaningful and sustainable manner. This echoes findings by Lee (2021), who noted the benefits of video-based reflection for novice educators. In later cycles, classroom observations and teaching practice under mentorship deepened instructional insight, as supported by Bognar et al. (2024) and Poonpaiboonpipat (2022). The model also incorporated peer coaching and dialogic feedback mechanisms, aligning with Robbins (1991) and Yang et al. (2021), who emphasize the epistemological value of expert guidance and collegial exchange in developing instructional expertise.

## 6. Conclusion

This research yielded two primary outcomes. Firstly, the development of a model for enhancing professional noticing skills in mathematics pre-service teachers, grounded in the professional learning community framework, resulted in a five-component structure: 1) Rationale and Significance of the Model, 2) Principles of the Model, 3) Objectives of the Model, 4) Developmental Process, and 5) Measurement and Evaluation. The developmental process was further delineated into two phases: Phase 1, focusing on establishing collaborative learning processes, and Phase 2, dedicated to cultivating professional noticing skills within the professional learning community through seven distinct stages: 1) PLC Group Formation, 2) Goal Setting, 3) Sharing of Best Practices, 4) Designing Observation Foci, 5) Providing and Exchanging Suggestions, 6) Enacting Observation, Teaching, and Co-observation, and 7) Reflection. The expert evaluation indicated a high level of suitability for this developed model ( $\bar{x} = 4.59$ ,  $SD = 0.56$ ). Secondly, the implementation of this developed model demonstrated a positive impact on the mathematics pre-service teachers' professional noticing skills. The findings revealed a significant improvement in their overall

professional observation abilities following their participation in the activities facilitated by the professional learning community-based model.

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