Journal of Education and Learning; Vol. 14, No. 1; 2025
ISSN 1927-5250 E-ISSN 1927-5269
Published by Canadian Center of Science and Education

Development of an Instructional Model to Enhance Mathematical Literacy for Secondary Students

Pannapawadee Boonsot[1] & Chowwalit Chookhampaeng[1]

[1] Faculty of Education, Mahasarakham University, Maha sarakham Province, Thailand

Correspondence: Chowwalit Chookhampaeng, Faculty of Education, Mahasarakham University, Mahasarakham Province, Thailand.

Received: April 20, 2024 Accepted: June 24, 2024 Online Published: September 15, 2024

doi:10.5539/jel.v14n1p257 URL: https://doi.org/10.5539/jel.v14n1p257

Abstract

This study aims (1) to develop an instructional model to enhance mathematical literacy for secondary students and (2) to examine the effects of using this instructional model. The sample group consisted of students from Lampabpla Wittayakarn School, under the jurisdiction of the Surin Secondary Educational Service Area Office in Thailand by using cluster random sampling, during the second semester of the 2021 academic year. Fifteen students from Grade 9/2 were selected as the experimental group, and 15 students from Grade 9/1 were selected as the control group. The data collection tools: 1) interviews; 2) focus group discussion; 3) mathematical literacy tests; and 4) student satisfaction questionnaires. The statistics used for data analysis include percentage, arithmetic mean, standard deviation, dependent and independent t-test. The research findings revealed that (1) the instructional model to enhance mathematical literacy for secondary students comprises six components: 1) principles and basic theoretical concepts, 2) objectives of the model, 3) instructional management procedures, 4) social system, 5) principles of response, and 6) support system. (2) results of using the instructional model showed that: 1) the experimental group of students had markedly higher mathematical literacy after the intervention compared to before, at the .05 significance level; 2) the experimental group had significantly higher mathematical literacy than the control group, at the .05 significance level; and 3) the experimental group reported the highest level of satisfaction with the instructional model to enhance mathematical literacy for secondary students, with an average score of 4.50 and a standard deviation of 0.17.

Keywords: Mathematical literacy, instructional model, mathematics teaching

1. Introduction

1.1 Background of the Study

Mathematics is a science of thinking and a pivotal tool for developing cognitive skills, learning processes, and systematic reasoning. It serves as a foundational knowledge base for various scientific disciplines and can be integrated into all subjects (Ministry of Education, 2008). Mathematics is essential for both societal development and human development. In terms of societal development, mathematics is used as a fundamental tool to create knowledge and innovations across various fields to efficiently solve problems and improve societal convenience. Regarding human development, mathematics helps enhance cognitive abilities (Amporn Makonong, 2014). This aligns with the Basic Education Core Curriculum of 2008, which aims to develop students' key competencies, including thinking skills, problem-solving abilities, communication skills, life skills, and technology skills (Ministry of Education, 2008). Furthermore, it corresponds with the National Education Plan 2017–2036, which emphasizes the characteristics of Thai children in the 21st century and the workforce demands of the 4.0 era.

Mathematics aims to cultivate each individual's potential to become a well-rounded person, augmenting their reasoning, creativity, systematic thinking, work planning, responsibility, and problem-solving abilities (Niyusanee Ama & Siriporn Thipkong, 2014). This aligns with the definition of Mathematical Literacy by the OECD, which states that mathematical literacy is the capacity of an individual to understand the role of mathematics, make judgments, and decisions based on pertinent data, and use mathematics in ways that meet the needs of each individual as a creative and quality citizen (OECD, 2006; De Lange, 1999; Jablonka, 2003). Mathematical literacy does not only mean having knowledge and the ability to follow steps but also includes the ability to apply mathematical knowledge and skills to proficiently solve challenges encountered in everyday life (OECD, 2003; Steen, Turner, & Tuan, 2007).

Discuss the relevant related literature, but do not feel compelled to include an exhaustive historical account. Assume that the reader is knowledgeable about the basic problem and does not require a complete accounting of its history. A scholarly description of earlier work in the introduction provides a summary of the most recent directly related work and recognizes the priority of the work of others. Citation of and specific credit to relevant earlier works are signs of scientific and scholarly responsibility and are essential for the growth of a cumulative science. In the description of relevant scholarship, also inform readers whether other aspects of this study have been reported on previously and how the current use of the evidence differs from earlier uses. At the same time, cite and reference only works pertinent to the specific issue and not those that are of only tangential or general significance. When summarizing earlier works, avoid nonessential details; instead, emphasize pertinent findings, relevant methodological issues, and major conclusions. Refer the reader to general surveys or research syntheses of the topic if they are available. Demonstrate the logical continuity between previous and present work. Develop the problem with enough breadth and clarity to make it generally understood by as wide a professional audience as possible (Beck & Sales, 2001). Do not let the goal of brevity lead you to write a statement intelligible only to the specialist.

1.2 Statement of the Problem

Thailand places substantial importance on mathematics education as a core subject in the curriculum. However, national and international assessment results disclose issues in teaching and learning management. Firstly, students tend to forget the content and formulas they learn, do not understand or appreciate the importance of mathematics, and perceive it as irrelevant to real life (Somwong Plangprasopchok, 2008; Chaweewan Kaewthaisong, 2017). Secondly, the mean scores in mathematics for Grade 9 students from the National Institute of Educational Testing Service (NIETS) have been uniformly below 50% and have shown a downward trend: 31.99%, 28.59%, and 25.82% for the academic years 2018, 2019, and 2020, respectively (NIETS, 2018, 2019, 2020). Thirdly, the PISA 2018 framework, which emphasizes problem-solving, using principles and processes to solve problems, interpreting and evaluating outcomes, found that 47% of Thai students scored at or above Level 2 in mathematics. In comparison, the OECD average was 76%. Level 2 denotes the ability to interpret and recognize simple situations and use mathematical symbols appropriately. Furthermore, only 2.3% of Thai students reached the highest proficiency levels (Levels 5 and 6), compared to the OECD average of 11%, demonstrating the ability to develop complex mathematical models and select, compare, and evaluate suitable problem-solving strategies (Institute for the Promotion of Teaching Science and Technology, Ministry of Education, 2019). These findings suggest that the Basic Education Core Curriculum B.E. 2551 might not be achieving its objectives and lacks adequate emphasis on promoting mathematical literacy. Constraints such as incomplete content in textbooks hinder students' mathematical literacy, reflecting Thailand’s inadequate emphasis on international education standards, as evidenced by the declining national assessment scores (Sathaporn Phuthatakul, 2012).

In PISA, mathematical literacy is defined as an individual's capacity to reason, apply mathematical concepts, solve, and interpret real-life mathematical problems (Özaydın & Arslan, 2022). Effective education must result from the development of new skills and knowledge in teaching, enabling teachers to enhance students’ necessary competencies and lead them to higher-order thinking (Wang, Chookhampaeng & Chano, 2024; Kamha & Chookhampaeng, 2023; Badescu & Stan, 2020; Beccuti & Robutti, 2022). Kozakli Ulger, Bozkurt, and Altun (2022) studied the use of problem-situation questioning processes by teachers to foster mathematical literacy by utilizing questions from PISA content, which encouraged discussions and evaluations that differ structurally from standard textbook problems. This approach resulted in higher student success compared to traditional questioning methods (Demir & Altun, 2018; Ozgen, 2019; Saka, 2023). This aligns with the development of guided inquiry learning with augmented reality (GILAR) by Pujiastuti and Haryadi (2023), which promotes student autonomy in problem-solving, observation, questioning, and reviewing content from books or other sources of interest outside the classroom (Wang & Jou, 2023). The GILAR approach led to higher mathematical literacy compared to traditional teaching methods, by integrating real-life scenarios with mathematical problems, enhancing student interaction and practical application (Yip, Wong, Yick, Chan, & Wong, 2019). In addition, research has shown that real-world problem-solving (RME) in mathematics education (Yuanita, Zulnaidi, & Zakaria, 2018; Nurmasari, Nurkamto, & Ramli, 2024; Sumirattana, Makanong, & Thipkong, 2017) and analyzing predictive factors influencing mathematical literacy achievement (Mulbar, Nasrullah, & Bustang, 2023; Saka, 2023; Kozakli Ulger, Bozkurt, & Altun, 2022; Cohen, 2021; Cohen, 2022; Aksu, Aksu, & Saracaloglu, 2022) are crucial. The characteristics of students with mathematical literacy (Kusuma, Sukestiyarno, & Cahyono, 2022; Wulandari, 2018) also play a significant role in fostering mathematical understanding.

Constructivist learning theory asserts that knowledge is constructed by individuals through interactions with their environment and society. It suggests that learning is an active, contextualized process of constructing knowledge

rather than acquiring it. It involves problem-solving, critical thinking, and applying knowledge in real-world contexts, leading to deeper understanding. Wijarn Panich (2013) stated that authentic learning enhances academic achievement, fosters collaboration among learners, and builds self-confidence. It allows learners to revisit and study subjects repeatedly until they achieve comprehension. Integrating authentic learning methods with flipped classroom approaches, utilizing technology to create an engaging learning environment, fosters true understanding. In this setup, each student or group studies lessons tailored to their needs, which may differ from those of others, and participates in collaborative activities. Teachers facilitate learning by providing support and assistance with activities, ensuring a flexible and personalized learning experience. Furthermore, making connections is crucial for meaningful mathematics learning, making the subject interesting beyond just learning theorems, rules, formulas, and definitions to solve problems exclusively in the classroom (Amporn Ma-khanong, 2010). The approach to mathematics education that connects real-life situations should guide students and give them opportunities to explore abstract mathematics. This means mathematics education should not focus on closed systems but rather on activities based on mathematical thinking (Marja van den Heuvel-Panhuizen, 2000).

Based on the aforementioned information, as the person responsible for overseeing mathematics education in schools under the Surin Secondary Educational Service Area Office, the researcher interested in formulating an instructional model to enhance mathematical literacy for secondary students. Using a research and development framework, it is anticipated that the outcomes of this research will serve as a guideline for effective learning management. This will help enhance students' mathematical literacy, preparing them to be quality citizens of the country. This model aims to meet the demands of the global labor market by enabling students to apply their knowledge to real-life problem-solving accurately and appropriately (Blass, 2020; Sumirattana, Makanong, & Thipkong, 2017).

1.3 Objective of the Study

1) To develop an instructional model to enhance mathematical literacy for secondary students.

2) To study the effects of using the developed an instructional model to enhance mathematical literacy for secondary students as follows:

① To compare the mathematical literacy of the experimental group of students who received the developed an instructional model before and after the intervention.

② To compare the mathematical literacy of the experimental group students who received the developed an instructional model with the control group students who received the conventional learning management model.

③ To study the satisfaction of the experimental group of students who received the developed an instructional model.

2. Scope of the Study

2.1 Development of an Instructional Model to Enhance Mathematical Literacy for Secondary Students

The informants include:

1) Experts: Seven experts in an instructional for enhancing mathematical literacy for secondary students, selected through purposive sampling, interviewed for their insights.

2) Mathematics Teachers: Six mathematics teachers from Chumphonwittayasan School, under the Secondary Educational Service Area Office Surin, for the second semester of the 2021 academic year. These teachers were selected through simple random sampling and participated in a focus group discussion for the PISA mathematical literacy assessment.

3) Students: A total of 117 Grade 10 students from four schools (classified as very large, large, medium, and small) in the Secondary Educational Service Area Office Surin, for the second semester of the 2021 academic year. These students were selected through stratified random sampling to test mathematical literacy and to respond to a questionnaire about their current situation, problems, and directions in learning mathematics.

4) Experts in Model Development: Five experts in the development of learning management models for enhancing mathematical literacy for secondary students, selected for an expert seminar.

5) Experts in Instrument Validation: Five experts to verify the quality and content validity, suitability, and feasibility of the research instruments used in developing the learning management model. These experts were selected through purposive sampling and included two experts in learning management model development for mathematical literacy for secondary students, two experts in mathematics learning management, and one expert in measurement and evaluation.

2.2 The Study of the Effectiveness of the Learning Management Model to Enhance Mathematical Literacy for Secondary Students Includes the Following Scope

1) Population: The population consists of 7,501 Grade 9 students from 85 schools under the Secondary Educational Service Area Office Surin, during the second semester of the 2021 academic year.

2) Sample Group: The sample group includes Grade 9 students from Lampabpla Witthayakhom School, Chumphon Buri District, Surin Province, under the Secondary Educational Service Area Office Surin, during the second semester of the 2021 academic year. The sample was selected using cluster sampling and simple random sampling methods to choose the classroom for the experimental use of the learning management model. The experimental group consists of 15 students from Grade 9/2, who were taught using the enhanced mathematical literacy teaching model, while the control group consists of 15 students from Grade 9/1, who were taught using the conventional teaching method.

3) Research Instruments:

① Learning Management Plan: The assessment of the suitability of the learning management plan for the basic mathematics course, was rated at a high level (Mean = 4.08, S.D. = 0.16).

② Mathematical Literacy Test: This test consists of 4 scenarios, each with 3 sub-items. The difficulty index (P) ranges from 0.40 to 0.80, the discrimination index (r) ranges from 0.74 to 0.92, and the reliability coefficient is 0.97.

③ Student Satisfaction Questionnaire: This questionnaire assesses the students' satisfaction with the learning management model to enhance mathematical literacy for secondary students. It contains 15 items, with a discrimination index (r) ranging from 0.41 to 0.89 and a reliability coefficient of 0.93.

3. Data Analysis

3.1 The Results of Develop an Instructional Model

The results of develop an instructional model to enhance mathematical literacy for secondary school students revealed that the model comprises six elements: 1) principles and basic theoretical concepts, 2) objectives of the model, 3) steps of learning management, 4) social system, 5) principles of response, and 6) support system. The researcher studied related theoretical concepts, including mathematical literacy according to the PISA assessment framework, constructivist learning theory, flipped classroom concept, approaches to enhancing the ability to connect mathematical knowledge, and realistic mathematics education. Moreover, the current conditions, problems, and ways to develop mathematical literacy were studied by educational experts, teachers, and students. The instructional steps were synthesized into five stages: 1) Preparation, 2) Identifying real-life problems, 3) Brainstorming solutions, 4) Summarizing solutions Together, and 5) Applying and evaluating the value. This is illustrated in Figure 1.

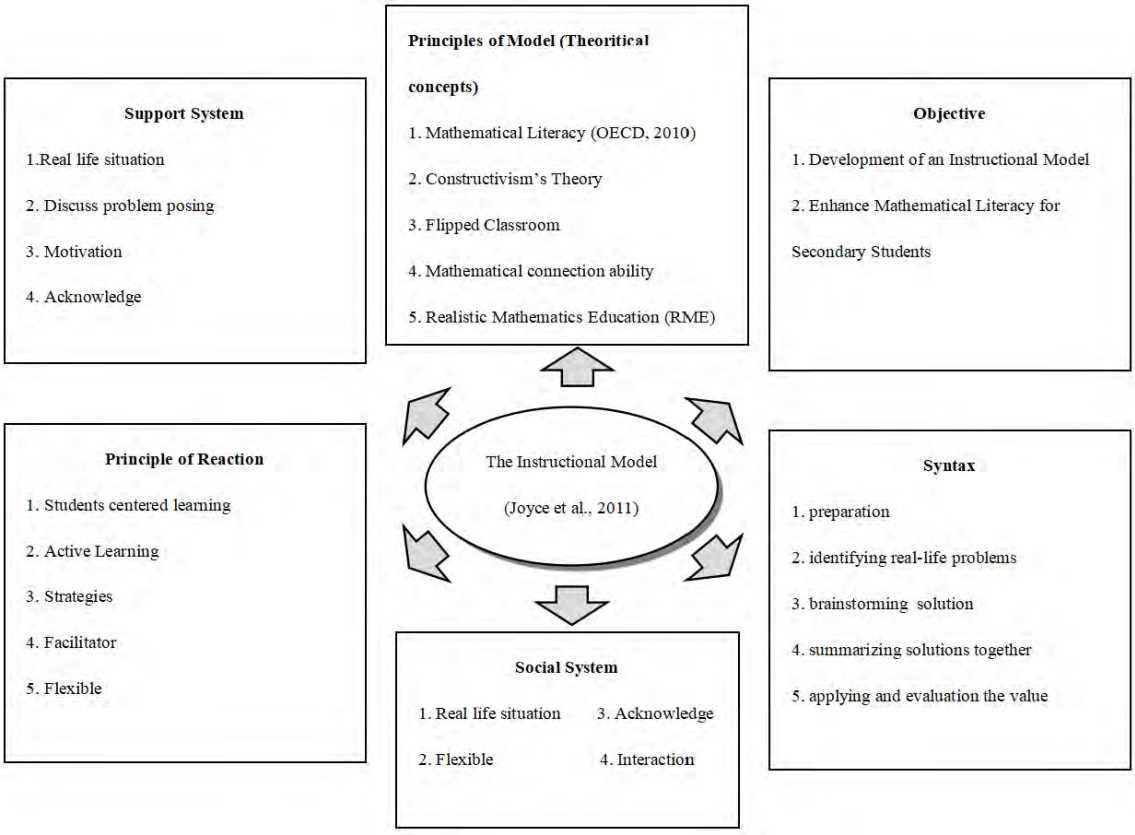

Figure 1. Instructional Model to Enhance Mathematical Literacy for Secondary School Students

The overall assessment results showed that the instructional model for enhancing mathematical literacy for secondary school students was rated as highly appropriate (Mean = 4.08, S.D. = 0.16). The most appropriate aspect was the social system of the instructional model to enhance mathematical literacy for secondary school students.

3.2 The Results of Using the Instructional Model to Enhance Mathematical Literacy for Secondary School Students

The results of using the instructional model to enhance mathematical literacy for secondary school students are as follows:

1) Secondary school students who received instructional using the developed model showed significantly higher post-test scores compared to pre-test scores at the .05 significance level, as shown in Table 1.

Table 1. Comparative Analysis Results of Mathematical Literacy Scores for Secondary School Students Using the Developed Instructional Model Pre-test and Post-test Scores (Full score = 60, n = 15)

Tests	Mean	S.D.	Mean Difference	S.D.	df	t	Sig
Pre-test	13.27	3.807	35.200	2.908	14	46.879*	0.000
Post-test	48.47	4.533					

Note. *Significant at the .05 level.

From Table 1, secondary school students who received instructional using the developed model for enhancing mathematical literacy scored significantly higher post-test than pre-test at the .05 level.

2) Secondary school students who received instructional using the model for enhancing mathematical literacy scored significantly higher than students who followed the normal instructional model at the .05 level, as shown in Table 2.

Table 2. Comparison of Mathematical Literacy of Secondary School Students Receiving Instructional Using the Model for Enhancing Mathematical Literacy and Students Following the Normal Instructional Model (Total Score: 60 Points)

Group	n	Mean	S.D.	Mean Difference	df	t	Sig
Experimental Group	15	48.47	5.54	12.47	29	3.3715*	0.000
Control Group	15	36.00	4.53				

Note. *Significant at the .05 level.

According to Table 2, the mean scores of secondary school students who received instructional using the model for enhancing mathematical literacy were significantly higher than those of students who followed the normal instructional model at the .05 significance level.

3) The overall satisfaction of secondary school students who received instructional using the model for enhancing mathematical literacy was at the highest level (Mean = 4.50, S.D. = 0.17), as shown in Table 3.

Table 3. Mean and Standard Deviation of the Satisfaction of Secondary School Students Who Received Instructional Using the Developed Model for Enhancing Mathematical Literacy (n = 15)

Items	Evaluation Items	Results of Data Analysis		
		Mean	S.D.	Level of Satisfaction
Learning Environment in the Classroom				
1	The teacher uses questions to stimulate thinking and encourages students to be committed to learning.	4.67	0.49	Highest
2	The teacher clearly specifies teaching methods, time, and materials for each topic and follows the steps.	4.73	0.46	Highest
3	Students learn by hands-on practice.	4.87	0.35	Highest
4	Classroom learning activities allow students to learn collaboratively with peers and teachers.	4.27	0.46	High
5	The teacher guides and facilitates student learning.	4.27	0.46	High
Average for Learning Environment in the Classroom		4.56	0.23	Highest
Satisfaction in Learning Mathematics				
1	I enjoy participating in mathematics learning activities.	4.13	0.64	High
2	I enjoy learning mathematics.	4.20	0.76	High
3	I can happily work with my group members.	4.60	0.51	Highest
4	I am satisfied with my previous mathematics learning.	4.40	0.5	High
5	I complete mathematics homework assigned by the teacher diligently.	4.67	0.49	Highest
Average for Satisfaction in Learning Mathematics		4.40	0.31	High
Satisfaction with Learning Activities				
1	The teacher uses modern technology media that promotes thinking and self-directed learning.	4.67	0.49	Highest
2	Students can choose various self-study methods and freely seek knowledge.	4.67	0.49	Highest
3	The classroom environment is free, respectful of opinions, and supports self-confidence in students.	4.60	0.51	Highest
4	Students exchange ideas, knowledge, and experiences with peers and teachers.	4.20	0.76	High
5	Students see the importance of learning mathematics and can apply the knowledge in daily life.	4.60	0.51	Highest
Average Satisfaction with Learning Activities		4.55	0.32	Highest
Overall Average		4.50	0.17	Highest

From Table 3, it was found that the overall satisfaction of secondary school students who received instructional using the developed model to enhance mathematical literacy was at the highest level (Mean = 4.50, S.D. = 0.17). When considering each aspect, it was found that the learning environment in the classroom was rated at the highest level (Mean = 4.56, S.D. = 0.23). The satisfaction in learning mathematics was also at the highest level (Mean = 4.40, S.D. = 0.31). Furthermore, the satisfaction with learning activities was rated at the highest level (Mean = 4.55, S.D. = 0.32).

4. Discussion

4.1 The Results of Develop an Instructional Model

Regarding the results of the Development of an Instructional Model to Enhance Mathematical Literacy for Secondary School Students, the instructional model designed to enhance mathematical literacy for secondary school students comprises the following components: principles and fundamental theoretical concepts, objectives of the model, steps in the instructional process, social system, responsiveness principles, and support system. This aligns with the model development concepts of Joyce et al. (2011). The researcher studied theoretical concepts related to model development, including mathematical literacy according to the PISA assessment framework, constructivist learning theory, flipped classroom concepts, methods to enhance the ability to connect mathematical knowledge, and realistic mathematics education (RME). The study of current conditions, problems, and guidelines for enhancing mathematical literacy involved input from educational experts, teachers, and students. The synthesized instructional steps are: (1) Preparation: setting the stage for learning by preparing materials and mental readiness; (2) Identifying Real-Life Problems: connecting the subject matter with real-life situations to make learning relevant; (3) Brainstorming Problem-Solving Methods: encouraging students to brainstorm and propose various solutions; (4) Summarizing Solutions Together: collaboratively summarizing and evaluating the proposed solutions; and (5) Applying and Evaluating Value: implementing the solutions and assessing their applicability and effectiveness. The overall suitability of the model was rated highly (Mean = 4.08, S.D. = 0.16), indicating that the instructional model is effective, practical, and suitable for the educational reform era. This outcome is due to the researcher's adherence to the research and development framework, which included studying current conditions, problems, and guidelines for enhancing mathematical literacy, creating and evaluating the quality of the learning model, and systematically studying the application results. This led to effective learning and enhanced mathematical literacy among students (Sumirattana, Makanong, & Thipkong, 2017) according to the PISA framework. The findings align with the National Education Plan 2017–2036, which aims to make the education system the main driver of the country and meet the workforce demands of the 21st century, essential for the country's economic and social development.

4.2 The Results of Using the Instructional Model to Enhance Mathematical Literacy for Secondary School Students

1) The study found that students who received instructional using the developed model to enhance mathematical literacy for secondary school students (experimental group) exhibited significantly higher post-test scores compared to pre-test scores at the 0.05 level. The research results indicated that implementing the instructional model to enhance mathematical literacy for secondary school students involved studying the current situation, identifying issues, and outlining instructional strategies from experts, teachers, and students. This was combined with the study, analysis, and synthesis of relevant theoretical concepts and knowledge in instructional . The researcher analyzed and synthesized that the theoretical concepts necessary for enhancing mathematical literacy must include Constructivism, real-life situation connections, Realistic Mathematics Education (RME), and the flipped classroom approach. As a result, students who received instructional through this developed model showed significantly higher post-test scores compared to their pre-test scores at the .05 significance level (Sreeya Chotitham et al., 2022; Sitthikorn Ruangsri, 2017; Thanyapim Janum, 2015; Kittiphan Vibunsilp, 2017; Khaerunisak et al., 2017; Nurmasari, 2024; Pujiastuti, 2023). It can be observed that learning based on Constructivism, the flipped classroom approach, connections to real-life situations, and Realistic Mathematics Education (RME) fosters self-directed knowledge discovery and problem-solving. Teachers play a crucial role by using thought-provoking questions and facilitating interaction among students and between students and teachers. This approach enhances understanding of real-world events, problem-solving, and linking knowledge to real-life contexts, thus promoting higher-order thinking skills (Larson & Keiper, 2011; Van Galen & Eerde, 2018; Van den Heuvel-Panhuizen & Drijvers, 2020; Kozakli Ulger, Bozkurt, & Altun, 2022).

2) Students who underwent instruction using the instructional model to enhance mathematical literacy for secondary school students (experimental group) scored significantly higher than those taught through conventional methods (control group) at the .05 level. The research findings indicate that this learning model promotes active student engagement, encourages articulation of opinions, stimulates thinking through real-life questions, fosters independent problem-solving, and facilitates communication, argumentation, and collaborative problem-solving with peers. This approach leads to better retention and learning outcomes. Consequently, students taught using this developed learning model significantly outperformed those taught using traditional methods at the .05 level (Sreeya Chotitham et al., 2022; Saranthanut Panyasetto, 2015; KADIR et al., 2015; Nurmasari, 2024; Pujiastuti, 2023; Larson and Keiper, 2011; Van Galen & Eerde, 2018; Van den Heuvel-Panhuizen & Drijvers, 2020).

3) The contentment of secondary school students who underwent instruction using the developed instructional

model to enhance mathematical literacy was at the highest level (Mean = 4.50, S.D. = 0.17). The research findings indicate that this instructional model aligns with the research hypothesis. The developed model specifies the roles of teachers and students, facilitates learning, includes content review before introducing new material, uses questions to stimulate student thinking, and links knowledge to real-life problems. It emphasizes the importance of student expression, values student responses, encourages student presentations, provides freedom in learning activities, and offers guidance for task completion. The classroom environment fosters independence under teacher supervision and values student opinions and responses (De Lange, 1999; Sitthikorn Ruangsri, 2017; Rungsaya Narin, 2019; Sreeya Chotitham et al., 2022; KADIR et al., 2015).

Acknowledgments

Not applicable.

Authors' contributions

Not applicable.

Funding

Not applicable.

Competing interests

Not applicable.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

References

Aksu, N., Aksu, G., & Saracaloglu, S. (2022). Prediction of the factors affecting PISA mathematics literacy of students from different countries by using data mining methods. *International Electronic Journal of Elementary Education*, *14*(5), 613–629. https://doi.org/10.26822/iejee.2022.267

Amphon, M.-K. (2010). *Skills and Processes in Mathematics: Development for Advancement*. Bangkok: Center for Textbooks and Academic Documents.

Badescu, O., & Stan, C. (2020). Training Mathematics Teachers for Developing Critical Thinking Skills in VI-Grade Pupils. *Acta Didactica Napocensia*, *13*(2), 186–195. https://doi.org/10.24193/adn.13.2.13

Beccuti, F., & Robutti, O. (2022). Teaching Mathematics in Today's Society: Didactic Paradigms, Narratives and Citizenship. *For the Learning of Mathematics*, *42*(2), 29–34.

Blass, N. (2020). *Achievements and gaps: The status of the Israeli education system*.

Chaveewan, K., & Boonthong, B. (2017). *Development of Assessment Tools for Mathematical Process Skills in Lower Secondary Education*. Bangkok: National Institute of Educational Testing Service (Public Organization).

Chookhampaeng, C., Kamha, C., Chookhampaeng, S. (2023). Problems and Needs Assessment to Learning Management of Computational Thinking of Teachers at the Lower Secondary Level. *Journal of Curriculum and Teaching*, *12*(3), 172–178. https://doi.org/10.5430/jct.v12n3p172

Cohen, S. (2021). What Can We Learn from the PISA Research about the Factors and Parameters Affecting the Success of Student Achievements in Mathematics? A Comparative Study between Israel and Finland. *Acta*

Didactica Napocensia, *14*(1), 214–222. https://doi.org/10.24193/adn.14.1.19

Cohen, S. E. (2022). Factors and Parameters Influencing Student Achievement in Mathematics: A Comparative Study between Israel and Finland. *European Journal of Educational Research*, *11*(3), 1813–1824. https://doi.org/10.12973/eu-jer.11.3.1813

De Lange, J. (1999). Framework for classroom assessment in mathematics. In W. I. Madison (Ed.), *National Center for Improving Student Learning and Achievement in Mathematics and Science*.

Demir, F., & Altun, M. (2018). Development of mathematical literacy question writing process and skills. *Education and Science*, *43*(194), 19–41.

Institute for the Promotion of Teaching Science and Technology, Ministry of Education. (2019). PISA 2018 Assessment Results: What 15-Year-Old Thai Students Know and Can Do. *FOCUS Issues from PISA*, *48*(December), 1–4.

Iskenderoglu, T., & Baki, A. (2011). Classification of the questions in an 8th grade mathematics textbook with respect to the competency levels of PISA. *Egitim ve Bilim*, *36*(161), 287.

Jablonka, E. (2003). Mathematical literacy. In *Second international handbook of mathematics education* (pp. 75–102). https://doi.org/10.1007/978-94-010-0273-8_4

Joyce, B., Weil, M., & Calhoun, E. (2011). *Models of Teaching* (A. Fawaid & A. Mirza). Yogyakarta: Pustaka Pelajar.

Kadir, M. A., Sani, A., & Cahyono, E. C. (2015). *Context in learning mathematics to enhance mathematical problem solving skills of secondary school students*.

Kamha, C.,, & Chookhampaeng, S. (2023). Implementation of a Curriculum to Enhance Learning Management Competency in Computational Thinking for the Lower Secondary Teachers. *Journal of Curriculum and Teaching*, *12*(3), 35–47. https://doi.org/10.5430/jct.v12n3p172

Karakoç, G., & Alacaci, C. (2015). Real world connections in high school mathematics curriculum and teaching. *Turkish Journal of Computer and Mathematics Education* (TURCOMAT), *6*(1), 31–46. https://doi.org/10.16949/turcomat.76099

Khaerunisak, K., Kartono, K., Hidayah, I., & Fahmi, A. Y. (2017). The Analysis of Diagnostic Assesment Result in Pisa Mathematical Literacy Based on Students Self-Efficacy in RME Learning. *Infinity*, *6*(1), 77–94. STKIP Siliwangi Bandung. https://doi.org/10.22460/infinity.v6i1.236

Kitipan, W. (2017). *The Effect of Mathematics Learning Activities Based on Flipped Classroom Combined with Active Learning on Problem-Solving Ability and Critical Thinking Ability of Grade 11 Students*. Master's Thesis in Mathematics Education, Faculty of Education, Chulalongkorn University.

Kozakli Ulger, T., Bozkurt, I., & Altun, M. (2022). Analyzing In-Service Teachers' Process of Mathematical Literacy Problem Posing. *International Electronic Journal of Mathematics Education*, *17*(3). https://doi.org/10.29333/iejme/11985

Krongthong, K. (2015). *Discovering mathematics: problem solving approach–base on the latest mathematics curriculum with student centered approach and PISA assessment, workbook*. PADA Education.

Kusuma, D., Sukestiyarno, Y. L., & Cahyono, A. N. (2022). The Characteristics of Mathematical Literacy Based on Students' Executive Function. *European Journal of Educational Research*, *11*(1), 193–206. https://doi.org/10.12973/eu-jer.11.1.193

Ministry of Education. (2008). *Basic Education Core Curriculum B.E. 2551*. Bangkok: Agricultural Cooperative Federation of Thailand Printing House Co., Ltd.

Ministry of Education. (2017). *Indicators and Core Learning Contents for the Mathematics Subject Group (Revised 2017) according to the Basic Education Core Curriculum B.E. 2551* (Revised 2017). Bangkok: Institute for the Promotion of Teaching Science and Technology.

Mulbar, U., Nasrullah, N., & Bustang, B. (2023). Content Analysis of Students' Argumentation Based on Mathematical Literacy and Creation Ability. *Mathematics Teaching Research Journal*, *15*(5), 226–238.

Nasrullah, & Baharman. (2018). Exploring Practical Responses of M3LC for Learning Literacy. Journal of Physics: Conference Series, 954(1). https://doi.org/10.1088/1742-6596/954/1/012007

Niyusanee, A., & Siriporn, T. (2014). *Organizing Mathematics Learning Activities on applications Using Heuristics*. Bangkok: Journal of Educational Review.

Nurmasari, L., Nurkamto, J., & Ramli, M. (2024). Realistic Mathematics Engineering for improving elementary school students' mathematical literacy. *Journal on Mathematics Education*, *15*(1), 1–26. https://doi.org/10.22342/jme.v15i1.pp1-26

OECD (2003). *OECD Annual Report 2003*. OECD Publishing, Paris. https://doi.org/10.1787/annrep-2003-en

OECD (2006). *OECD Annual Report 2006*. OECD Publishing, Paris. https://doi.org/10.1787/annrep-2006-en

OECD. (2010). *Learning Mathematics for Life: A View Perspective From PISA.*

OECD (2019). *PISA 2018 Result*s (Volume I: What Students Know and Can Do). PISA, OECD Publishing, Paris. https://doi.org/10.1787/5f07c754-en

Office of the Education Council Secretariat. (2017). *National Education Plan B.E. 2560–2579*. Bangkok: Prikwan Graphic Co., Ltd.

Özaydın, Z., & Arslan, Ç. (2022). Assessment of mathematical reasoning competence in accordance with PISA 2021 mathematics framework. *Journal of Theoretical Educational Science*, *15*(3), 453–474. https://doi.org/10.30831/akukeg.1027601

Ozgen, K. (2019). Problem-posing skills for mathematical literacy: The sample of teachers and pre-service teachers. *Eurasian Journal of Educational Research*, *19*(84), 179–212. https://doi.org/10.14689/ejer.2019.84.9

Phitsinee, S. (2018). *Development of a Cloud-Based Flipped Classroom Model Using Problem-Based Learning in a Multicultural Society to Promote Critical Thinking*. Doctoral dissertation, Faculty of Education, Chulalongkorn University.

Pujiastuti, H., & Haryadi, R. (2023). Enhancing Mathematical Literacy Ability through Guided Inquiry Learning with Augmented Reality. *Journal of Education and e-Learning Research*, *10*(1), 43–50. https://doi.org/10.20448/jeelr.v10i1.4338

Rangsiya, N. (2019). *Development of a Flipped Classroom Learning Management Model Using Activity-Based Learning to Enhance Perseverance in Upper Secondary School Students*. Master's Thesis, Faculty of Education, Nakhon Si Thammarat Rajabhat University.

Saka, E. (2023). An Analysis of The Questions on Mathematical Literacy Designed by Mathematics Teachers with A Postgraduate Degree. *Journal of Theoretical Educational Science*, *16*(3), 617–640. https://doi.org/10.30831/akukeg.1238865

Sakon, T., & Amphon, M. (2017). Development of Mathematics Activities Based on Contextual Learning and Mathematical Modeling to Enhance Mathematical Knowledge Connectivity and Attitudes Towards Mathematics for Grade 9 Students. *Online Journal of Education*, *12*(3), 442–458.

Saranthanut, P. (2015). *The Effects of Organizing Mathematics Learning Activities Based on Problem-Based Learning and Supplemental Instruction on Mathematical Connection and Communication Abilities of Grade 8 Students*. Master's Thesis in Mathematics Education, Faculty of Education, Chulalongkorn University.

Sathaporn, P. (2012). *Student Quality…. Results from the Learning Process*. Chonburi: Burapha University.

Sembiring, R. K., Hadi, S., & Dolk, M. (2008). Reforming mathematics learning in Indonesian classrooms through RME. *ZDM*, *40*, 927–939. https://doi.org/10.1007/s11858-008-0125-9

Sitthikorn, R., Sunisa, S., & Chaweewan, S. (2017). Inquiry-Based Learning Management Focused on Real-Life Mathematical Problems on Derivatives and Their Applications to Promote Reasoning Ability and Valuation in Mathematics of Grade 12 Students. *SWU Science Journal*, *33*(1), 231–246.

Somwong, P., Somdet, B., & Janya, P. (2008). Survey Results on the Causes of Thai Students' Weakness in Mathematics and Solutions. *Journal of Mathematics*, *53*, 20–28.

Sreeya, C., Thanannantana, R., & Usanee, L. (2022). Research and Development of a Growth Mindset Promotion Program to Enhance Mathematical Literacy of Grade 8 Students under Bangkok Metropolitan Administration. *Journal of Research Methodology*, *35*(2), 185–199.

Steen, L. A. (2001). *Mathematics and democracy: The case for quantitative literacy*. NCED Princeton, NJ.

Sumirattana, S., Makanong, A., & Thipkong, S. (2017). Using realistic mathematics education and the DAPIC problem-solving process to enhance secondary school students' mathematical literacy. *Kasetsart Journal of Social Sciences*, *38*(3), 307–315. https://doi.org/10.1016/j.kjss.2016.06.001

Thanyapimon, C. (2015). *The Effects of Learning Activities Based on Realistic Mathematics Education and Child Development on Mathematical Reasoning and Communication Skills of 8th Grade Students*. Master's thesis, Faculty of Education, Chulalongkorn University.

Van Den Heuvel-Panhuizen, M. (2000). Mathematics education in the Netherlands: A guided tour. In *Freudenthal Institute CD-rom for ICME9* (pp. 1–32).

Van den Heuvel-Panhuizen, M., & Drijvers, P. (2020). Realistic mathematics education. *Encyclopedia of Mathematics Education*, 713–717. https://doi.org/10.1007/978-3-030-15789-0_170

Van Galen, F., & van Eerde, D. (2018). *Mathematical investigations for primary school*. Utrecht: Utrecht University.

Wang, J., & Jou, M. (2023). The influence of mobile-learning flipped classrooms on the emotional learning and cognitive flexibility of students of different levels of learning achievement. *Interactive Learning Environments*, *31*(3), 1309–1321. https://doi.org/10.1080/10494820.2020.1830806

Wicharn, P. (2013). *Teachers for Students: Creating Flipped Classrooms*. Bangkok: S.R. Printing Mass Products Co., Ltd.

Wulandari, N. F. (2018). Mathematics Skill of Fifteen Years Old Students in Yogyakarta in Solving Problems Like PISA. *Journal on Mathematics Education*, *9*(1), 129–144. https://doi.org/10.22342/jme.9.1.4231.129-144

Yip, J., Wong, S.-H., Yick, K.-L., Chan, K., & Wong, K.-H. (2019). Improving the quality of teaching and learning in classes by using augmented reality video. *Computers & Education*, *128*, 88–101. https://doi.org/10.1016/j.compedu.2018.09.014

Yuanita, P., Zulnaidi, H., & Zakaria, E. (2018). The effectiveness of Realistic Mathematics Education approach: The role of mathematical representation as the mediator between mathematical belief and problem-solving. *PloS One*, *13*(9), e0204847. https://doi.org/10.1371/journal.pone.0204847

Zulkardi, Z. (1999). *How to Design Mathematics Lessons Based on the Realistic Approach*?