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THE DEVELOPMENT OF A TRAINING CURRICULUM TO PROMOTE MATHEMATICAL LEARNING DESIGN AND TEST CONSTRUCTION ABILITIES ACCORDING TO THE PISA MATHEMATICAL LITERACY ASSESSMENT GUIDELINES FOR UNDERGRADUATE STUDENTS MAJORING IN MATHEMATICS

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ABSTRACT

The objective of this research was to develop and evaluate the effectiveness of a training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines. The sample comprised 31 undergraduate students majoring in mathematics from the Faculty of Education, Burapha University, enrolled in the first semester of the 2024 academic year, who volunteered and were interested in participating in this training curriculum. The research methodology consisted of four steps: Step 1 was conducted by studying and analyzing basic data, Step 2 was conducted by developing a draft of the training curriculum and conducting a pilot test, Step 3 was conducted by implementing the training curriculum with the sample, and Step 4 was conducted by evaluating the effectiveness and refining the training curriculum. The findings revealed that: 1) the developed training curriculum contained six components. Its structure indicated the highest level of consistency (M = 4.97, SD = 0.17) and appropriateness (M = 4.90, SD = 0.30); 2) an assessment of the curriculum's effectiveness revealed that, at post-training, students showed a higher knowledge level regarding PISA mathematical literacy assessment compared to pre-training levels, exceeding the 70% criterion with a statistical significance level of 0.05. Moreover, students' mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines at post-training were higher than the 70% criterion, with a statistical significance level of 0.05. Overall, the students rated the training curriculum at the highest level (M = 4.52, SD = 0.58), meeting all effectiveness criteria as specified in the training curriculum guidelines.

Keywords: Training curriculum development; mathematical learning design abilities; mathematical test construction abilities; PISA mathematical literacy assessment

1. INTRODUCTION

The Programme for International Student Assessment (PISA) aims to assess the quality of education systems in preparing individuals with the fundamental skills required for life in a rapidly changing world. The assessment focuses on three domains of reading, mathematics, and science. In PISA 2022, mathematics was the major domain of assessment, referred to as Mathematical Literacy. Mathematical Literacy is an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts. It includes concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals in understanding the role that mathematics plays in the world and in making well-founded judgements and decisions needed by constructive, engaged, and reflective 21st century citizens. The PISA 2022 mathematical literacy framework is comprised of three components: 1) Mathematical Processes, including mathematical reasoning and problem solving; 2) Mathematical Content Knowledge; and 3) Context, real-life situations relevant to the assessment (Organisation for Economic Co-operation and Development [OECD], 2023; National PISA Operations Center, The Institute for the Promotion of Teaching Science and Technology [IPST], 2025).

From PISA 2000 to PISA 2022, Thailand's average mathematics scores have consistently fallen below the OECD average and have shown a declining trend. Thai students' average mathematics scores were 427, 415, 419, and 394 in PISA 2012, 2015, 2018, and 2022, respectively, while the OECD average scores were 494, 490, 489, and 472 for the corresponding years. Furthermore, in the 2018 and 2022 PISA assessments, only 47% and 31% of Thai students, respectively, achieved a minimum proficiency level (Level 2) in mathematics, compared to approximately 76% and 69% among OECD member countries (National PISA Operations Center, IPST, 2024).

From the PISA mathematics assessment results, Thai students' mathematical literacy remains at a level that requires improvement. A deeper analysis of the problems reveals that Thai students often struggle with interpreting mathematical questions. They face challenges in discerning whether the information presented in problems is relevant or contradictory, making it difficult for them to arrive at correct answers. Findings from PISA 2022 emphasize the need for urgent measures to enhance mathematics learning by focusing on teacher development (IPST, 2024). In line with this, Stacey et al. (2015) presented the influence of PISA on the thoughts and practices of mathematics education, stating that the results of the PISA assessment have prompted various initiatives in many countries, including the initiation of projects aimed at improving assessment outcomes, particularly the development of teachers. One factor contributing to Finland's success in PISA is its effective teacher training curricular (IPST, 2018). In conjunction with this research, Meepan (2020) explored guidelines for improving the quality of education in mathematics, science, and reading to prepare for the upgrading of PISA test results of Bangkok Metropolitan Schools. The study results indicated the importance of school administrators and teachers understanding the PISA mathematical literacy framework, designing PISA-aligned learning activities, and constructing tests according to PISA guidelines.

Consequently, the researcher is interested in developing a training curriculum to promote mathematical learning design and test construction abilities according to the PISA Mathematical Literacy Assessment Guidelines for undergraduate students majoring in mathematics as future mathematics educators. The study also aims to evaluate the effectiveness of the developed curriculum. The findings from this research would be beneficial as guidelines for curriculum development, learning design, and test construction according to the PISA mathematical literacy assessment framework for mathematics teachers, ultimately contributing to the advancement of students in mathematics classrooms.

2. FRAMEWORK OF RESEARCH

In order to construct the framework for this research, the researcher reviewed relevant documents as follows:

The PISA 2022 mathematical literacy framework includes three main components: 1) Mathematical Processes, including mathematical reasoning and problem-solving. Problem-solving in mathematics comprises three sub-processes: Formulating situations mathematically, employing mathematical concepts, facts, and procedures, and Interpreting, applying, and evaluating mathematical outcomes; 2) Mathematical Content Knowledge, comprising the topics of change and relationships, space and shape, quantity, and uncertainty and data; and 3) Context, including personal, occupational, societal, and scientific contexts (National PISA Operations Center, IPST, 2025; OECD, 2023). However, for this study, mathematical content knowledge was adapted based on the core mathematics curriculum in Thailand's Basic Education Core Curriculum (2017 revised version) in accordance with Thailand's Basic Education Core Curriculum B.E. 2551 (A.D. 2008). This curriculum includes three main areas: Content Area 1: Numbers and Algebra, Content Area 2: Measurement and Geometry, and Content Area 3: Statistics and Probability. This adaptation ensures alignment and suitability for classroom instruction.

A training curriculum is a comprehensive learning experience or instructional plan designed to develop learners' characteristics according to specified objectives. The process of developing a training curriculum includes the following steps: 1) Identifying the necessity for training, 2) Creating and defining the content of the training curriculum, 3) Designing training methods and carrying out the training, and 4) Assessing the effectiveness of the training (Patphol, 2011; Ornstein & Hunkins, 2018). The training curriculum is comprised of the following principles, objectives, structure and content, training methods/activities, training materials, and evaluation methods (Thongthew, 2012; Kaiyawan, 2016; Taba, 1962). For the training methods and activities, the researcher incorporated key concepts of learning empowerment and the power of questioning techniques to facilitate the training activities.

Learning design is a systematic planning process for learning activities as a guideline for organizing instructional events presented in a lesson plan, with the goal of enhancing student learning (Pornkul, 2009; Dick et al., 2009). The construction of mathematics tests involves creating instruments that systematically measure knowledge and various mathematical skills, allowing test-takers to demonstrate observable and measurable behaviors indicating the extent of the knowledge being assessed (Office of the Civil Service Commission [OCSC], 2010; Angganapattarakajorn, 2012). From the examination of PISA test formats, four types were identified: 1) Multiple-choice questions, 2) Complex multiple-choice questions, 3) Fill-in-the-blank questions, and 4) Explanation- or solution-based questions (National PISA Operations Center, IPST, 2025).

The conceptual framework is constructed based on the review of the literature presented above, as shown in Figure 1.

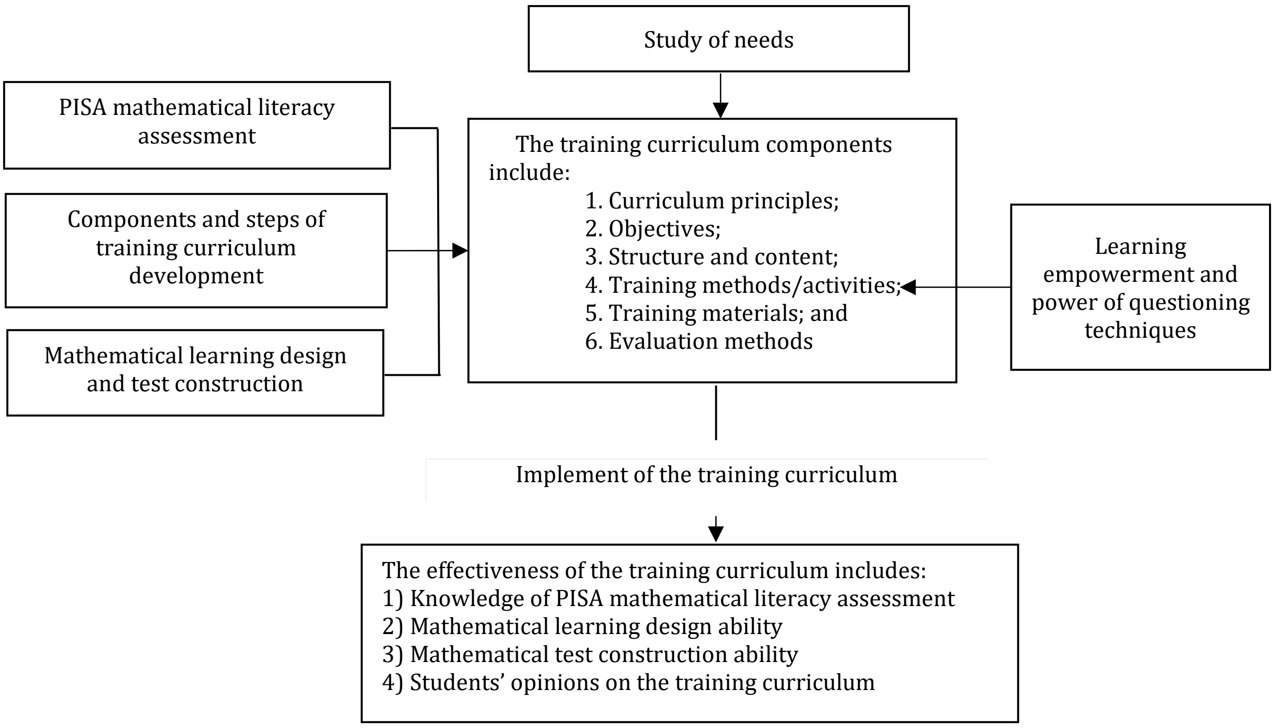

Figure 1: Framework of research

3. METHODOLOGY

3.1 Population and sampling

The population for this research consisted of 138 undergraduate students majoring in mathematics from the first to the fourth year in the Faculty of Education at Burapha University, enrolled in the first semester of the 2024 academic year.

The sample included 31 undergraduate students majoring in mathematics from the first to the fourth year in the Faculty of Education at Burapha University, enrolled in the first semester of the 2024 academic year, who volunteered and were interested in participating in this training curriculum.

3.2 Research Procedures

This research follows four main implementation steps:

Step 1: Studying and analyzing basic data: This includes 1) studying and analyzing basic data regarding the assessment of mathematical literacy according to PISA, the development of a training curriculum, mathematical learning design, mathematical test construction, learning empowerment, and the power of questioning techniques; 2) studying the needs for the assessment of mathematical literacy according to PISA, mathematical learning design and test construction among undergraduate students majoring in mathematics from their first to fourth years who studied in the second semester of the academic year 2023, totaling 126 students. The study results revealed that students' overall need for the assessment of mathematical literacy according to PISA was rated as high (M = 4.29, SD = 0.56), and their overall need for the mathematical learning design and test construction was also rated as high (M = 4.47, SD = 0.55).

Step 2: Development of the training curriculum (draft version). This step involves the synthesis of the basic data collected from Step 1 to develop the training curriculum (draft version). The draft version of the training curriculum consisted of six components: 1) Curriculum principles, 2) Objectives, 3) Structure and content, 4) Training methods/activities, 5) Training materials, and 6) Evaluation methods. The draft version of the training curriculum was submitted to three experts (one expert in curriculum development and two experts in mathematics education) for evaluation of its quality in terms of consistency and appropriateness. Moreover, assessment tools were developed to evaluate the effectiveness of the training curriculum. Subsequently, the draft training curriculum and the various tools were pilot-tested with a group of 35 undergraduate students majoring in mathematics, who were not part of the sample group (pilot experimental group), during the first semester of the academic year 2024 from August 3 to 18, 2024. The results of the development and pilot testing of the assessment tools for evaluating the effectiveness of the training curriculum are as follows:

1. The assessment of knowledge of the PISA mathematical literacy assessment consists of a multiple-choice test with four options, comprising a total of 20 items. For each item, an Item-Objective Congruence (IOC) value assessed by experts was 1.00, and the assessment tool showed a reliability coefficient of 0.714.

2. Mathematical learning design ability assessment according to the PISA mathematical literacy assessment guidelines consists of 10 items and is structured as a three-level rating scale. Level 2 indicates a score representing complete correctness, Level 1 indicates a score for partial correctness, and Level 0 indicates a score for incorrect or unattempted responses. For each item, an Item-Objective Congruence (IOC) value assessed by experts was 1.00, and the assessment tool showed a reliability coefficient of 0.812.

3. Mathematical test construction ability assessment according to the PISA mathematical literacy assessment guidelines consists of 10 items and is structured as a three-level rating scale. Level 2 indicates a score representing complete correctness, Level 1 indicates a score for partial correctness, and Level 0 indicates a score for incorrect or unattempted responses. For each item, an Item-Objective Congruence (IOC) value assessed by experts was 1.00, and the assessment tool showed a reliability coefficient of 0.746.

4. The questionnaire for evaluating opinions on the training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines comprises 20 items. It utilizes a five-level rating scale: Highest, High, Moderate, Low, and Lowest. For each item, an Item-Objective Congruence (IOC) value assessed by experts was 1.00, and the questionnaire showed a reliability coefficient of 0.926.

Step 3: The training curriculum was conducted with a sample of 31 undergraduate students majoring in mathematics during the first semester of the 2024 academic year, from September 7 to 22, 2024. The process included the following steps:

1. Prior to the training, the researcher administered a knowledge assessment regarding the PISA mathematical literacy assessment to the sample. Subsequently, the researcher marked each student's assessment.

2. The researcher conducted the training according to the developed training curriculum with the sample. During the training, the researcher evaluated each student's mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines using an assessment tool created by the researcher.

3. After the training, the researcher again administered the knowledge assessment regarding the PISA mathematical literacy assessment to the sample and graded each student's assessment.

4. The researcher provided the sample with a questionnaire to evaluate their opinions on the training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines. The results were then analyzed to assess the students' feedback.

The researcher analyzed the various scores obtained using statistical methods, including mean (M), standard deviation (SD), dependent sample t-tests, and one-sample t-tests.

Step 4: Evaluating the effectiveness and refining the training curriculum. The researcher compared the analysis results with the effectiveness criteria established for the training curriculum, which are defined as follows:

1. Students showed a higher knowledge level regarding the PISA mathematical literacy assessment at post-training compared to pre-training levels, exceeding the 70% criterion with a statistical significance level of 0.05.

2. Students' mathematical learning design ability according to the PISA mathematical literacy assessment guidelines at post-training was higher than the 70% criterion with a statistical significance level of 0.05.

3. Students' mathematical test construction ability according to the PISA mathematical literacy assessment guidelines at post-training was higher than the 70% criterion with a statistical significance level of 0.05.

4. Students' opinions regarding the training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines were at a high level or above.

The training curriculum was then revised and refined by incorporating feedback and suggestions collected during the trial implementation to finalize a comprehensive training curriculum.

4. RESULTS

The presentation of the research results was divided into two sections, with details as follows:

4.1 Results of the development of the training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines for undergraduate students majoring in mathematics

From the training curriculum development, the draft version of the training curriculum consisted of six components: 1) Curriculum principles, 2) Objectives, 3) Structure and content, consisted of five learning units, 4) Training methods/activities, 5) Training materials, and 6) Evaluation methods.

The evaluation of the draft training curriculum by three experts in curriculum development or mathematics education revealed that the components of the training curriculum overall were consistent at the highest level (M = 4.97 and SD = 0.17) and appropriate at the highest level (M = 4.90 and SD = 0.30).

The pilot implementation of the draft training curriculum with 35 undergraduate students majoring in mathematics who were not part of the sample (pilot experimental group) indicated that the training curriculum was feasible for practical application. However, the total duration of the training curriculum (draft version) was adjusted from 14 hours to 17 hours. This extension involved adding hours to Learning Unit 2: PISA mathematical literacy assessment framework, as understanding the components of the PISA mathematical literacy framework was new to the students and required substantial time to comprehend, particularly the mathematical process components. Hours were also added to Unit 3: Mathematical learning design according to PISA mathematical literacy assessment guidelines, as the lesson planning phase required students to select content, design student-centered learning activities, and develop mathematical processes according to the PISA mathematical literacy assessment framework. This took considerable time, and students requested additional time to present, discuss, and exchange insights on their created lesson plans. Furthermore, additional hours were allocated to Learning Unit 4: Mathematical test construction according to PISA mathematical literacy assessment guidelines. This increase was necessary because students had to select, adapt, or find relevant scenarios to create test items, which was time-intensive. Students also requested more time to present and discuss the test items they developed. Additionally, the researcher adjusted the language in the training plan and supporting documents to enhance quality and comprehension for the students, as well as modified the font size in PowerPoint materials for greater clarity and visibility. Additionally, the various tools developed demonstrated quality suitable for use with the sample.

4.2 Evaluative results of the effectiveness of a training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines for undergraduate students majoring in mathematics

The results of this section consisted of the following:

4.2.1 The results of the implementation of the training curriculum

The results of the implementation of the training curriculum with the sample of undergraduate students majoring in mathematics are presented in four key areas:

4.2.1.1 Knowledges of PISA mathematical literacy assessment

Students showed higher knowledge levels regarding the PISA mathematical literacy assessment at post-training, compared to pre-training levels and exceeding the 70% criterion with a statistical significance level of 0.05, as presented in Tables 1–2, respectively.

Table 1: Comparison of the mean scores of knowledges of the PISA mathematical literacy assessment between pre- and post-training periods

Knowledge measurement period	Number of students	*M* (Full score of 20)	*SD*	t	p-value
Pre-training period	31	11.32	2.197	11.237*	.00
Post-training period	31	16.48	1.877		

*$p < .05$

Table 2: Comparison of the mean scores of knowledges of the PISA mathematical literacy assessment between post-training and 70% criterion

Test	Number of students	μ (70 %)	*M* (Full score of 20)	*SD*	t	p-value
Knowledge of the PISA mathematical literacy assessment	31	14	16.48	1.877	7.366*	.00

*$p < .05$

4.2.1.2 Mathematical learning design ability

Students' mathematical learning design ability at post-training according to the PISA mathematical literacy assessment guidelines was found to exceed the 70% criterion, with a statistical significance level of 0.05, as presented in Table 3.

Table 3: Comparison of mean scores for mathematical learning design ability between post-training and 70% criterion

Test	Number of students	μ (70 %)	*M* (Full score of 20)	*SD*	t	p-value
Mathematical learning design abilities	31	14	15.55	1.964	4.390*	.00

*$p < .05$

4.2.1.3 Mathematical test construction ability

Students' mathematical test construction ability at post-training according to the PISA mathematical literacy assessment guidelines was found to exceed the 70% criterion, with a statistical significance level of 0.05, as presented in Table 4.

Table 4: Comparison of mean scores for mathematical test construction ability between post-training and 70% criterion

Test	Number of students	μ (70 %)	*M* (Full score of 20)	*SD*	t	p-value
Mathematical test construction abilities	31	14	15.35	1.836	4.109*	.00

*$p < .05$

4.2.1.4 Students' opinions on the training curriculum

Students' overall opinions on the training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines were at the highest level ($M = 4.52$, $SD = 0.58$). Their additional opinions included:

- Students gained an increased understanding of the PISA assessment framework and test structure, with practical application in developing lesson plans. They saw the approach of using real-life information in test questions.

- Students improved their mathematical learning design ability because the training involved writing practice, hands-on exercises, studying examples, working in groups, analyzing, and drafting lesson plans that incorporated PISA-based assessments.

- Students were able to construct mathematical tests due to the practice they received in designing different types of tests based on the PISA framework, including exercises in analyzing the construction of distractors in multiple-choice questions.

- In their future careers as teachers, they plan to use PISA-based tests in practice exercises to help students perceive connections between mathematics and real-life contexts. In addition, they will manage learning by encouraging students to think and take action on their own.

4.2.2 Evaluative results of effectiveness and revision of training curriculum for undergraduate students majoring in mathematics

From the evaluative results of the training curriculum effectiveness, it was found that all specified effectiveness criteria were met. Following the implementation, the researcher refined the training curriculum's structure and content by enhancing the clarity of the activity worksheets. This process resulted in a comprehensive training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines for undergraduate students majoring in mathematics. The finalized training curriculum comprised six components as follows:

1. Principles of the training curriculum included: 1) This training curriculum was designed for undergraduate students majoring in mathematics, focusing on promoting mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines, and 2) The training process emphasized participatory engagement, hands-on practice, the power of questioning, and collaborative learning between trainers and trainees.

2. Objectives of the training curriculum were for participants to: 1) Gain knowledge of the PISA mathematical literacy assessment, 2) Develop the mathematical learning design ability according to the PISA mathematical literacy assessment guidelines, and 3) Acquire mathematical test construction ability and scoring criteria according to PISA mathematical literacy assessment guidelines.

3. Structure and content of the training curriculum comprised five learning units as follows: Learning Unit 1: Characteristics and outcomes of PISA assessment; Learning Unit 2: PISA mathematical literacy assessment framework; Learning Unit 3: Mathematical learning design according to PISA mathematical literacy assessment guidelines; Learning Unit 4: Mathematical test construction according to PISA mathematical literacy assessment guidelines; and Learning Unit 5: Construction of scoring criteria for constructed-response questions that require explanations or solutions.

4. For training methods/activities, this training utilized learning empowerment and power of questioning methods as follows: 1) Trainees participated actively in training activities, engaged in hands-on practice, and completed various tasks; 2) Trainees presented their work, exchanged knowledge, and shared ideas collaboratively; 3) Trainers played roles as coaches, providing guidance, support, facilitation, and actively participating in the learning process of the trainees; and 4) Trainers prepared questions for the trainees, ensuring that these questions were non-directive, clear, specific, and varied, while allowing trainees adequate time to consider their responses.

5. The training materials consisted of the training curriculum documents, activity sheets, knowledge sheets, and PowerPoint presentations.

6. The evaluation of the training curriculum included the following components: 1) A knowledge test on the PISA mathematical literacy assessment; 2) An assessment of mathematical learning design ability according to the PISA mathematical literacy assessment guidelines; 3) An assessment of mathematical test construction ability according to the PISA mathematical literacy assessment guidelines; and 4) An evaluation of the students' opinions on the training curriculum.

5. DISCUSSION

The findings from this research were derived from the development and evaluation of the effectiveness of a training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines for 31 undergraduate students majoring in mathematics at the Faculty of Education, Burapha University, enrolled in the first semester of the 2024 academic year, who volunteered and were interested in participating in this training curriculum.

1. From the results of the development of a training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines for undergraduate students majoring in mathematics (draft version), experts concurred that overall, the training

curriculum showed the highest level of consistency and appropriateness. When the training curriculum was trialed, it was found to be effective and applicable in practice. This may be attributed to the systematic research and development process followed by the researcher in creating the training curriculum, which comprises four steps. These included Step 1: Studying and analyzing basic data; Step 2: Development of the training curriculum (draft version), experts' evaluation of its consistency and appropriateness and pilot test; Step 3: Implementing the training curriculum with the sample; and Step 4: Evaluating effectiveness and refining the training curriculum. This aligned with the steps of training curriculum development by Patphol (2011), which included: 1) needs assessment for training, 2) training design, 3) implementation of training, and 4) evaluation of training outcomes. Furthermore, the training curriculum consisted of six components: 1) Curriculum principles, 2) Objectives, 3) Structure and content, 4) Training methods/activities, 5) Training materials, and 6) Evaluation methods. These components are consistent with the components of a training curriculum for professional teacher students to enhance competency in the creation of reading literacy assessment tools according to the PISA style, as proposed by Tanyabut et al. (2022), and the components of a mathematical literacy curriculum for elementary school students presented by Ngamying (2020). These frameworks indicate that curriculum components should include the curriculum principles, objectives, structure, content, training activities/methods, training materials and media, duration, and evaluation of the curriculum. However, for this research, the mathematical content knowledge in the structure and content component of the training curriculum was adapted based on the core mathematics curriculum in Thailand's Basic Education Core Curriculum (2017 revised version) in accordance with Thailand's Basic Education Core Curriculum B.E. 2551 (A.D. 2008). If this training curriculum is to be implemented, the mathematical content should be adjusted to align with the mathematics curriculum of each country.

2. The evaluative results from the evaluation of the effectiveness of the training curriculum to promote mathematical learning design and test construction abilities according to the PISA mathematical literacy assessment guidelines for undergraduate students majoring in mathematics indicated that all established effectiveness criteria were met. This may be attributed to the developed training curriculum, where participating students were actively involved in the training process. The focus on hands-on practice allowed them to exchange knowledge and reflect on their learning alongside the researcher and other trainees, which corresponds to Singapore's curriculum reform that have shifted towards aligning with the skill sets in the PISA competencies and emphasizing skills such as critical thinking, collaboration, and problem-solving abilities (Deng & Gopinathan, 2016). In addition, Colwell and Enderson (2016) suggested preparing teachers to integrate mathematics literacy (through PISA-Based problem) in a smooth and effective manner to support students' mathematical literacy learning. This was further supported by the organization of training activities in the following units:

2.1 The organization of training activities in Learning Unit 1: Characteristics and outcomes of PISA assessment and Learning Unit 2: PISA mathematical literacy assessment framework. Trainees evaluated the examples of PISA test items presented to them, considering which mathematical processes, mathematical content knowledge, and contexts were assessed according to the PISA mathematical literacy assessment framework, as well as the types of test formats utilized. The use of exemplary techniques facilitated a more concrete understanding of the components within the PISA mathematical literacy assessment framework. As stated by Pornkul (2011), the exemplary technique is one of the best techniques for training those who are unfamiliar with various topics. Its strength lies in promoting learning through observation, enabling learners to clearly see the steps or processes involved, which stimulates their thinking and allows them to reason through these steps until they can understand and apply the knowledge independently.

2.2 The organization of training activities in Learning Unit 3: Mathematical learning design according to PISA mathematical literacy assessment guidelines. Trainees studied and analyzed examples of learning management plans prepared by the researcher. They engaged in hands-on practice by independently designing their own mathematical learning management plans that aligned with the PISA mathematical literacy assessment framework. These processes were in line with the statements made by Boonpattanaporn (2017) that allowing learners to learn through practice and hands-on activities gradually enhance their understanding, and systematic training fosters deeper comprehension among learners. Additionally, during the training, the researcher prepared and employed questions to stimulate the participants in achieving the training objectives. As stated by Wongyai and Patphol (2014), utilizing the power of questioning is a crucial strategy that teachers employ to assess the knowledge and understanding each learner possesses, as well as to provide feedback that enables teachers to assist and promote each learner's understanding in achieving the learning objectives established by the educator.

2.3 The organization of training activities in Learning Unit 4: Mathematical test construction according to PISA mathematical literacy assessment guidelines and Learning Unit 5: Construction scoring criteria for constructed-response questions that require explanations or solutions. Trainees practiced finding answers to test questions and examined how distractors in multiple-choice questions were formulated. They utilized the established scoring criteria to evaluate student responses. They engaged in hands-on activities to create and present multiple-choice questions, complex multiple-choice questions, constructed-response questions that require explanations or solutions, as well as their respective scoring criteria. These methods and activities were consistent with the statements made by Panich et al. (2023) that the best learning occurs through practice or direct personal experience. Furthermore, the statement by Saengloetuthai et al. (2020) emphasized that learning through practice promotes learners to construct knowledge independently, leading to a solid understanding of the material learned and resulting in successful learning outcomes.

Additionally, the researcher encouraged trainees to engage in discussions and provide justifications for their reasoning. For instance, in Learning Unit 2, the trainees explained with reasons the components measured by the presented PISA test items according to the PISA mathematical literacy assessment framework. In Learning Unit 5, trainees utilized the established scoring criteria to evaluate student responses, assign scores, and articulate their reasoning. The researcher also created an environment conducive to presentations, interaction, and knowledge exchange among trainees. These activities fostered a positive attitude toward mathematics and the training curriculum developed by the researcher. As stated by Tougaw (1994) and Tucker (2014), creating an atmosphere that encourages discussion, interaction, discovery, and the examination of supporting rationale will help learners have a good experience and enhance learners' positive perceptions of mathematics.

6. CONCLUSION

The research results reflect that the developed training curriculum was effective and applicable. Additionally, this training curriculum has also promoted mathematics teachers to gain knowledge about the PISA mathematical literacy assessment framework and practice considering the PISA test examples that assess mathematical processes, mathematical content knowledge, and contexts according to this assessment framework, which will help teachers understand the PISA mathematical literacy assessment framework more clearly. If educational institution administrators and mathematics teachers want to implement this developed training curriculum, they should thoroughly understand the curriculum and be able to adapt the training activities and duration flexibly according to the context of each educational institution. Furthermore, mathematics teachers can utilize the knowledge of learning design and test construction according to the assessment guidelines' mathematical literacy of PISA and PISA test formats obtained from studying the developed training curriculum to write lesson plans, organize learning activities, and create various tests to assess students in mathematics classes. This will promote students' familiarity with the characteristics of mathematics tests and assessments according to the PISA guidelines. Moreover, this developed training curriculum can serve as a foundational resource for designing textbooks and organizing learning activities at the lower secondary level to enhance mathematical processes, mathematical content knowledge, and contexts according to the PISA mathematical literacy assessment framework.

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